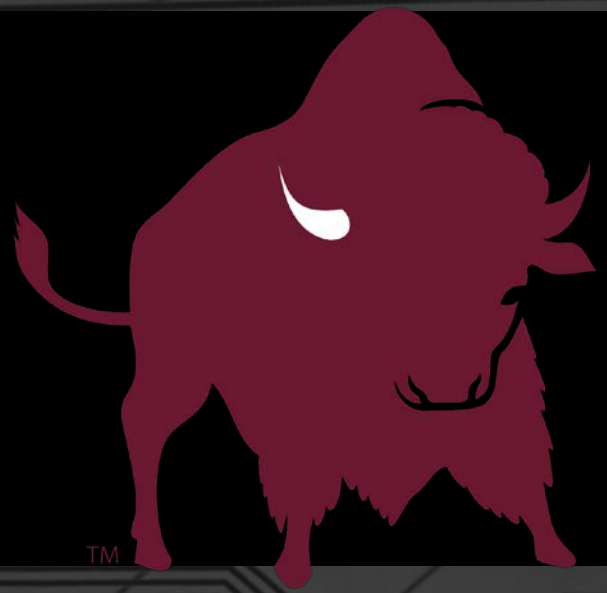
Thunder the Robot

We Teach CS June 06, 2017



Presented by H. Paul Haiduk
hhaiduk@wtamu.edu

Computer Science Program Coordinator

School of Engineering, Computer Science and Mathematics

West Texas A&M University

Canyon, TX

(806) 651-2450

So . . . if you do not yet have a copy of this presentation . . .

- It is yours for the copying from GitHub. Please use the URL:

https://github.com/HHaiduk/thunder

- Use the https download to download the file

thunder-master.zip

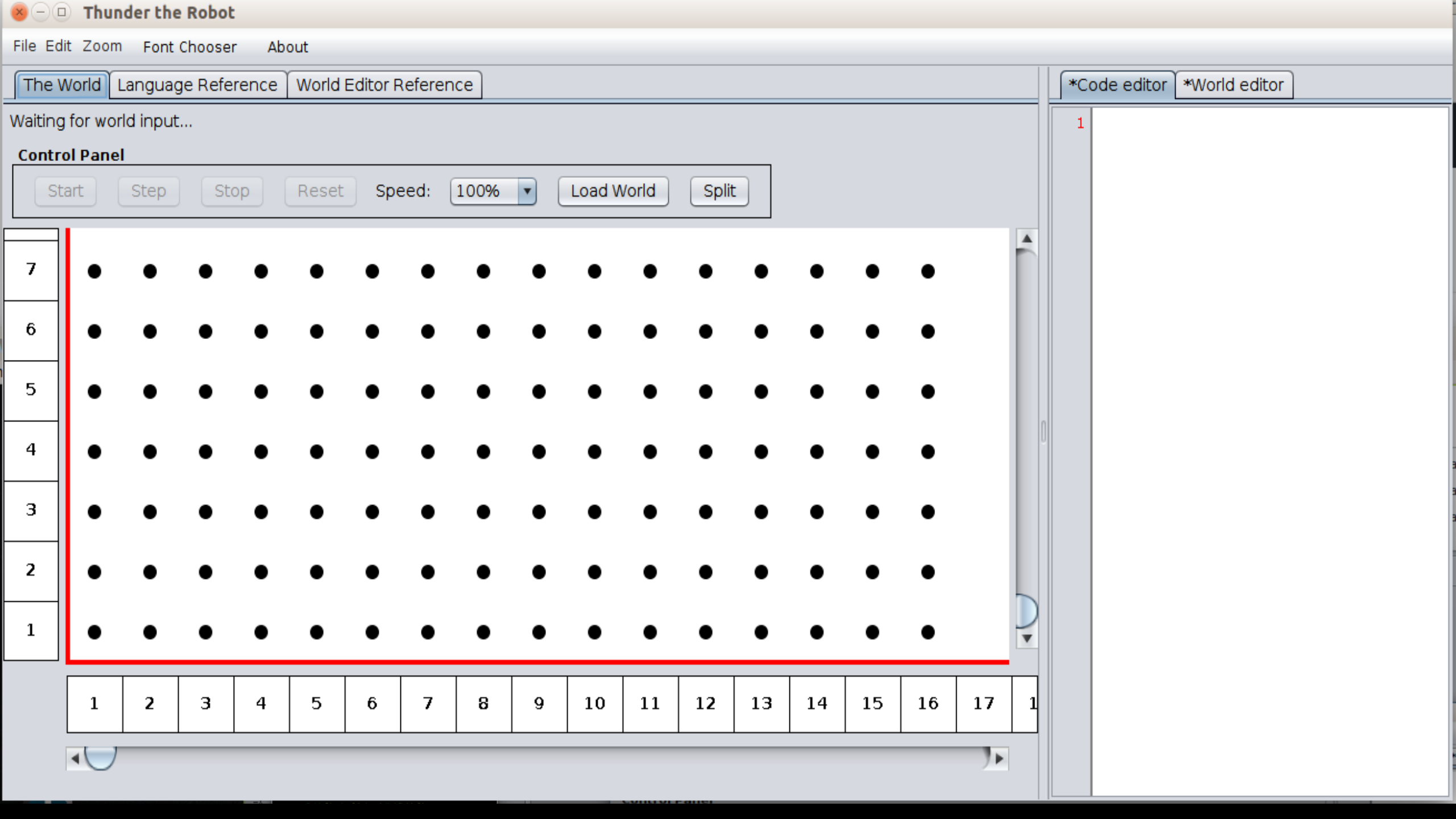
You should extract contents of the zip file which creates the directory/folder **thunder-master.** Navigate to that directory/folder and click on the file **thunder-setup.exe** (assuming that you are running MS Windows) to install the application. The file is **thunderLINUX-setup** if you are running Linux. Sorry, no version for the MAC yet.

Attribution to Richard Pattis

- Karel the Robot *circa* 1981 for the seminal book ***Karel the Robot***.
- The word robot comes from the Czech word *robota*, meaning drudgery or slave-like labor. It was first used to describe fabricated workers in a fictional 1920's play by Czech author Karel Capek called *Rossum's Universal Robots.* According to Pattis, the name Karel the Robot was derived from that early fictional concept and author.
- The work as presented today is motivated by the desire to keep alive one of the most profound concepts in computing and one from which literally hundreds of my students have begun their journey into that facet of computational thinking called algorithmic thinking.
- Original version of the software written in Pascal and was designed to lead students into the world of Pascal programming. Subsequent versions have been focused on C++ and also Java.

Thunder the Robot

- Named so to recognize the mascot for WTAMU . . . a buffalo named Thunder.
- Designed to be a “gentle” introduction to the art of algorithmic thinking and programming
- Designed to be a gentle introduction to text-based programming with syntax very similar to Python syntax
- Written in Java with a “look and feel” designed to be essentially the same in Chrome OS, Linux, Mac and Windows – any platform that supports the Java Virtual Machine
- Subsequent work planned to render software completely platform independent by use of JavaScript and HTML 5.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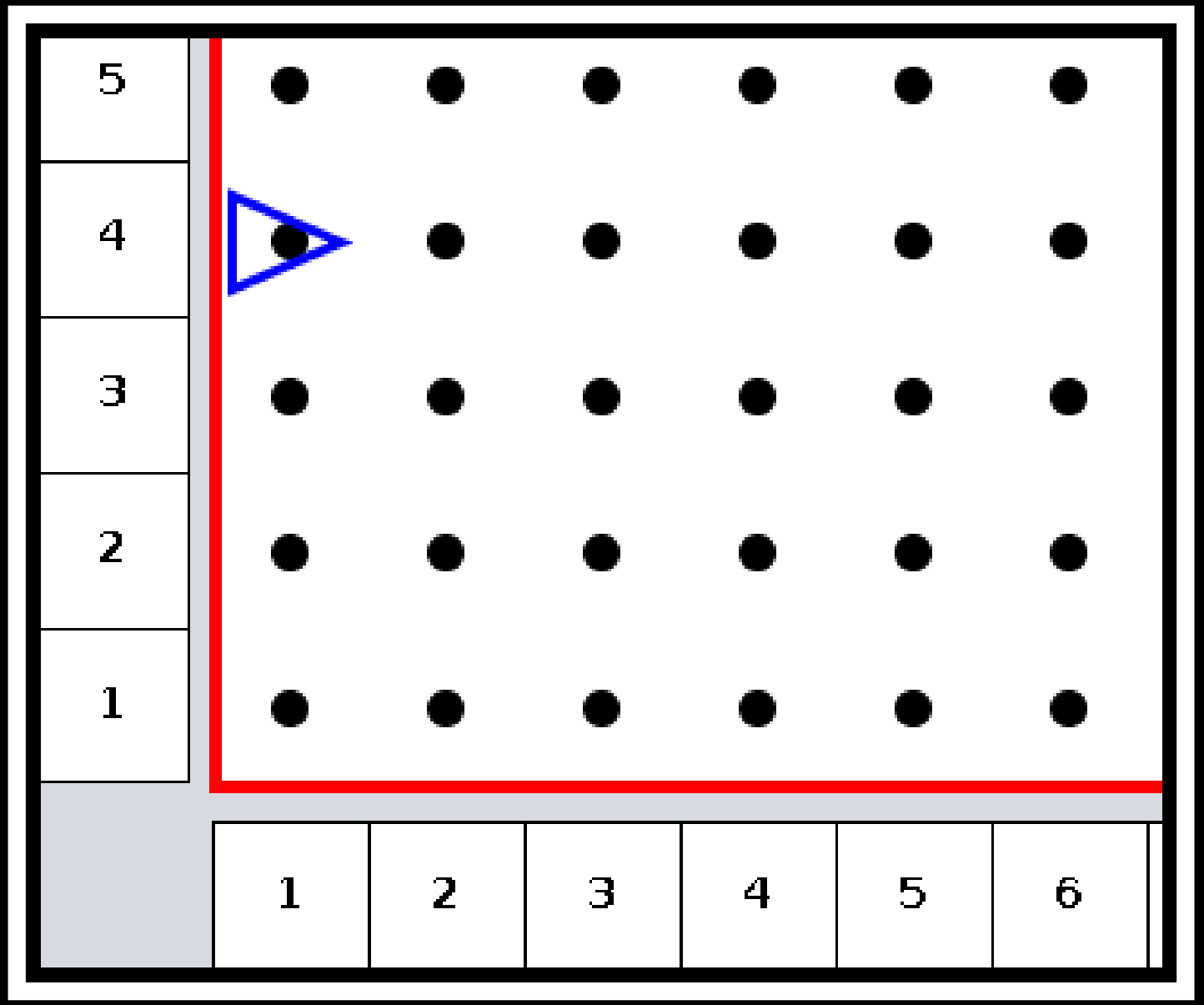
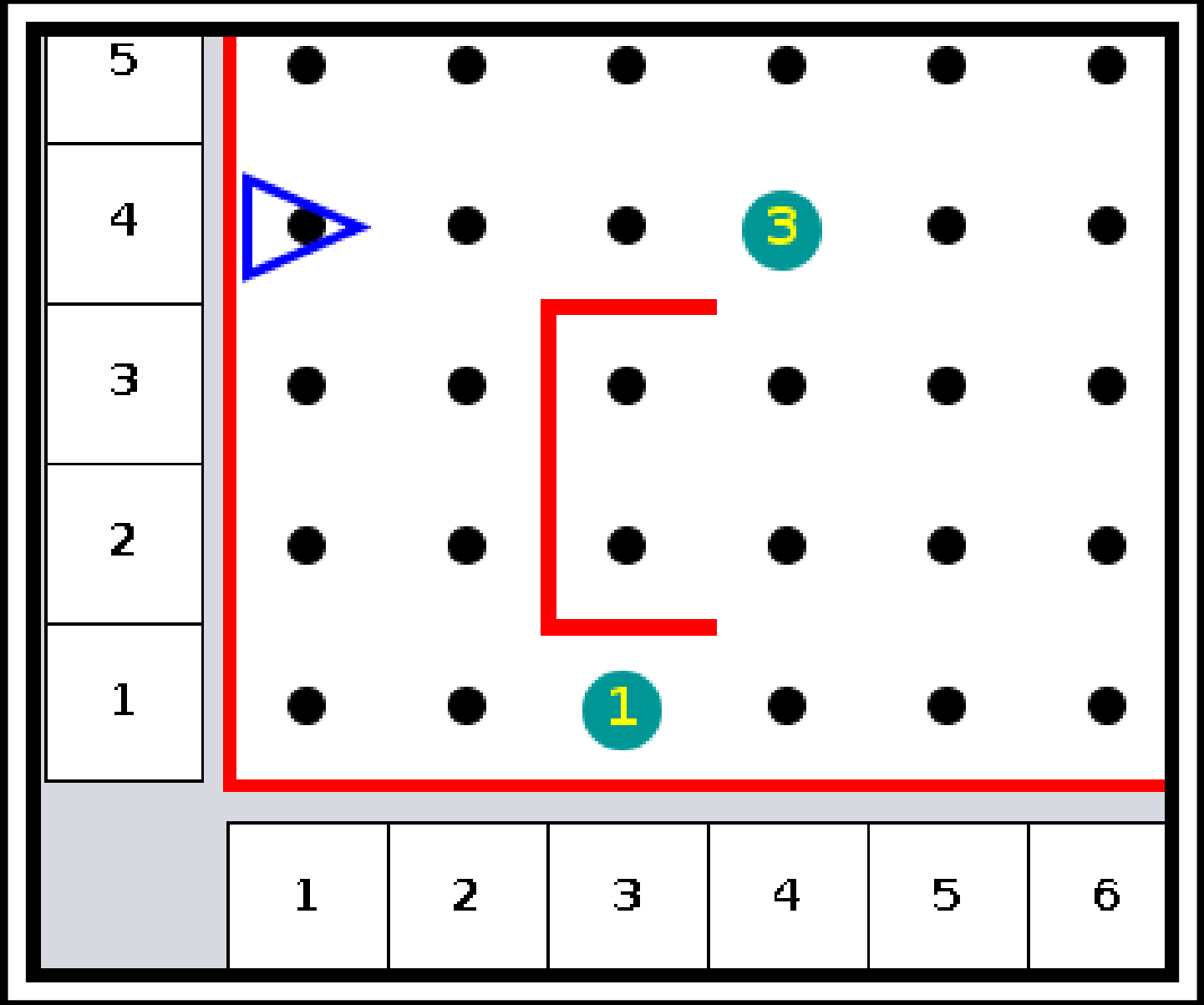


Thunder's World from the "origin"

- Dots represent intersection of streets and avenues
- The triangle is the robot located at first avenue and fourth street
- Think of north/south orientation as the Avenues while the streets are east/west
- The robot (yes . . . Intentionally very simple representation) is facing east.
- This world is finite with 1,000 avenues and 1,000 streets
- Think x = avenue and y = street



Thunder's World (more)

- World is bordered with impenetrable walls
- We may build more walls in the world to pose challenges to the robot's travel – these walls are placed between streets and/or avenues. Also note that these interior walls are also impenetrable
- We may place beepers (little devices that emit a sound) at intersections. Note that the robot must be immediately over the beeper to "hear" its sound.

- **move** -- exactly one block in direction Thunder is facing– this can cause Thunder to break apart if it strikes a wall

- **turnleft** -- rotate left exactly 90° -- Thunder can always accomplish this no matter where it is located

- **pickbeeper** – pick up one beeper and place it in a "virtual" beeper bag – this may cause a runtime failure if there is no beeper to pick up

- **putbeeper** – retrieve a beeper from the "virtual" beeper bag and place it at the current intersection – this may cause a runtime failure if there is no beeper in the beeper bag

- **turnoff** – this instruction must be executed when Thunder has completed any given task

Thunder's builtin capabilities

Consider these the primitives of the language supporting the robot

- front_is_clear
- front_is_blocked
- left_is_clear
- left_is_blocked
- right_is_clear
- right_is_blocked

Thunder's sensors

Wall detection tests

- next_to_a_beeper
- not_next_to_a_beeper
- any_beepers_in_beeper_bag
- no_beepers_in_beeper_bag

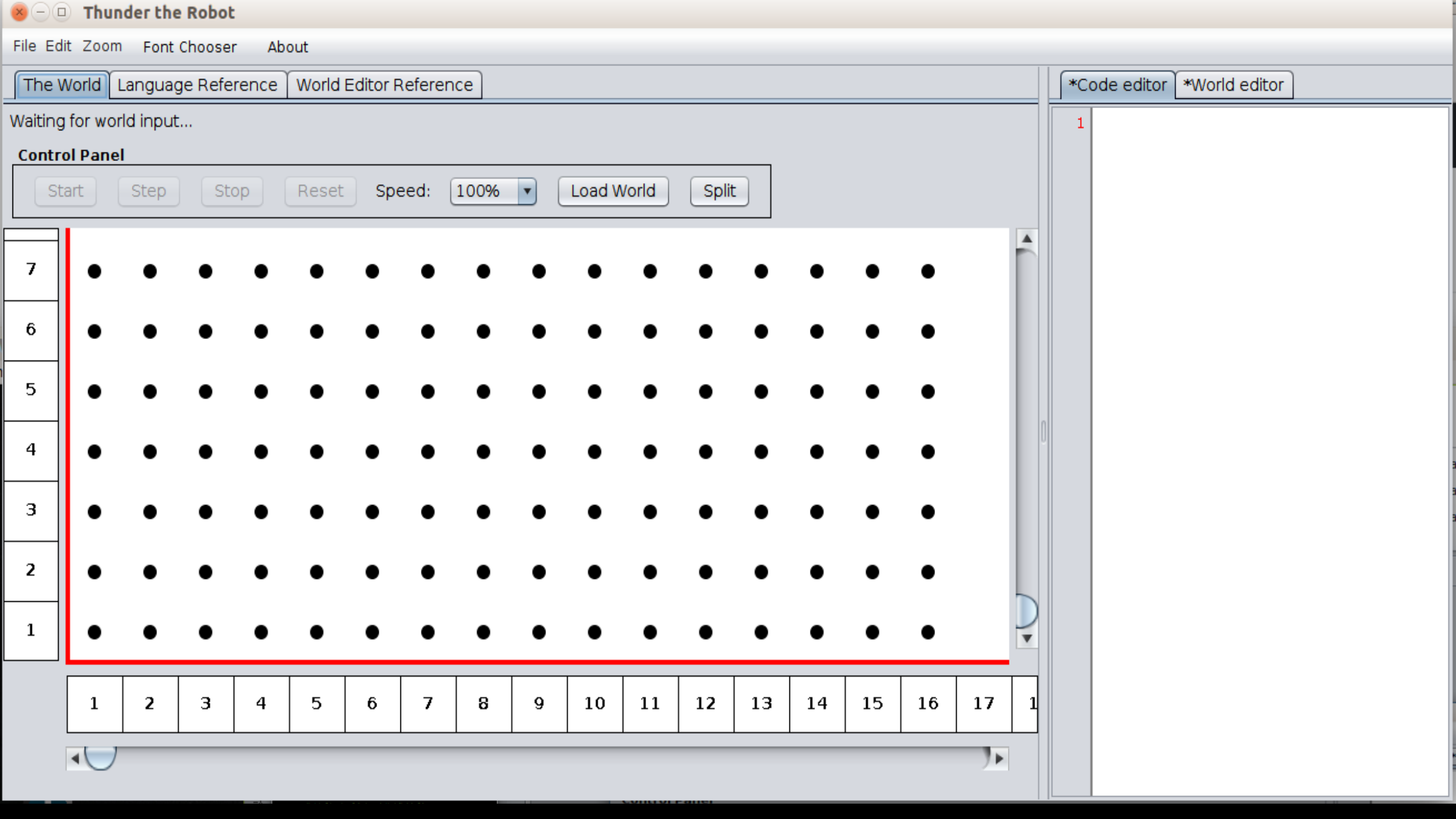
Thunder's sensors

Beeper detection tests

- facing_north
- not_facing_north
- facing_south
- not_facing_south
- facing_east
- not_facing_east
- facing_west
- not_facing_west

Thunder's sensors

Direction detection tests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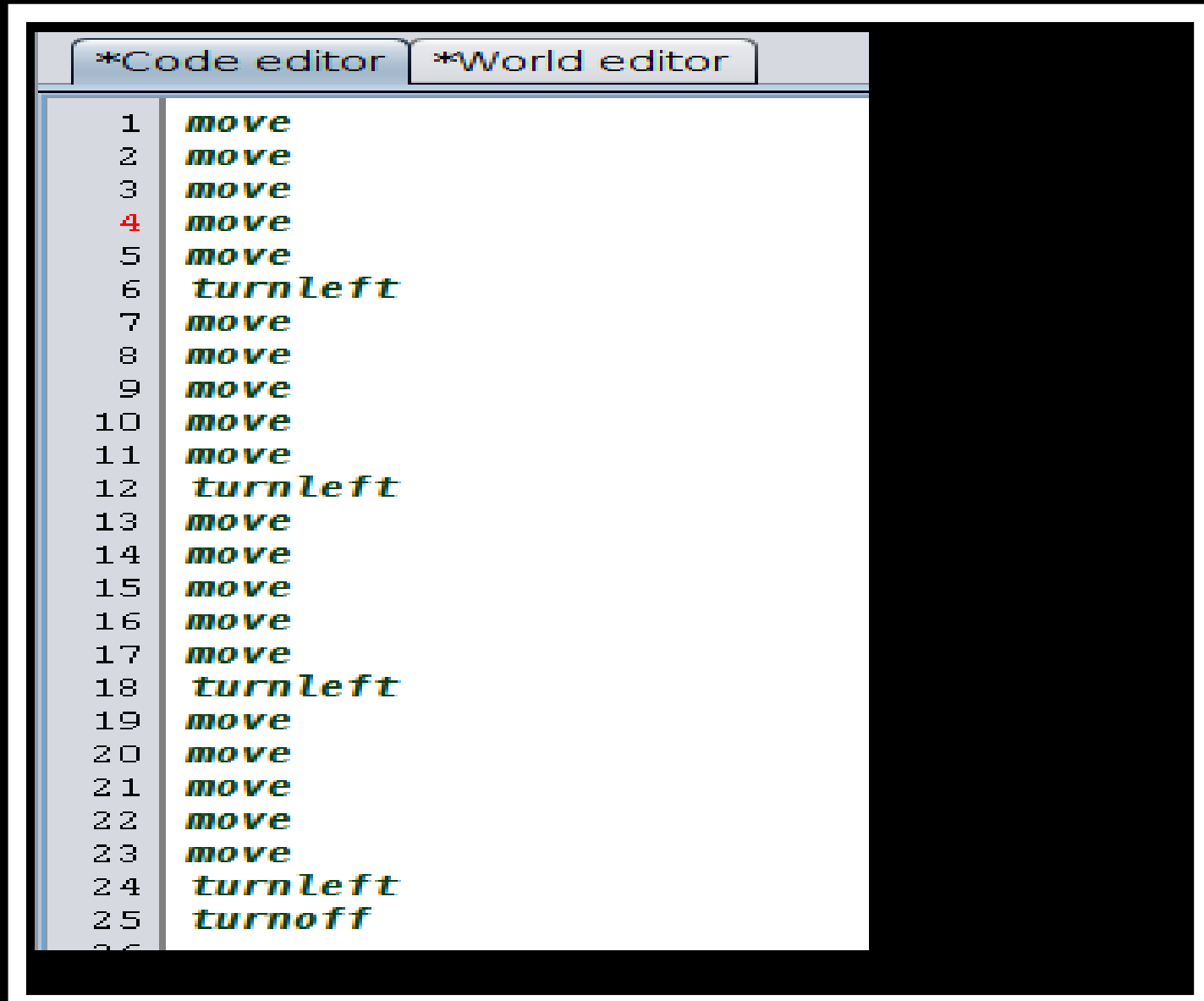
Simple Thunder world

- First we must create the world in which Thunder will operate.
- Click on the World Builder tab in the application and enter/edit the text to appear as:

```
ROBOT 1 1 E 0
```

- This directs the application to "draw" Thunder at 1st Avenue and 1st Street, facing East, with 0 beepers in the beeper bag.
- Next, click the Load World button in the Control Panel to cause that initial scenario to be displayed. **Please note positioning Thunder in the world is the only manual coding required for the world builder. Creation of walls and beepers can all be accomplished with a mouse in real time**.



Simple Thunder program

Traverse a path that is five by five and turn off.

To avoid typing this in, first Split the editor pane away from the application pane and click File/Open Source File and navigate to the directory/folder `thunder-master` and load `program01.thunder`

One should also File/Open World File and load `program01.world`.

One can than launch the program by clicking Start in the Control Panel or single-step through the program with Step.

- Each Thunder the Robot instruction must be on a separate line. A sequence of one or more Thunder the Robot instructions that are all indented the same number of spaces compose a **block** of code.
- **<instruction>** refers to any of the five primitive instructions, conditional branching or iteration instructions, or a user defined instruction.
- Thus, a block appears as:

```
<instruction>
<instruction>

    ...

<instruction>
```

Control Structures

Sequence or “block”

Control Structures

- Conditional branching refers to the ability of a program to alter it's flow of execution based on the result of the evaluation of a conditional. The three types of conditional branching instructions in Thunder the Robot are **`if`** and **`if/else`** and **`if/elif/else`**. In the below examples, ***<test>*** refers to one of the eighteen conditionals or sensor tests presented previously. Each ***<test>*** evaluation results in true or false.

```
if <test>:
    <block>
```

```
if <test>:
    <block>
else:
    <block>
```

```
if <test>:
    <block>
elif <test>:
    <block>
   ...

elif <test>:
    <block>
else:
    <block>
```

Conditional or selection

NOTE that the controlled blocks are “opened” by placing a colon (:) immediately after the <test>

We say that the colon “opens” a scope of control. Yes, this is very Python like (by design)

Control Structures

- Iteration refers to the ability of a program to repeat an instruction (or block of instructions) repeatedly. The two types of iteration instructions are the definite and indefinite.
- Definite iteration is supported by the **do <pos_number>** where **<pos_number>** must be an unsigned integer greater than zero.

```
do <pos_number>:
    <block>
```

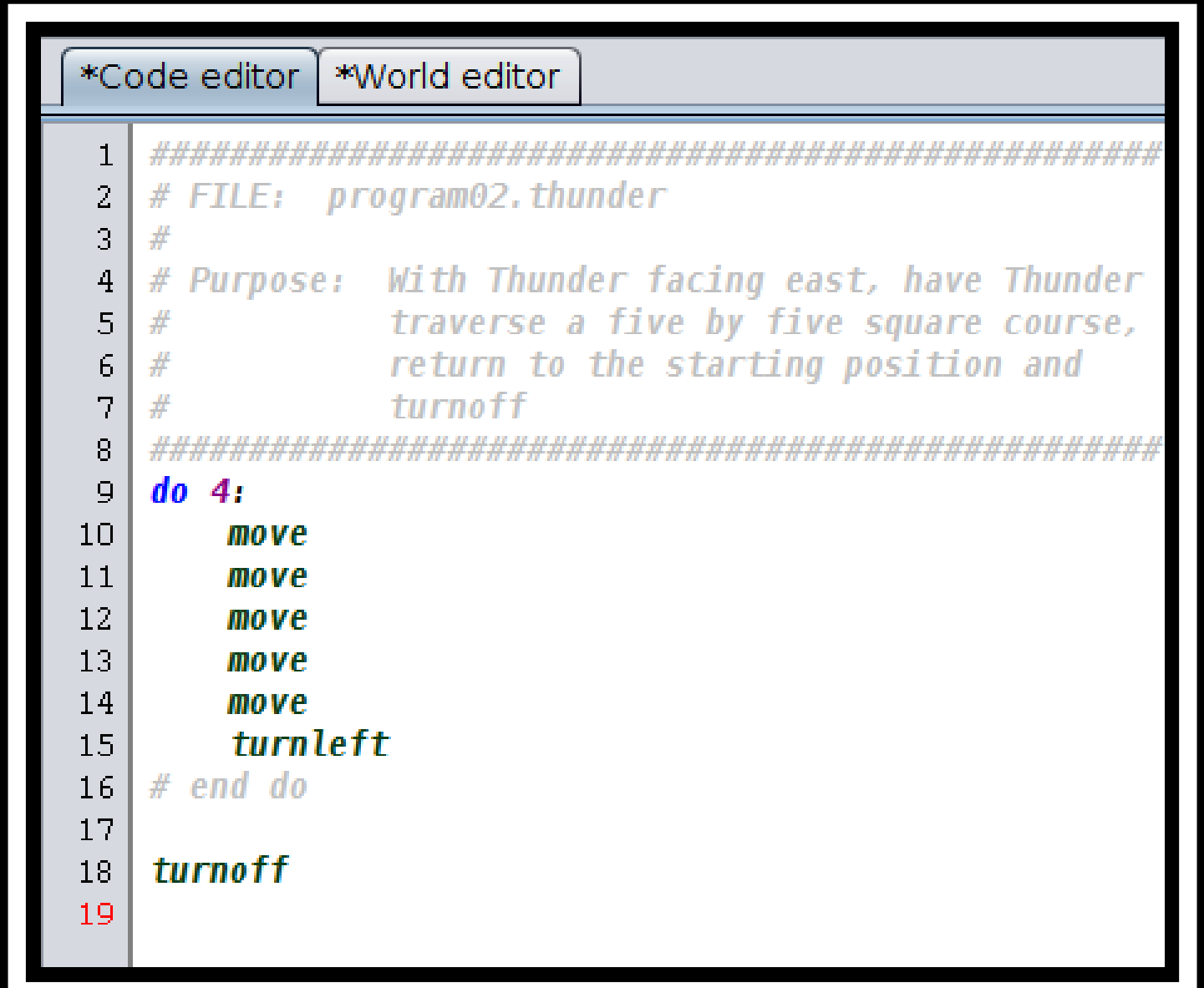
- Indefinite iteration means that the number of iterations can vary from none to many with termination controlled by some <test>.

```
while <test>:
    <block>
```

- NOTE: that the do repetition is the only place in the Thunder the Robot language where counting is possible.

Iteration
repetition
looping

Again note the colon (:) “opens” the scope of control



Using definite repetition

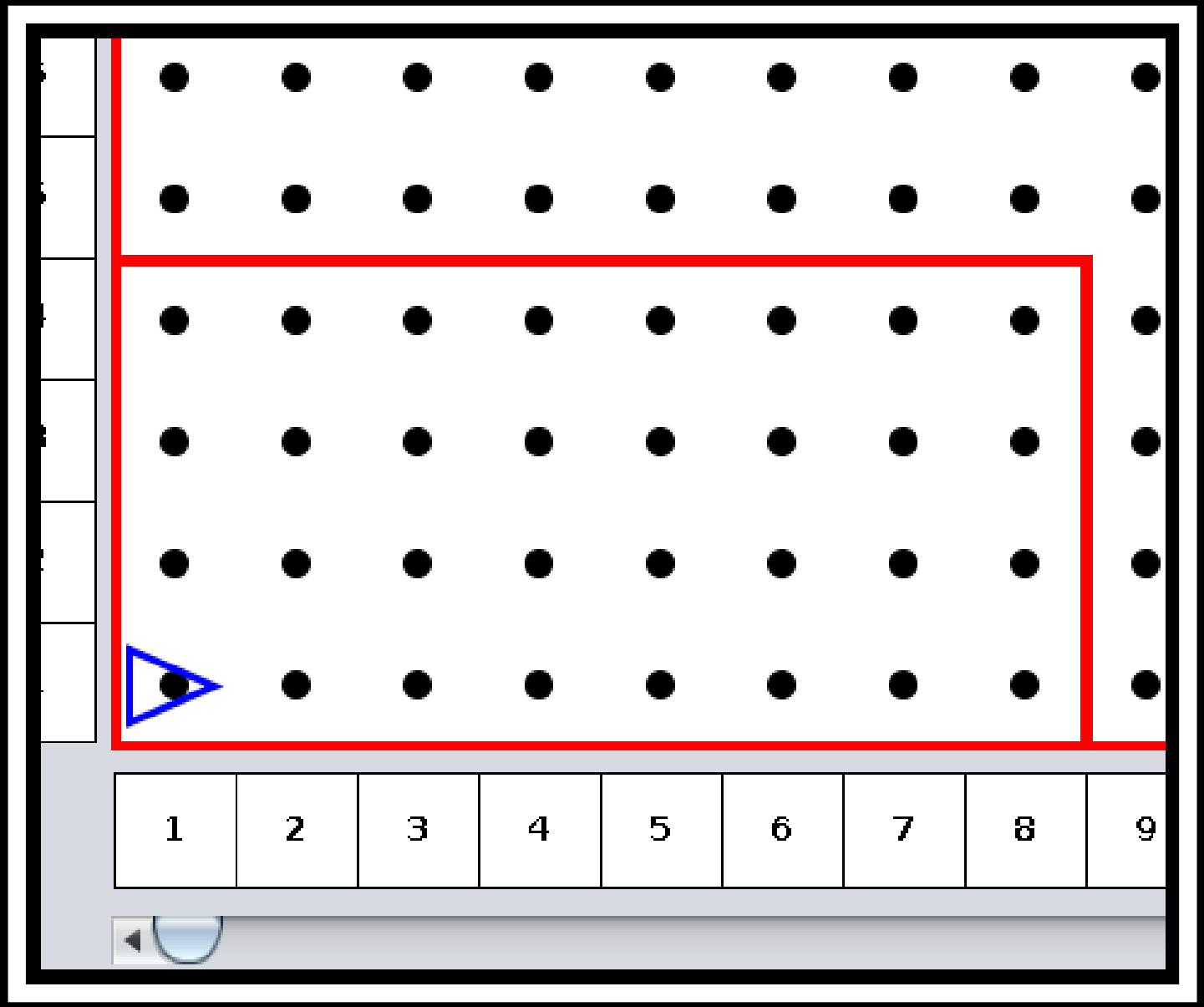
And adding comments to enhance readability

See `program02.thunder`

Comments? The symbol # begins a comment with the remainder of the line considered the comment. They are ignored by the interpreter.

And refining a bit more

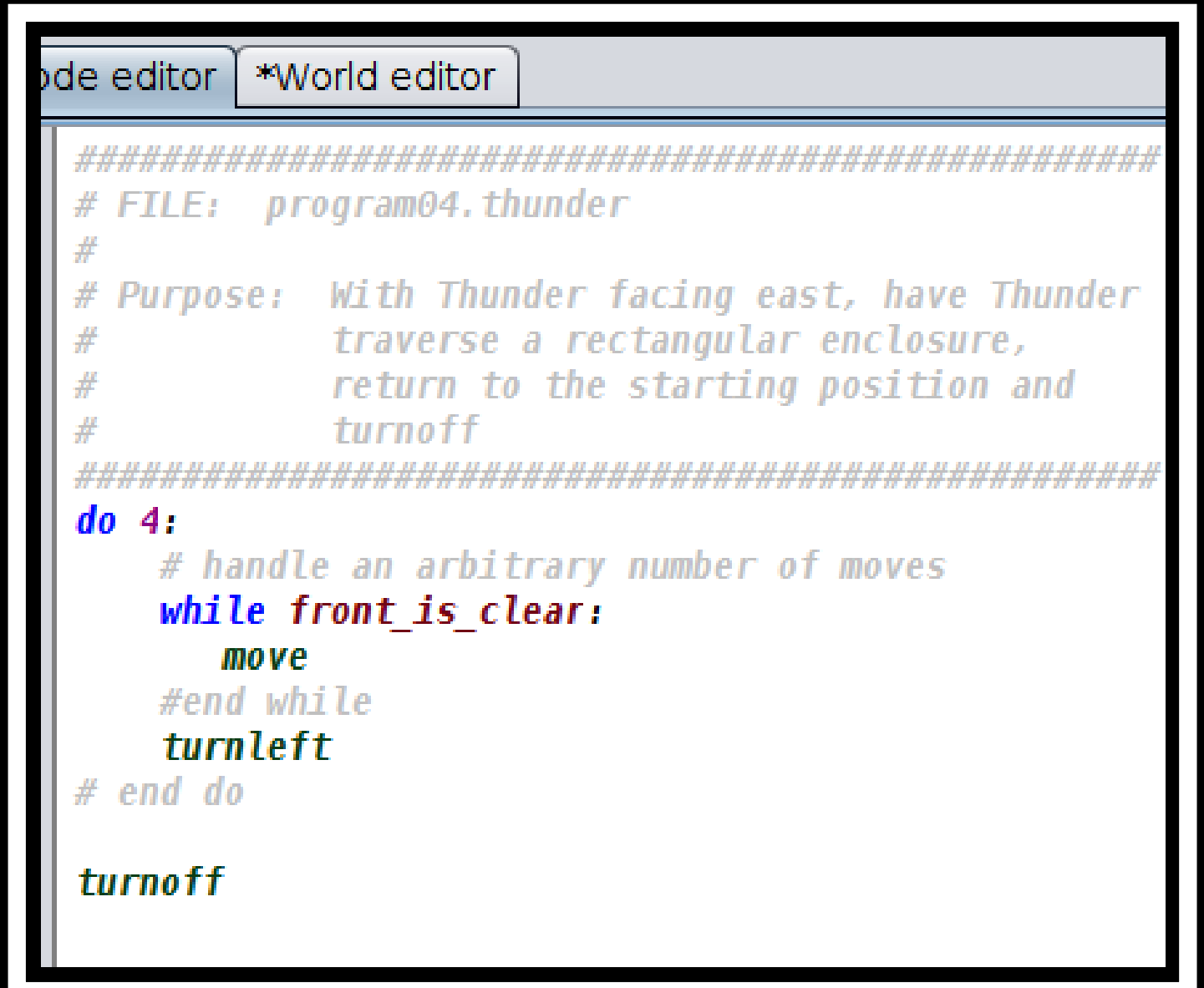
See `program03.thunder`



Using indefinite iteration

Yes, if we knew that the boundaries were fixed and would remain the same, we could solve this similarly to the five by five.

However, we want Thunder to navigate any rectangular enclosure and return to starting point.



Using indefinite iteration

We have a problem similar to the previous one EXCEPT that we now have constraints (walls) that we cannot penetrate AND we do not know in advance how big the enclosure is.

Note, however, this is a problem similar to the previous problem.

See `program04.thunder`

*Code editor | World editor

```
1  ##################################################
2  # FILE:  program05.thunder
3  #
4  # Purpose:  With Thunder facing east, have Thunder
5  #           traverse a rectangular enclosure of
6  #           arbitrary size and stop when a beeper
7  #           is found.  Then Thunder should turnoff.
8  #           Assume that the beeper is located at the
9  #           beginning of one side of the enclosure
10 ##################################################
11 move
12 while not_next_to_a_beeper:
13     # handle an arbitrary number of moves
14     while front_is_clear:
15         move
16     #end while
17     turnleft
18 # end while
19
20 turnoff
21
```

Using indefinite iteration

Now lets change the problem up just a bit. We want Thunder to walk around the enclosure until a beeper is found. Then Thunder is to turnoff. Assume that the beeper is at the beginning of one of the sides of the enclosure.

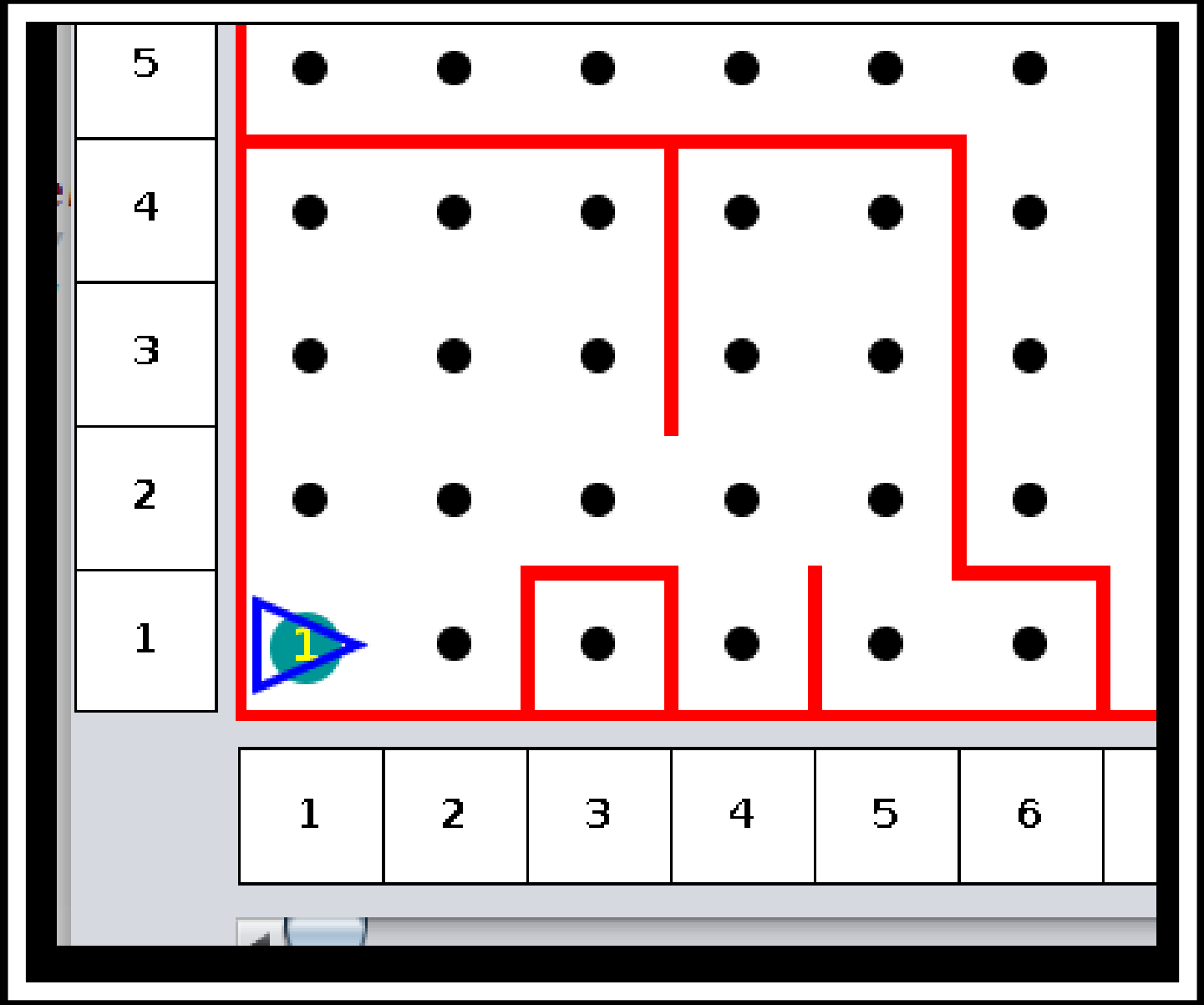
See `program05.thunder` and `program05.world`

```
3  #
4  # Purpose:  With Thunder facing east, have Thunder
5  #           traverse a rectangular enclosure of
6  #           arbitrary size and stop when a beeper
7  #           is found.  Then Thunder should turnoff.
8  #           Assume that the beeper is located at the
9  #           beginning of one side of the enclosure.
10 #
11 #           Traversal is accomplished clockwise.
12 ###########################################################
13 define turnright:
14     do 3:
15         turnleft
16     #end do
17 # end turn_right
18
19 move
20 while not_next_to_a_beeper:
21     # handle an arbitrary number of moves
22     while front_is_clear:
23        move
24     #end while
25     turnright
26 # end while
27
```

Introducing procedural abstraction

Now lets change the problem up just a bit. We want Thunder to walk around the enclosure until a beeper is found. Then Thunder is to turnoff. Assume that the beeper is at the beginning of one of the sides of the enclosure. However, instead of completing the course counter clockwise, we want to navigate the course clockwise.

See `program06.thunder` and `program06.world`



A challenging problem

Navigate an enclosure that has irregular shape.
See `program07.world`

Issues:

- Cannot collide with a beeper
- Must navigate around walls that fall away from us

Strategy:

- How do we follow the wall?
- One strategy is to always follow the wall to the right

```
# FILE:  program07.thunder
#
# Purpose:  With Thunder facing east, have Thunder
#           traverse a rectangular enclosure of
#           arbitrary size and stop when a beeper
#           is found.  Then Thunder should turnoff.
#           Assume that the beeper is located at the
#           beginning of one side of the enclosure.
#
#           Traversal is accomplished counter
#           clockwise.
#########################################################
define turnright:
    do 3:
        turnleft
    #end do
# end turn_right

def follow_right_wall:
    if right_is_clear:
        turnright
        move
    elif front_is_clear:
        move
    else:
        turnleft
    #end if
#end follow_wall_right

move
while not_next_to_a_beeper:
   follow_wall_right

turnoff
```

Follow wall to the right

See program07.thunder

follow_right_wall good for navigating a maze

- Assume that there are NO islands in the maze
- Assume that we place a beeper to the right of the single exit from the maze
- Assume that we position Thunder so that it is at the entrance

See **followWall.thunder** and **followWall.world**

See also **mazeBig.world**

How about cleaning trash from an enclosed park?

- An enclosed “park” of arbitrary length and arbitrary width (avenues and streets) contains scattered piles of beepers. It is Thunder’s responsibility to start in the southwest corner of the park facing east and sweep by street and clean up all the piles of beepers.
- Once all the beepers are cleaned up, they are to be deposited in the northeast corner of the park.
- Then Thunder is to return to the southwest corner, face east and turn off.
- See **`cleanTrash.thunder`** and **`trash1.world`** and **`trash2.world`**

How about “sorting” into ascending order the heights of columns of beepers

- See **`Sort.thunder`** and **`Sort.world`**
- Givens:
  - “stacks” of beepers of arbitrary height from zero to many
  - “stacks” are represented by a single beeper at an intersection
  - Arbitrary number of “stacks”
  - “stacks” are bounded on east and west by a wall that is at minimum at least one unit higher than the height of the tallest “stack” of beepers
  - “stacks” of beepers are guaranteed to exist in a situation in which there is an empty “stack” on the west and the east of the “stacks” to be considered
  - Thunder is to start the sort by facing east at 1st Avenue and 1st Street and is to return to the “home” position at 1st Avenue and 1st Street.
  - Solution developed that the “main” logic is to drive what happens including turning off.

Iteration vs. Recursion

Iteration

```
def face_east:
    while not_facing_east:
        turnleft
    #end while
# end face_east
```

Recursion

```
def face_east:
    if not_facing_east:
        turnleft
        face_east
    #end if
# end face_east
```

Questions, observations, etc.

The End