1. Tic-Tac-Toe: Exploring state

One of my favorite movies is the 1983 release "War Games" starring Matthew Broderick whose character "David" plays a young hacker who enjoys cracking into computers systems ranging from his school's grade book to a Pentagon server that has the potential to launch intercontinental ballistic missiles. Central to the plot is the game of "Tic-Tac-Toe," a game so simple that it usually ends in a draw between the two players. In the movie, David engages Joshua, an artificial intelligence (AI) agent, who is capable of playing lots of nice games like chess. David would rather play the game "Global Thermonuclear War" with Joshua. Eventually David realizes that Joshua is using the simulation of a war game to trick the US military into initiating a nuclear first strike against the Soviet Union. Understanding the Mutually Assured Destruction (MAD) doctrine, David asks Joshua to play himself at Tic-Tac-Toe so that he can explore the futility of games that can never result in victory. After hundreds or thousands of rounds all ending in draws, Joshua concludes that "the only winning strategy is not play," at which point Joshua stops trying to destroy the Earth and suggests instead that they could play "a nice game of chess."

I assume you already know the game of Tic-Tac-Toe, but we'll review briefly in case your childhood missed countless games of this with your friends. The game starts out with a 3-by-3 square grid. There are two players who take turns marking first `X` and then `O` into the cells. A player wins by placing the same mark in any three squares in a straight line horizontally, vertically, or diagonally. This is usually impossible as each player will generally use their moves to block a potential win by their opponent.

We will program a simulation of the game that will explore the idea of program "state" which is a way to think of how the pieces of a program change over time. For instance, we start off with a blank board, and the first player to go is `X`. After each round, some cell on the board is taken by a player, and play alternates between the `X` and `O`. We will need to keep track of these ideas and more so that, at any moment, we always know the "state" of the game.

If you recall, the hidden state of the `random` module proved to be a problem in the "Password" chapter where an early solution we explored produced inconsistent results depending on the order of operations that used the module. In this exercise, we're going to think about ways to make the "state" of our game and — any changes to it — explicit.

In our version of Tic-Tac-Toe, we'll write a program that plays just one round of the game. Your program will be given a string that represents a Tic-Tac-Toe board at any time during a game. The default is the empty board at the beginning of the game, before either player has a move. The program may also be given one move to add to that board. It will print a picture of the board and report if there is a winner.

For our program, need to track at least two ideas in our state:

1. The board, or which player has marked which squares of the grid.
2. The winner, if there is one.

In the next chapter, we'll write an interactive version of the game where we will need to track and update several more items in our state through as many rounds as needed to finish a game.

In this exercise, you will:

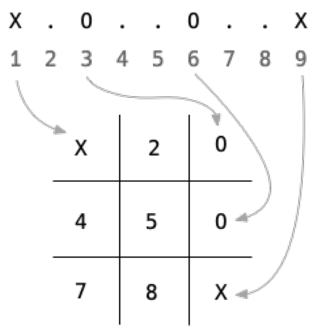
- Consider how to use elements like strings and lists to represent aspects of a program's state.
- Enforce the rules of a game as code such as preventing a player from taking a cell that has already been taken.
- Use a regular expression to validate the initial board.
- Use `and` and `or` to reduce combinations of boolean values to a single value.
- Use lists of lists to find a winning board.
- Use the `enumerate()` function to iterate a `list` with the index and value.

1.1. Writing `tictactoe.py`

The initial state of the board will come from a `-b` or `--board` option that describes which cells are occupied by which players. Since there are nine cells, we'll use a string that is nine characters long composed only of the characters `X` and `O` or the dot (`.`) to indicate the cell is open. The default board will be 9 dots, and the grid should number the cells from 1 to 9 as they are all empty. As there is no winner, the result will be "No winner":

```
$ ./tictactoe.py
-------------
| 1 | 2 | 3 |
-------------
| 4 | 5 | 6 |
-------------
| 7 | 8 | 9 |
-------------
No winner.
```

The `--board` will describe which cells to mark for which player where each position of the string describes each cell ascending from 1 to 9. In the string `X.O..O..X`, the positions 1 and 9 are occupied by "X" and positions 3 and 6 by "O".



Here is how the grid would be rendered by the program:

```
$ ./tictactoe.py -b X.O..O..X
-------------
| X | 2 | O |
-------------
| 4 | 5 | O |
-------------
| 7 | 8 | X |
-------------
No winner.
```

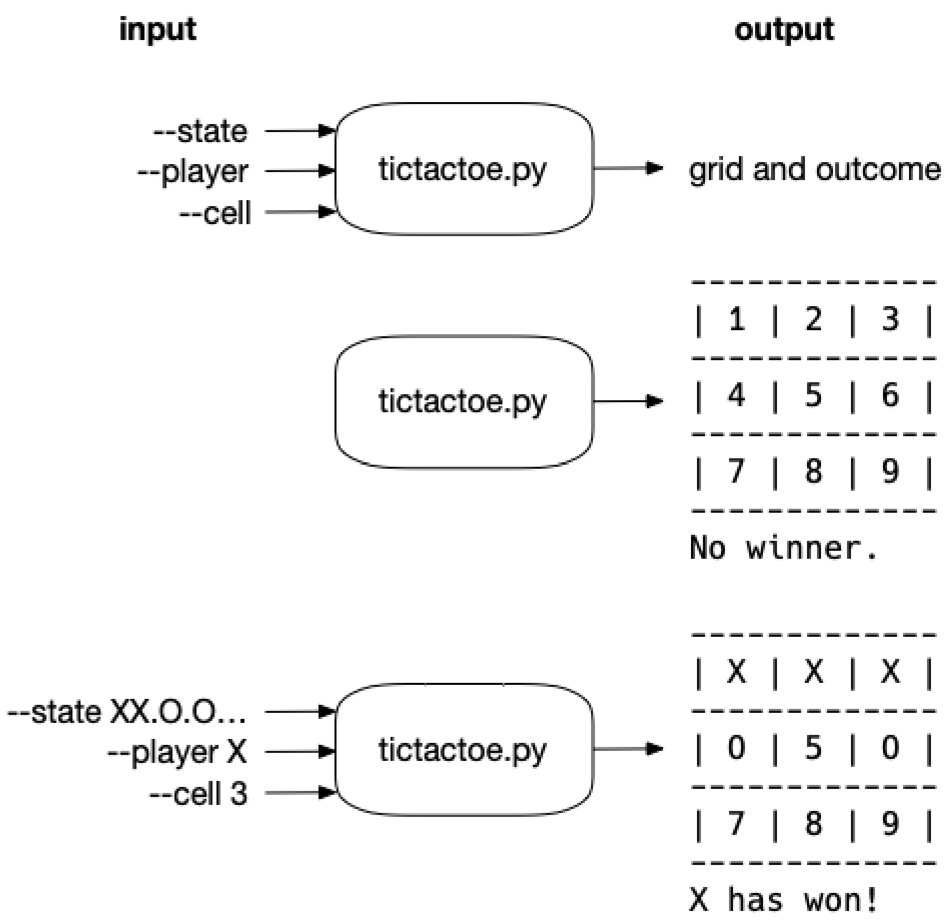
We can additionally modify the given `--board` by passing a `-c` or `--cell` option of 1-9 *and* a `-p` or `--player` of "X" or "O". For instance, we can mark the first cell as "X" like so:

```
$ ./tictactoe.py --cell 1 --player X
-------------
| X | 2 | 3 |
-------------
| 4 | 5 | 6 |
-------------
| 7 | 8 | 9 |
-------------
No winner.
```

The winner, if any, should be declared with gusto:

```
$ ./tictactoe.py -b XXX......
-------------
| X | X | X |
-------------
| 4 | 5 | 6 |
-------------
| 7 | 8 | 9 |
-------------
X has won!
```

As usual, we’ll use a test suite to ensure that our program works properly. Here is our string diagram:



```
-------------
| 1 | 2 | 3 |
-------------
| 4 | 5 | 6 |
-------------
| 7 | 8 | 9 |
-------------
No winner.
```

```
-------------
| X | X | X |
-------------
| O | 5 | O |
-------------
| 7 | 8 | 9 |
-------------
X has won!
```

1.1.1. Validating user input

There's a fair bit of input validation that needs to happen. The `--board` needs to ensure that any argument is exactly 9 characters and composed only of `X`, `O`, and `.`:

```
$ ./tictactoe.py --board XXXOOO..
usage: tictactoe.py [-h] [-b board] [-p player] [-c cell]
tictactoe.py: error: --board "XXXOOO.." must be 9 characters of ., X, O
```

Likewise, the `--player` can only be `X` or `O`:

```
$ ./tictactoe.py --player A --cell 1
usage: tictactoe.py [-h] [-b board] [-p player] [-c cell]
tictactoe.py: error: argument -p/--player: \
invalid choice: 'A' (choose from 'X', 'O')
```

And the `--cell` can only be an integer value from 1 to 9:

```
$ ./tictactoe.py --player X --cell 10
usage: tictactoe.py [-h] [-b board] [-p player] [-c cell]
tictactoe.py: error: argument -c/--cell: \
invalid choice: 10 (choose from 1, 2, 3, 4, 5, 6, 7, 8, 9)
```

Both --player and --cell must be present together or neither can be present:

```
$ ./tictactoe.py --player X
usage: tictactoe.py [-h] [-b board] [-p player] [-c cell]
tictactoe.py: error: Must provide both --player and --cell
```

Lastly, if the --cell specified is already occupied by an X or an O, the program should error out:

```
$ ./tictactoe.py --player X --cell 1 --board X..O.....
usage: tictactoe.py [-h] [-b board] [-p player] [-c cell]
tictactoe.py: error: --cell "1" already taken
```

I would recommend you put all this error checking into get_args() so that you can use parser.error() to throw the errors and halt the program.

1.1.2. Altering the board

The initial board, once validated, describes which cells are occupied by which player. This board can be altered by the addition of the --player and --cell arguments. It may seem silly to not just pass in the already altered --board, but this is necessary practice for writing the interactive version.

If you represent board as a str value like 'XX.O.O..X' and you need to change, for instance, cell 3 to an X, how will you do that? For one thing, the "cell" 3 is not found at *index* 3 in the given board — the index is *one less* than the cell number. The other issue is that a str is immutable. Just as in "Telephone," you'll need to figure out a way to modify one character in the board value.

1.1.3. Printing the board

Once you have a board, you need to format it with ASCII characters to create a grid. I recommend you make a function called format_board() that takes the board as an argument and returns a str that uses dashes - and vertical pipes | to create a table. I have provided a unit.py file that contains, for instance, the following test for the default, unoccupied grid:

```
def test_board_no_board():
    """makes default board"""

    board = """ ①
-------------
| 1 | 2 | 3 |
-------------
| 4 | 5 | 6 |
-------------
| 7 | 8 | 9 |
-------------
""".strip()

    assert format_board('.' * 9) == board ②
```

① Use the triple quotes as the string has embedded newlines. The final `str.strip()` call will remove the trailing newline which I used to format the code.

② If you multiply a string by an integer value, Python will create a new `str` by repeating the given string that number of times. Here we create a string of nine dots as the input to `format_board()`. We expect the return should be an empty board as formatted above.

Then try formatting a board with some other combination. Here's another test I wrote that you may like to use, but feel free to write your own:

```
def test_board_with_board():
    """makes board"""

    board = """
-------------
| 1 | 2 | 3 |
-------------
| O | X | X |
-------------
| 7 | 8 | 9 |
-------------
""".strip()

    assert format_board('...OXX...') == board ①
```

① The given board should have the first and third rows open and the second row with "OXX".

It would be impractical to test every possible combination for the board. When you're writing tests, you often have to rely on spot-checking your code. Here I am checking the empty board and a non-empty board. Presumably if the function can handle these two arguments, it can handle any others.

1.1.4. Determining a winner

Once you have validated the input and printed the board, the last task is to declare a winner if there is one. I chose to write a function called `find_winner()` that returns either `X` or `O` if one of those is the winner or returns `None` if there is no winner. To test this, I wrote out every possible winning board to test my function with values for both players. You are welcome to use this test:

```
def test_winning():
    """test winning boards"""

    wins = [('PPP......'), ('...PPP...'), ('......PPP'), ('P..P..P..'), ①
            ('.P..P..P.'), ('..P..P..P'), ('P...P...P'), ('..P.P.P..')]

    for player in 'XO':                               ②
        other_player = 'O' if player == 'X' else 'X' ③

        for board in wins:                            ④
            board = board.replace('P', player)        ⑤
            dots = [i for i in range(len(board)) if board[i] == '.'] ⑥
            mut = random.sample(dots, k=2)            ⑦
            test_board = ''.join([                    ⑧
                other_player if i in mut else board[i]
                for i in range(len(board))
            ])
            assert find_winner(test_board) == player ⑨
```

① This is a `list` of the board indexes that, if occupied by the same player, would win.

② Check for both players `X` and `O`.

③ The test will randomly select a couple of the empty cells to fill with the other player, so figure out which one that will be.

④ Iterate through each of the lists of winning combinations.

⑤ Change all the `P` (for "player") values in the given `board` to the given `player` that we're checking.

⑥ Find the indexes of the open cells indicated by a dot.

⑦ Randomly sample two open cells. We will mutate these, so I call them `mut`.

⑧ Alter the `board` to change the two selected `mut` cells to the `other_player`.

⑨ Assert that `find_winner()` will determine that this board wins for the given `player`.

I also wanted to be sure I would not falsely claim that a losing board is winning, so I also wrote the following test to ensure that `None` is returned when there is no winner:

```
def test_losing():
    """test losing boards"""

    losing_board = list('XXOO.....') ①

    for _ in range(10):              ②
        random.shuffle(losing_board) ③
        assert find_winner(''.join(losing_board)) is None ④
```

① No matter how this board is arranged, it cannot win as there are only two marks for each player.

② Run 10 tests.

③ Shuffle the losing board into another configuration.

④ Assert that, no matter how the board is arranged, will still find no winner.

If you choose the same function names as I did, then you can run `pytest -xv unit.py` to run the unit tests I wrote. If you wish to write different functions, you can create your own unit tests either inside your `tictactoe.py` or in another unit file.

After printing the board, be sure to print "{winner} has won!" or "No winner" depending on the outcome. All righty, you have your orders, so get marching!

1.2. Solution

```
#!/usr/bin/env python3
"""Tic-Tac-Toe"""

import argparse
import re


# --------------------------------------------------
def get_args():
    """Get command-line arguments"""

    parser = argparse.ArgumentParser(
        description='Tic-Tac-Toe',
        formatter_class=argparse.ArgumentDefaultsHelpFormatter)

    parser.add_argument('-b',                   ①
                        '--board',
                        help='The state of the board',
                        metavar='board',
                        type=str,
                        default='.' * 9)

    parser.add_argument('-p',                   ②
                        '--player',
                        help='Player',
                        choices='XO',
                        metavar='player',
                        type=str,
                        default=None)

    parser.add_argument('-c',                   ③
                        '--cell',
                        help='Cell 1-9',
                        metavar='cell',
                        type=int,
                        choices=range(1, 10),
                        default=None)

    args = parser.parse_args()

    if any([args.player, args.cell]) and not all([args.player, args.cell]): ④
        parser.error('Must provide both --player and --cell')

    if not re.search('^[.XO]{9}$', args.board): ⑤
        parser.error(f'--board "{args.board}" must be 9 characters of ., X, O')

    if args.player and args.cell and args.board[args.cell - 1] in 'XO': ⑥
        parser.error(f'--cell "{args.cell}" already taken')

    return args


# --------------------------------------------------
def main():
    """Make a jazz noise here"""

    args = get_args()
    board = list(args.board)            ⑦

    if args.player and args.cell:       ⑧
        board[args.cell - 1] = args.player ⑨

    print(format_board(board))          ⑩
    winner = find_winner(board)         ⑪
    print(f'{winner} has won!' if winner else 'No winner.')  ⑫


# --------------------------------------------------
def format_board(board):        ⑬
    """Format the board"""

    cells = [str(i) if c == '.' else c for i, c in enumerate(board, 1)] ⑭
    bar = '-------------'
    cells_tmpl = '| {} | {} | {} |'
    return '\n'.join([          ⑮
        cells_tmpl.format(*cells[:3]), bar,
        cells_tmpl.format(*cells[3:6]), bar,
        cells_tmpl.format(*cells[6:]), bar
    ])


# --------------------------------------------------
def find_winner(board):        ⑯
    """Return the winner"""

    winning = [[0, 1, 2], [3, 4, 5], [6, 7, 8], [0, 3, 6], [1, 4, 7],
               [2, 5, 8], [0, 4, 8], [2, 4, 6]] ⑰

    for player in ['X', 'O']:   ⑱
        for i, j, k in winning: ⑲
            combo = [board[i], board[j], board[k]] ⑳
            if combo == [player, player, player]:
                return player


# --------------------------------------------------
if __name__ == '__main__':
    main()
```

① The `--board` will default to nine dots. If you use the multiplication operator `*` with a `str` value and an `int` (in any order), the result is the `str` value repeated `int` times. So `'.' * 9` will produce `'.........'`.

② The `--player` must be either `X` or `O` which can be validated using `choices`.

③ The `--cell` must be an integer between 1 and 9 which can be validated with `type=int` and `choices=range(1, 10)` remembering that the upper bound (10) is not included.

④ The combination of `any()` and `all()` is a way to test that both arguments are present or neither is.

⑤ Use a regular expression to check that the `--board` is comprised of exactly nine valid characters.

⑥ If both `--player` and `--cell` are present and valid, then verify that the cell in the board is not currently occupied by an `X` or an `O`.

⑦ Since we may need to alter the `board`, it's easiest to convert it to a `list`.

⑧ We modify `board` if `cell` and `player` are "truthy." We validated the arguments in `get_args()`, so it's safe to use them here. That is, we won't accidentally assign an index value that is out of range because we have taken the time to check that the `cell` value is acceptable.

⑨ Since we use 1-based counting for the cells, we need to subtract 1 from the `cell` to change the correct index in `board`.

⑩ Now that we have possibly modified `board`, we can print the board.

⑪ Look for a winner in the `board`.

⑫ Print the outcome of the game. The `find_winner()` function returns either `X` or `O` if one of the players has won or `None` to no indicate no winner.

⑬ Define a function to format the board. The function does not `print()` the board because that would make it hard to test. The function returns a new `str` value that can be printed or tested.

⑭ Iterate through the cells in the board and decide whether to print the cell number if the cell is unoccupied or the player occupying the cell.

⑮ The return from the function is a new `str` created by joining all the lines of the grid on newlines.

⑯ Define a function that returns a winner or the value `None` if there is no winner. Again, the function does not `print()` the winner but only returns an answer that can be printed or tested.

⑰ There are 8 winning boards which are defined as 8 lists of the cells that need to be occupied by the same player. Note that I chose here to represent the actual zero-offset index values and not the 1-based values we expect from the user.

⑱ Iterate through both players, `X` and `O`.

⑲ Iterate through each winning combination of cells, unpacking them into the variables `i`, `j`, and `k`.

⑳ Create a `combo` that is the value of the `board` for each of `i`, `j`, and `k`.

Check if the `combo` is the same `player` in every position.

If that is `True`, return the `player`. If this is never `True`, we fall off the end of the function, and the value `None` is returned by default.

1.2.1. Validating the arguments and mutating the board

Most of the validation can be handled by using `argparse` effectively. Both the `--player` and `--cell` options can be handled by the `choices` option. It's worth taking time to appreciate the use of `any()` and `all()` in this code:

```
if any([args.player, args.cell]) and not all([args.player, args.cell]):
    parser.error('Must provide both --player and --cell')
```

We can play with these functions in the REPL. The `any()` function is the same as using `or` in between boolean values:

```
>>> True or False or True
True
```

If *any* of the items in a given `list` is "truthy," then the whole expression will evaluate to `True`:

```
>>> any([True, False, True])
True
```

If `cell` is a non-zero value and `player` is not the empty string, then they are both "truthy":

```
>>> cell = 1
>>> player = 'X'
>>> any([cell, player])
True
```

The `all()` function is the same as using `and` in between all the elements in a `list`, so *all* of the elements need to be "truthy" in order for the whole expression to be `True`:

```
>>> cell and player
'X'
```

Why does that return `X`? It returns the last "truthy" value which is the `player` value, so if we reverse the arguments, we'll get the `cell` value:

```
>>> player and cell
1
```

If we use `all()`, it evaluates the truthiness of `and`ing the values, which will be `True`:

```
>>> all([cell, player])
True
```

We are trying to figure out if the user has provided only *one* of the arguments for `--player` and `--cell`, because we need both or we want neither. So pretend `cell` is `None` (the default) but `player` is `X`. It's true that `any()` of those values is "truthy":

```
>>> cell = None
>>> player = 'X'
>>> any([cell, player])
True
```

But it's not true that they *both* are:

```
>>> all([cell, player])
False
```

So when we `and` those two expressions, they return `False`:

```
>>> any([cell, player]) and all([cell, player])
False
```

Because that is the same as saying:

```
>>> True and False
False
```

The default for `--board` is provided, and we can use a regular expression to verify that it's correct. Our regular expression creates a character class composed of the the dot, "X," and "O" by using `[.XO]`. The `{9}` indicates that there must be exactly 9 characters, and the `^` and `$` characters anchor the expression to the beginning and end of the string, respectively.

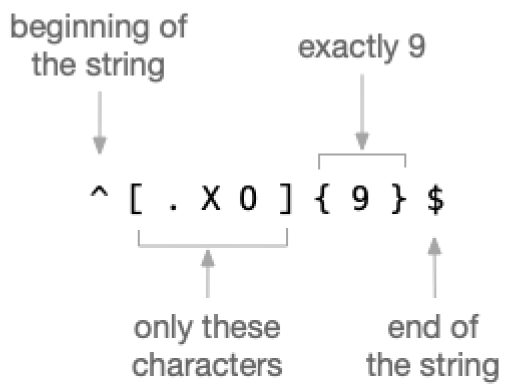


Figure 21. 1. We can use a regular expression to exactly describe a valid `--board`.

You could manually validate this using the magic of `all()` again to check:

1. Is the length of `board` exactly 9 characters?
2. Is it true that each of the characters is one of those allowed?

Here is one way to write it:

```
>>> board = '...XXXOOO'
>>> len(board) == 9 and all([c in '.XO' for c in board])
True
```

The `all()` part is checking this:

```
>>> [c in '.XO' for c in board]
[True, True, True, True, True, True, True, True, True]
```

Since each character `c` ("cell") in `board` is in the allowed set of characters, all the comparisons are `True`. If we change one of the characters, a `False` will show up:

```
>>> board = '...XXXOOA'
>>> [c in '.XO' for c in board]
[True, True, True, True, True, True, True, True, False]
```

And any `False` value in an `all()` expression will return `False`:

```
>>> all([c in '.XO' for c in board])
False
```

The last piece of validation checks if the `--cell` being set to `--player` is already occupied:

```
if args.player and args.cell and args.board[args.cell - 1] in 'XO':
    parser.error(f'--cell "{args.cell}" already taken')
```

Because the `--cell` starts counting from 1 instead of 0, we must subtract 1 when we use it as an index into the `--board` argument. Given the following inputs where the first cell has been set to `X` and now `O` wants the same cell:

```
>>> board = 'X........'
>>> cell = 1
>>> player = 'O'
```

We can ask if the value in `board` at `cell - 1` has already been set:

```
>>> board[cell - 1] in 'XO'
True
```

Or you could instead check if that position is *not* a dot:

```
>>> board[cell - 1] != '.'
True
```

It's rather exhausting to validate all the inputs, but this is the only way to ensure that the game is played properly. In the `main()` function, we can use the arguments to possibly mutating the `board` of the game. At this point, we've completely validated that we have good values for `player` and `cell` and that we are allowed to alter `board` at a given position. I decided to make `board` into a `list` precisely because I might need to alter it in this way:

```
if player and cell:
    board[cell - 1] = player
```

1.2.2. Formatting the board

Now it's time to create the grid. I chose to create a function that returns a `str` that I could test rather than directly printing the grid. Here is my version:

```
def format_board(board):
    """Format the board"""

    cells = [str(i) if c == '.' else c for i, c in enumerate(board, start=1)] ①
    bar = '-------------'
    cells_tmpl = '| {} | {} | {} |'
    return '\n'.join([
        bar,
        cells_tmpl.format(*cells[:3]), bar, ②
        cells_tmpl.format(*cells[3:6]), bar,
        cells_tmpl.format(*cells[6:]), bar
    ])
```

① I used a list comprehension to iterate through each position and character of `board` using the `enumerate()` function. Because I would rather start counting from index position 1 instead of 0, I use the `start=1` option. If the character is a dot, I want to print the position as the cell number, otherwise print the character which will be `X` or `O`.

② The "splat" (`*`) is a shorthand to expand the `list` returned by the list slice operation into values that the `str.format()` function can use. The "splat" syntax of `*cell[:3]` is a shorter way of writing the code like so:

```
return '\n'.join([
    bar,
    cells_tmpl.format(cells[0], cells[1], cells[2]), bar,
    cells_tmpl.format(cells[3], cells[4], cells[5]), bar,
    cells_tmpl.format(cells[6], cells[7], cells[8]), bar
])
```

The `enumerate()` function returns a `list` of tuples that include the index and value of each element in a `list`. Since it's a lazy function, I must use the `list()` function in the REPL to view the values:

```
>>> board = 'XX.O.O...'
>>> list(enumerate(board))
[(0, 'X'), (1, 'X'), (2, '.'), (3, 'O'), (4, '.'), (5, 'O'), (6, '.'), (7, '.'), (8,
'.')]
```

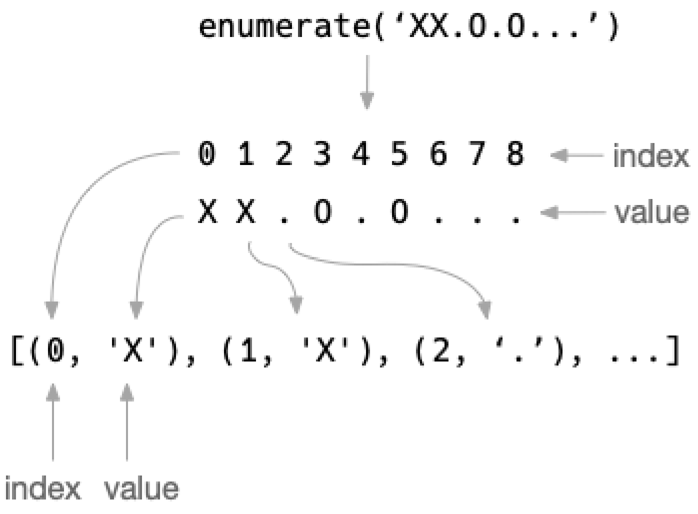


Figure 21. 2. The `enumerate()` function will return the index and value of items in a series. By default, the initial index is 0.

In this instance, we would rather start counting at 1, so we can use the `start=1` option:

```
>>> list(enumerate(board, start=1))
[(1, 'X'), (2, 'X'), (3, '.'), (4, 'O'), (5, '.'), (6, 'O'), (7, '.'), (8, '.'), (9,
'.')]
```

Our list comprehension could be written instead as a `for` loop, but since the intention is to create a `list` I would definitely recommend the above version:

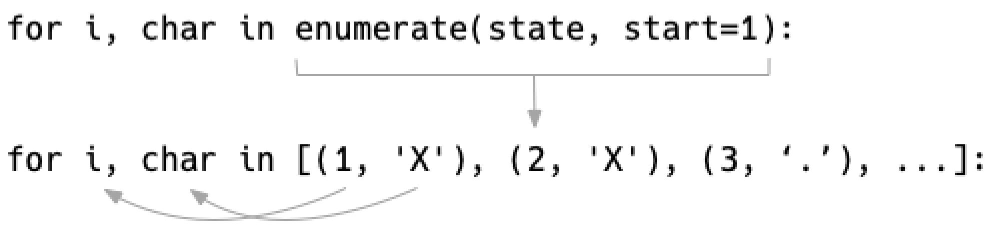
```
cells = []                                          ①
for i, char in enumerate(board, start=1):           ②
    cells.append(str(i) if char == '.' else char)   ③
```

① Initialize an empty `list` to hold the `cells`.

② Unpack each `tuple` of the index (starting at 1) and value of each character in `board` into the variable variables `i` (for "integer") and `char`.

③ If the `char` is a dot, then we want to use the `str` version of the `i` value; otherwise we use the `char` value.

Here is a visualization of how the `enumerate()` is unpacked into `i` and `char`:



```
for i, char in enumerate(state, start=1):

for i, char in [(1, 'X'), (2, 'X'), (3, '.'), ...]:
```

Figure 21. 3. The tuples containing the index and values returned by `enumerate()` can be assigned to two variables in the `for` loop.

This version of `format_board()` passes all the tests found in `unit.py`.

1.2.3. Finding the winner

The last major piece to this program is determine if either player has won by placing three of their marks in a row horizontally, vertically, or diagonally.

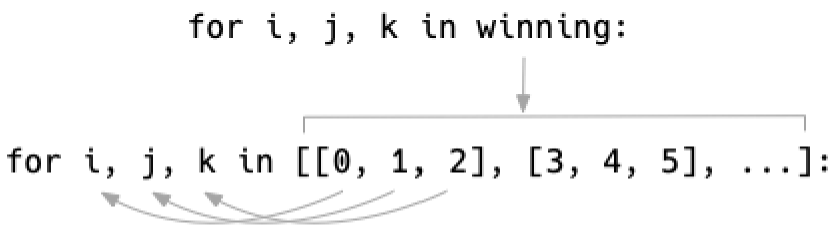
```
def find_winner(board):
    """Return the winner"""

    winning = [[0, 1, 2], [3, 4, 5], [6, 7, 8], [0, 3, 6], [1, 4, 7], ①
               [2, 5, 8], [0, 4, 8], [2, 4, 6]]

    for player in ['X', 'O']:
        for i, j, k in winning: ②
            combo = [board[i], board[j], board[k]]
            if combo == [player, player, player]:
                return player
```

① There are 8 winning postions — the three horizontal rows, the three vertical columns, and the two diagonals — so I decided to create a `list` where each element is also a `list` that contains the three cells in a winning configuration.

② It's typical to use `i` as a variable name for "integer" values, especially when their life is rather brief as here. When more similar names are needed in the same scope, it's also common to use `j`, `k`, `l`, etc. You may prefer to use names like `cell1`, `cell2`, and `cell3`, which are more descriptive but also longer to type. The unpacking of the cell values is exactly the same as the unpacking of the tuples in the above `enumerate()` code.



```
for i, j, k in winning:
for i, j, k in [[0, 1, 2], [3, 4, 5], ...]:
```

Figure 21. 4. As with the above unpacking of the `enumerate()` tuples, each list of three elements can be unpacked into three variables in the `for` loop.

The rest of the code is checking if either `X` or `O` is the only character at each of the three positions. I worked out half a dozen ways to write this, but I'll just share this one alternate version that uses two of my favorite functions, `all()` and `map()`:

```
for combo in winning:                              ①
    group = list(map(lambda i: board[i], combo)) ②
    for player in ['X', 'O']:                      ③
        if all(x == player for x in group):        ④
            return player                          ⑤
```

① Iterate through the tuple `combo` in `winning`.

② Use `map()` to get the value of `board` at each position in `combo`.

③ Check for each player `X` and `O`.

④ See if `all()` the values in the `group` are equal to the given `player`.

⑤ If so, return that `player`.

If a function has no explicit `return` or never executes a `return` as would be the case here when there is no winner, then Python will use the `None` value as the default `return`. We'll interpret that to mean there is no winner when we print the outcome of the game:

```
winner = find_winner(board)
print(f'{winner} has won!' if winner else 'No winner.')
```

That covers our version of the game that plays just one round of a game of Tic-Tac-Toe. In the next chapter, we'll expand these ideas into an interactive version that starts with a blank board and dynamically requests user input to play the game.

1.3. Review

- Our program uses a `str` value to represent the board of the Tic-Tac-Toe board with nine characters representing `X`, `O`, or `.` to indicate a taken or empty cell, respectively, but we sometimes convert that to a `list` to make it easier to modify.
- A regular expression is a handy way to validate the initial board. We can declaratively describe that it should be a string exactly nine characters long composed only of the characters `.`, `X`, and `O`.
- The `any()` function is like chaining `or` between multiple boolean values. It will return `True` if *any*

of the values is "truthy."

- The `all()` function is like using `and` between multiple boolean values. It will return `True` only if every one of the values is "truthy."
- The `enumerate()` function will return the list index and value for each element in an iterable like a `list`.

1.4. Going further

- Write a game that will play one hand of a card game like Blackjack ("Twenty-one") or "War"