Assignment 3A

In this assigment, you will implement and test Monte Carlo Tree Search.

TODO:

1. Enter your information below.
2. Rename `mcts_search_assigned.py` to `mcts_search.py`.
3. Complete the implementation of `mcts` in `mcts_search.py`.
4. Change the default A# from 'A12345678' to your own number.
5. Run all code.
6. Create a pdf version of the notebook.
7. Submit `mcts_search.py`, `assignment3a.pdf`, and `assignment3a.ipynb`. Do not zip them; attach and submit three separate files.

Enter your information below.

Name: ...
CWID: ...

In [1]:
```
from game_boards import MNKNode, ConnectFour, DictGameNode
from game_search import alpha_beta_search
from game_play import maxplayer, randplayer, game_play
from mcts_search import mcts
from mcts_utils import ucb1, mcts_player, dot_graph, dot_graph_path

from IPython.display import Image
```

In [2]:
```
def create_empty_ttt():
    empty_board = []

    for _ in range(3):
        empty_board.append(['-', '-', '-'])

    return MNKNode(empty_board, k = 3)
```

In [3]:
```
def create_empty_c4():
    empty_board = []

    for _ in range(6):
        empty_board.append(['-', '-', '-', '-', '-', '-', '-'])

    return ConnectFour(board=empty_board)
```

In [4]:
```
moves = {'A': ['B', 'C', 'D'], 'B': ['E', 'F', 'G'], 'C': ['H', 'I'], 'D': ['J', 'K',

terminal_nodes = {'E': 0.5, 'F': +1, 'G': 0.5, 'H': +1, 'I': 0, 'J': +1, 'L': +1, 'M'

DictGameNode._moves = moves
DictGameNode._terminal_nodes = terminal_nodes
```

```
dg_initial_gn = DictGameNode(board = 'A', np = 'X')
```

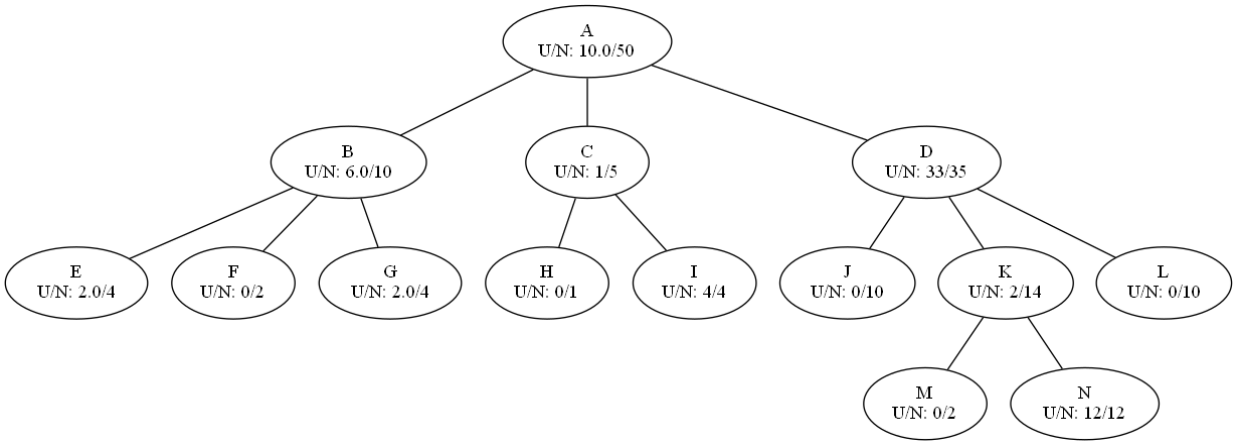
In [5]:
```
CWID='A12345678' # TODO Change to your own A#.

simul_seed = int(CWID[1:])
```

Testing out MCTS

Dictionary Game

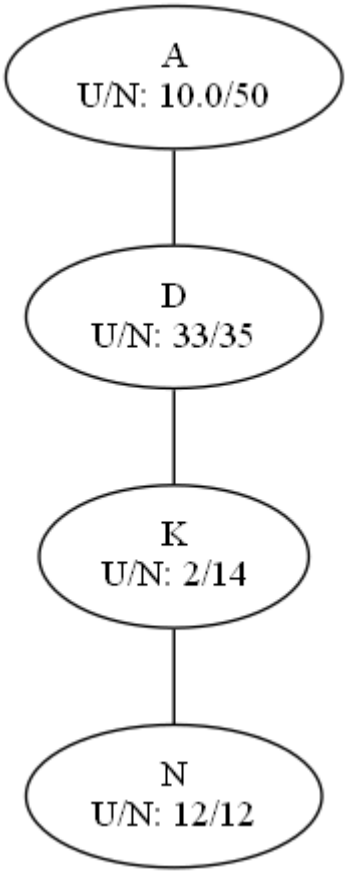
In [6]:
```
dg_root_mcnode = mcts(dg_initial_gn, ucb1, seed=simul_seed, max_iter=50)
pydot_graph = dot_graph(dg_root_mcnode)
Image(pydot_graph.create_png())
```

Out[6]:



In [7]:
```
pydot_graph = dot_graph_path(dg_root_mcnode)
Image(pydot_graph.create_png())
```

Out[7]:



Tic-Tac-Toe

In [8]:
```
ttt_initial_gn = create_empty_ttt()
```

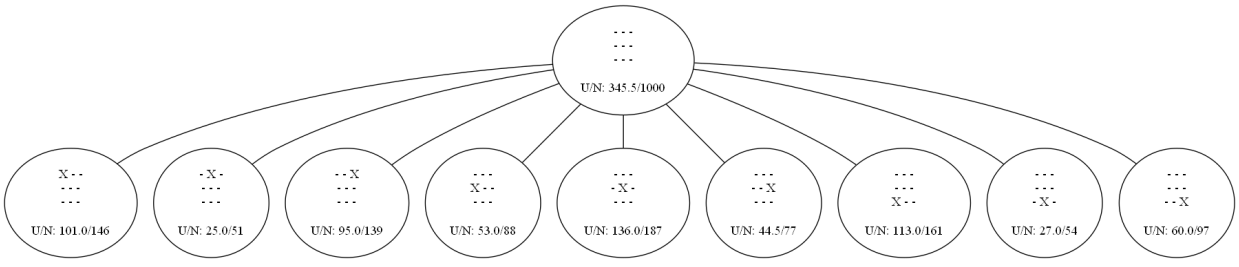
C=1.4

In [9]:
```
util_f = lambda mcnode: ucb1(mcnode, C=1.4)
```

In [10]:
```
ttt_root_mcnode = mcts(ttt_initial_gn, util_f, seed=simul_seed, max_iter=1000)
```

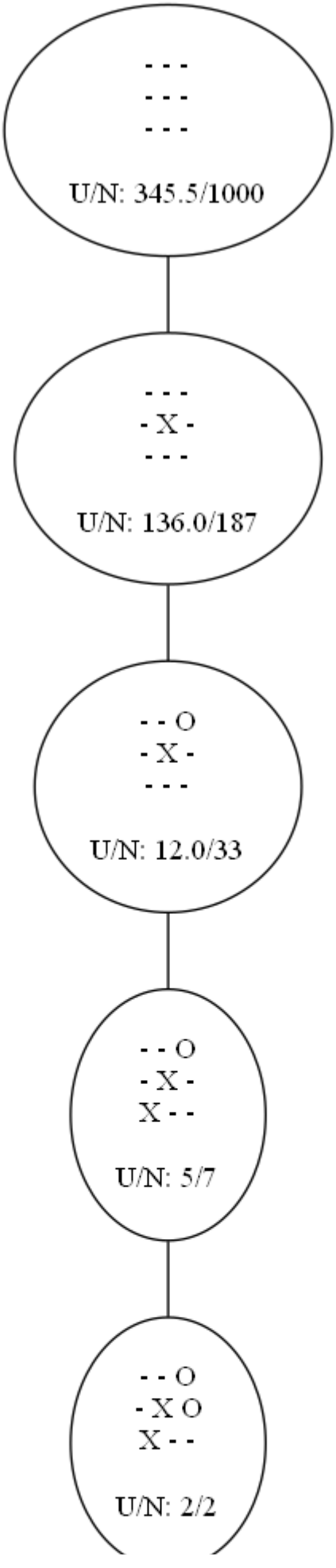
In [11]:
```
pydot_graph = dot_graph(ttt_root_mcnode, max_nodes = 10)
Image(pydot_graph.create_png())
```

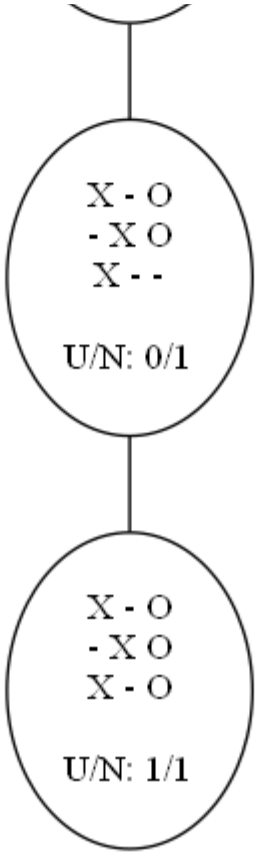
Out[11]:



In [12]:
```
pydot_graph = dot_graph_path(ttt_root_mcnode)
Image(pydot_graph.create_png())
```

Out[12]:





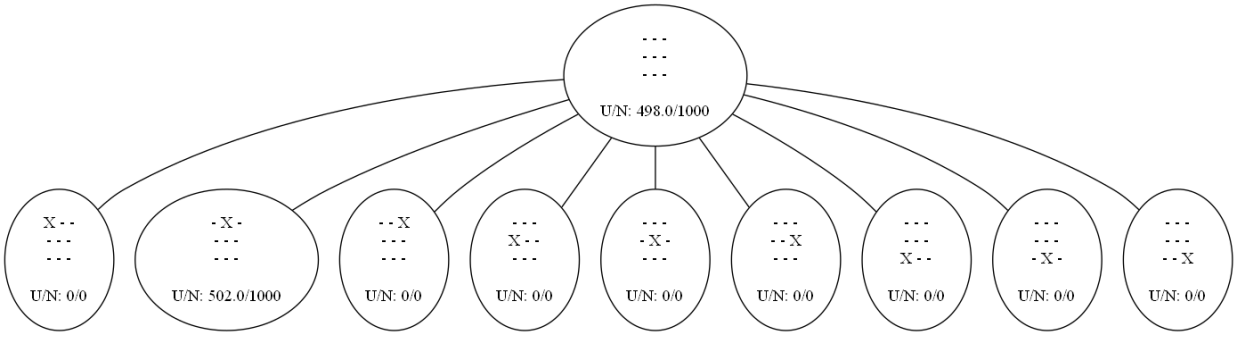
C=0

In [13]:
```
util_f = lambda mcnode: ucb1(mcnode, C=0)
```

In [14]:
```
ttt_root_mcnode = mcts(ttt_initial_gn, util_f, seed=simul_seed, max_iter=1000)
```

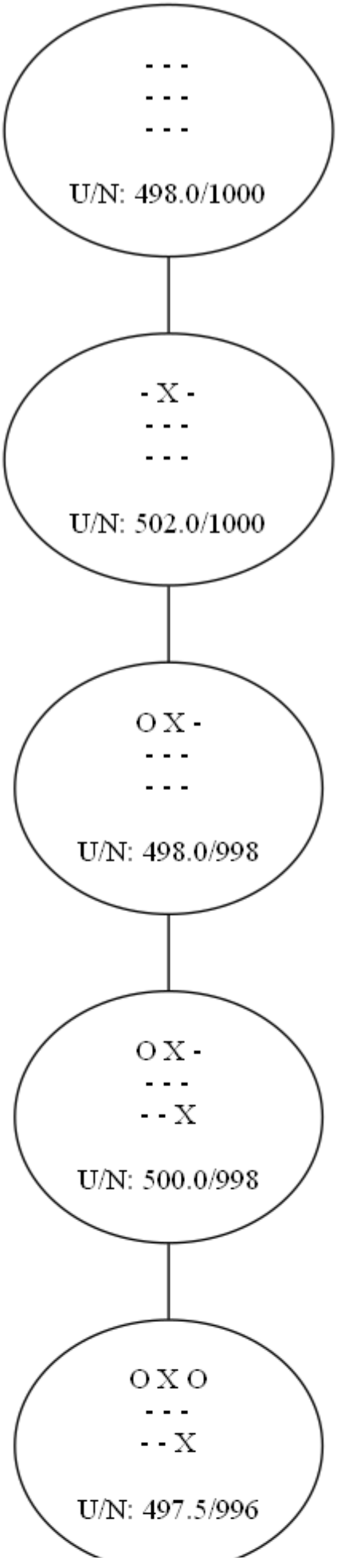
In [15]:
```
pydot_graph = dot_graph(ttt_root_mcnode, max_nodes = 10)
Image(pydot_graph.create_png())
```

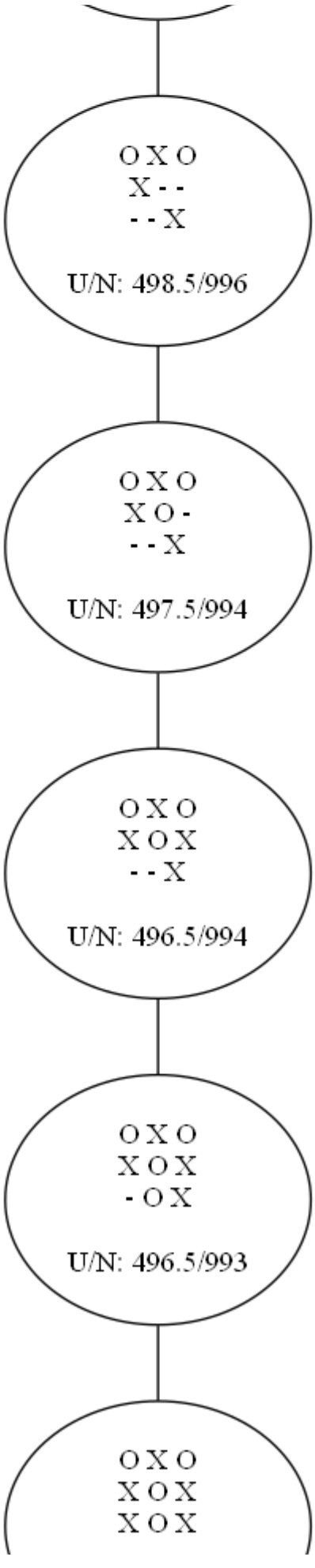
Out[15]:

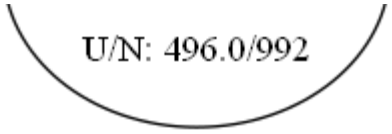


In [16]:
```
pydot_graph = dot_graph_path(ttt_root_mcnode)
Image(pydot_graph.create_png())
```

Out[16]:


- - -
- - -
- - -
U/N: 498.0/1000
- X -
- - -
- - -
U/N: 502.0/1000
O X -
- - -
- - -
U/N: 498.0/998
O X -
- - -
- - X
U/N: 500.0/998
O X O
- - -
- - X
U/N: 497.5/996


O X O
X - -
- - X
U/N: 498.5/996
O X O
X O -
- - X
U/N: 497.5/994
O X O
X O X
- - X
U/N: 496.5/994
O X O
X O X
- O X
U/N: 496.5/993
O X O
X O X
X O X



Connect 4

In [17]:
```
c4_initial_gn = create_empty_c4()
```

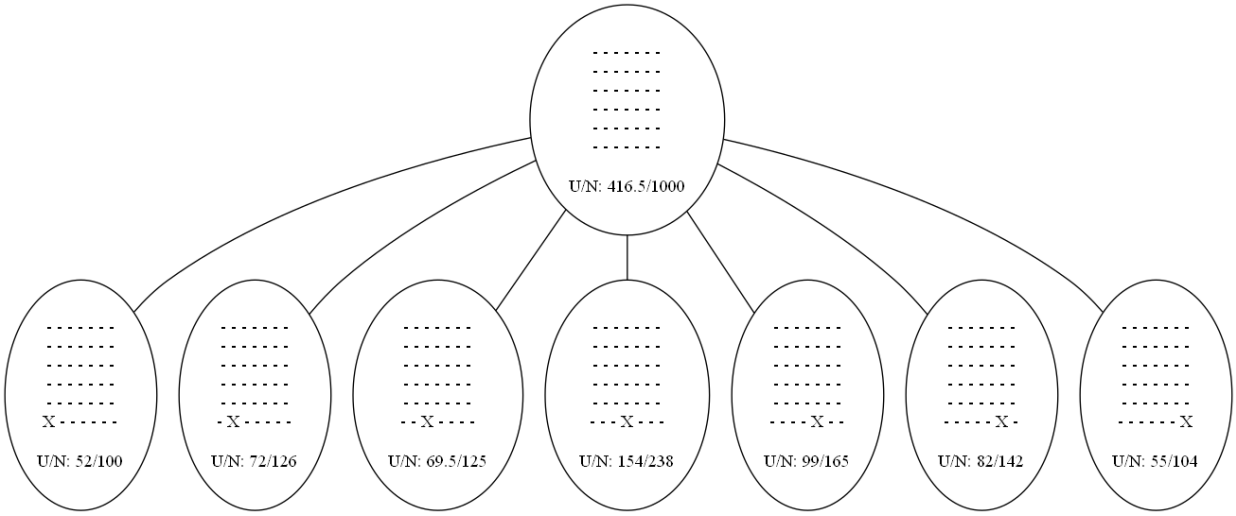
C=1.4

In [18]:
```
util_f = lambda mcnode: ucb1(mcnode, C=1.4)
```

In [19]:
```
c4_root_mcnode = mcts(c4_initial_gn, util_f, seed=simul_seed, max_iter=1000)
```

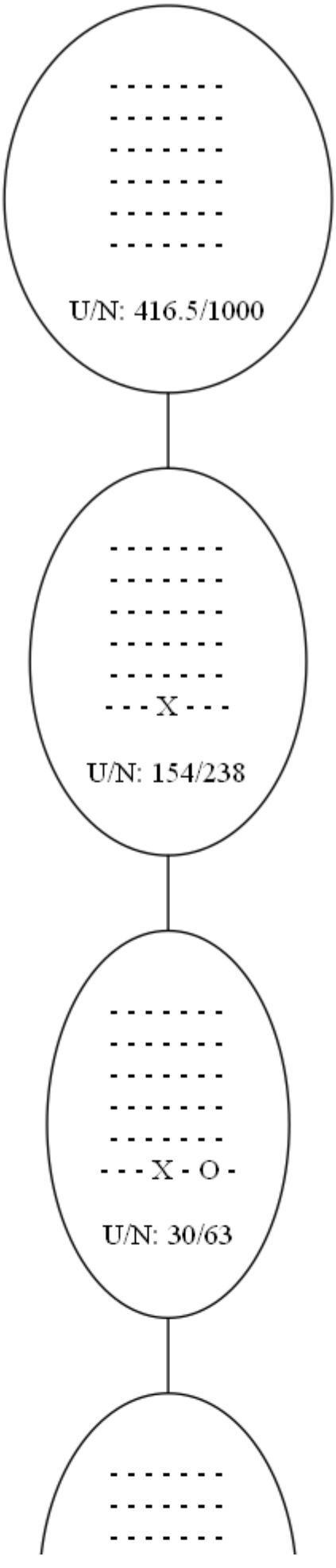
In [20]:
```
pydot_graph = dot_graph(c4_root_mcnode, max_nodes = 8)
Image(pydot_graph.create_png())
```

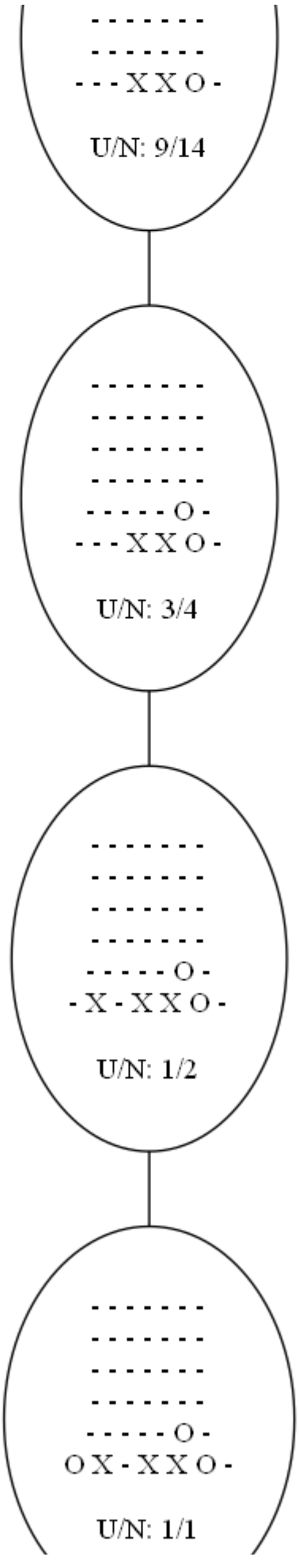
Out[20]:

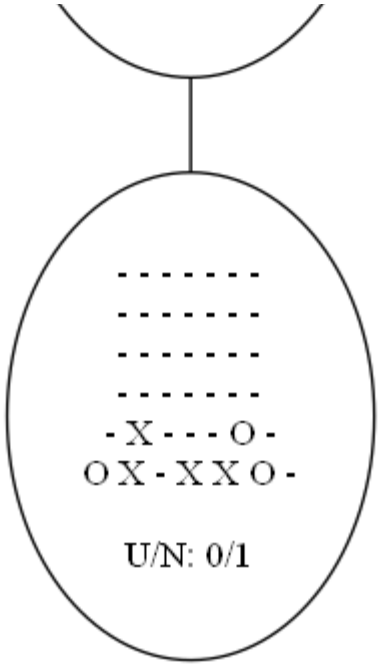


In [21]:
```
pydot_graph = dot_graph_path(c4_root_mcnode)
Image(pydot_graph.create_png())
```

Out[21]:




- - - - - - -
- - - - - - -
- - - X X O -
U/N: 9/14
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - O -
- - - X X O -
U/N: 3/4
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - O -
- X - X X O -
U/N: 1/2
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - O -
O X - X X O -
U/N: 1/1



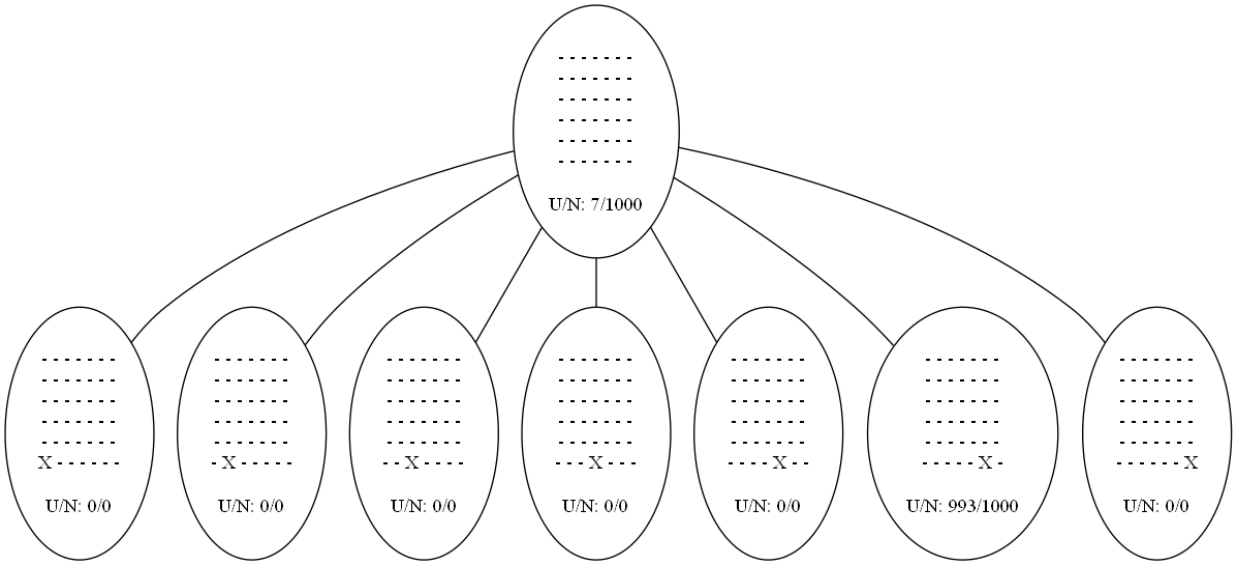
C = 0

In [22]:
```
util_f = lambda mcnode: ucb1(mcnode, C=0)
```

In [23]:
```
c4_root_mcnode = mcts(c4_initial_gn, util_f, seed=simul_seed, max_iter=1000)
```

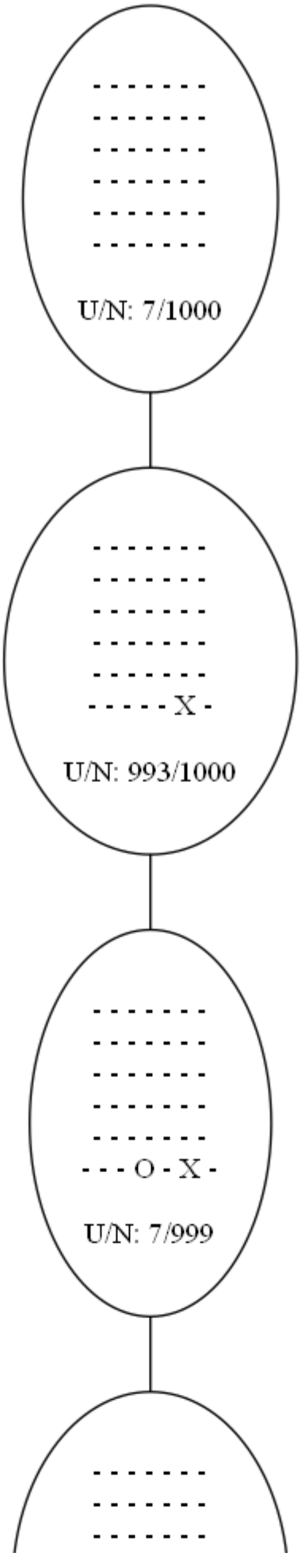
In [24]:
```
pydot_graph = dot_graph(c4_root_mcnode, max_nodes = 8)
Image(pydot_graph.create_png())
```

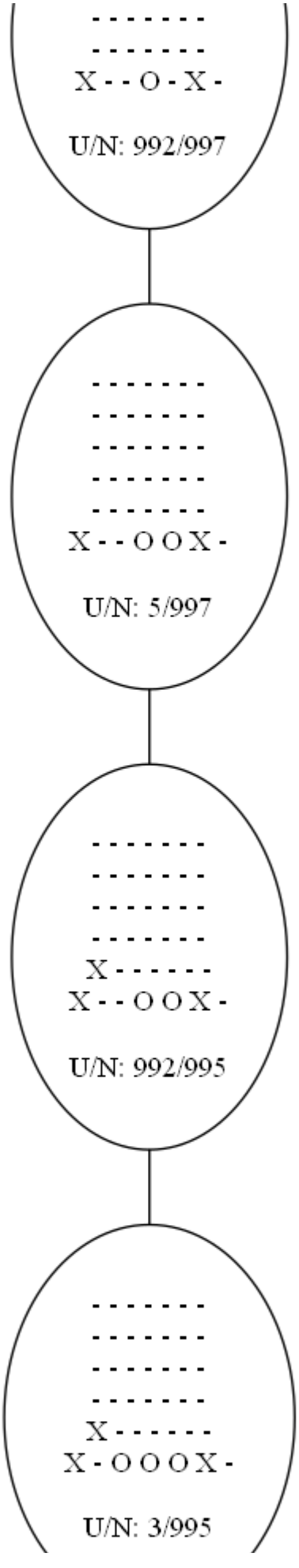
Out[24]:

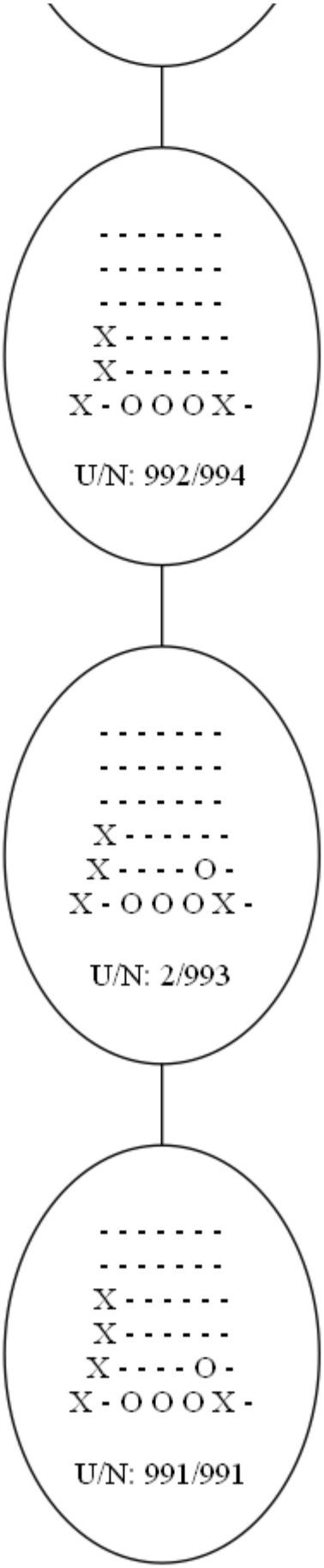


In [25]:
```
pydot_graph = dot_graph_path(c4_root_mcnode)
Image(pydot_graph.create_png())
```

Out[25]:




- - - - - - -
- - - - - - -
X - - O - X -
U/N: 992/997
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
X - - O O X -
U/N: 5/997
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
X - - - - - -
X - - O O X -
U/N: 992/995
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
X - - - - - -
X - O O O X -
U/N: 3/995



MCTS vs Random Player

In [26]:
```
util_f = lambda mcnode: ucb1(mcnode, C=1.4)

x_player = lambda b:  mcts_player(b, util_f, seed = simul_seed, max_iter=1000)
o_player = lambda b: randplayer(b, seed=0)

game_play(ttt_initial_gn, x_player, o_player)
```

```
- - -
- - -
- - -

It's X's turn.
136.0/187 = 0.73
Chosen move (1, 1, 'X').

- - -
- X -
- - -

It's O's turn.
Chosen move (2, 1, 'O').

- - -
- X -
- O -

It's X's turn.
204.0/231 = 0.88
Chosen move (2, 0, 'X').

- - -
- X -
X O -

It's O's turn.
Chosen move (1, 0, 'O').

- - -
O X -
X O -

It's X's turn.
438/438 = 1.00
Chosen move (0, 2, 'X').


Game ended.
- - X
O X -
X O -

Winner is X.
```

In [27]:
```
util_f = lambda mcnode: ucb1(mcnode, C=1.4)

x_player = lambda b:  mcts_player(b, util_f, seed = simul_seed, max_iter=1000)
o_player = lambda b: randplayer(b, seed=0)

game_play(c4_initial_gn, x_player, o_player)
```

```
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -

It's X's turn.
154/238 = 0.65
Chosen move (5, 3, 'X').

- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - X - - -

It's O's turn.
Chosen move (5, 6, 'O').

- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - X - - O

It's X's turn.
123/173 = 0.71
Chosen move (5, 1, 'X').

- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- X - X - - O

It's O's turn.
Chosen move (4, 6, 'O').

- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - O
- X - X - - O

It's X's turn.
355/410 = 0.87
Chosen move (5, 2, 'X').

- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - O
- X X X - - O
```

```
It's O's turn.
Chosen move (3, 6, 'O').

- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - O
- - - - - - O
- X X X - - O

It's X's turn.
384/384 = 1.00
Chosen move (5, 0, 'X').


Game ended.
- - - - - - -
- - - - - - -
- - - - - - -
- - - - - - O
- - - - - - O
X X X X - - O

Winner is X.
```

MCTS vs Alpha-Beta

In [28]:
```
util_f = lambda mcnode: ucb1(mcnode, C=1.4)

x_player = lambda b:  mcts_player(b, util_f, seed = simul_seed, max_iter=1000)
o_player = lambda b: maxplayer(b, algo=alpha_beta_search)

game_play(ttt_initial_gn, x_player, o_player)
```

```
- - -
- - -
- - -

It's X's turn.
136.0/187 = 0.73
Chosen move (1, 1, 'X').

- - -
- X -
- - -

It's O's turn.
Chosen move (0, 0, 'O').

O - -
- X -
- - -

It's X's turn.
203.5/252 = 0.81
Chosen move (0, 1, 'X').

O X -
- X -
- - -

It's O's turn.
Chosen move (2, 1, 'O').

O X -
- X -
- O -

It's X's turn.
223.5/337 = 0.66
Chosen move (1, 0, 'X').

O X -
X X -
- O -

It's O's turn.
Chosen move (1, 2, 'O').

O X -
X X O
- O -

It's X's turn.
195.5/367 = 0.53
Chosen move (0, 2, 'X').

O X X
X X O
- O -

It's O's turn.
Chosen move (2, 0, 'O').
```

```
O X X
X X O
O O -

It's X's turn.
500.0/1000 = 0.50
Chosen move (2, 2, 'X').


Game ended.
O X X
X X O
O O X

Draw.
```

In [29]:

```
util_f = lambda mcnode: ucb1(mcnode, C=1.4)


x_player = lambda b: maxplayer(b, algo=alpha_beta_search)
o_player = lambda b:  mcts_player(b, util_f, seed = simul_seed, max_iter=1000)

game_play(ttt_initial_gn, x_player, o_player)
```

```
- - -
- - -
- - -

It's X's turn.
Chosen move (0, 0, 'X').

X - -
- - -
- - -

It's O's turn.
114.0/260 = 0.44
Chosen move (1, 1, 'O').

X - -
- O -
- - -

It's X's turn.
Chosen move (0, 1, 'X').

X X -
- O -
- - -

It's O's turn.
420.5/730 = 0.58
Chosen move (0, 2, 'O').

X X O
- O -
- - -

It's X's turn.
Chosen move (2, 0, 'X').

X X O
- O -
X - -

It's O's turn.
465.5/858 = 0.54
Chosen move (1, 0, 'O').

X X O
O O -
X - -

It's X's turn.
Chosen move (1, 2, 'X').

X X O
O O X
X - -

It's O's turn.
250.0/500 = 0.50
Chosen move (2, 1, 'O').
```

```
X X O
O O X
X O -

It's X's turn.
Chosen move (2, 2, 'X').


Game ended.
X X O
O O X
X O X

Draw.
```

In [ ]: