Boggle YEAH Hours

Brahm Capoor

(Some slides adapted from Spring 2017 YEAH slides)

Road Map

– – –

Lecture review

Road Map

– – –

Lecture review

Assignment overview

Road Map

– – –

Lecture review

Assignment overview

Q&A!

Recursive Backtracking

Choose. Explore. Unchoose. Repeat.

Recursion vs backtracking

```
bool subseq(string &s1, string &s2) {
      if (s2 == “”) return true;
      if (s1 == “”) return false;
      if (s1[0] == s2[0]){
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            return subseq(r1, r2);
      } else {
            string r1 = s1.substr(1);
            return subseq(r1, s2);

      }
}
```

Recursion vs backtracking

```
bool subseq(string &s1, string &s2) {
      if (s2 == “”) return true;
      if (s1 == “”) return false;
      if (s1[0] == s2[0]){
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            return subseq(r1, r2);
      } else {
            string r1 = s1.substr(1);
            return subseq(r1, s2);

      }
}
```

- In recursion, you only ever do one recursive call at every level of the recursion
- In recursion, you know that your recursive call will work (it’s the leap of faith!)

Recursion vs backtracking

```
bool subseq(string &s1, string &s2) {
      if (s2 == “”) return true;
      if (s1 == “”) return false;
      if (s1[0] == s2[0]){
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            return subseq(r1, r2);
      } else {
            string r1 = s1.substr(1);
            return subseq(r1, s2);

      }
}
```

```
string LCS(string &s1, string &s2) {
      if (s1 == “” || s2 == “”) return “”;
      if (s1[0] == s2[0]){
            string r2 = s2.substr(1);
            string r2 = s2.substr(1);
            return s1[0] + LCS(r1, r2);
      } else {
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            string p1 = LCS(s1, r2);
            string p2 = LCS(r1, s2);
            if (p1.length() > p2.length()) {
                  return p1;
            } else {
                  return p2;
            }
      }
}
```

Recursion vs backtracking

```
bool subseq(string &s1, string &s2) {
      if (s2 == “”) return true;
      if (s1 == “”) return false;
      if (s1[0] == s2[0]){
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            return subseq(r1, r2);
      } else {
            string r1 = s1.substr(1);
            return subseq(r1, s2);

      }
}
```

```
string LCS(string &s1, string &s2) {
      if (s1 == “” || s2 == “”) return “”;
      if (s1[0] == s2[0]){
            string r2 = s2.substr(1);
            string r2 = s2.substr(1);
            return s1[0] + LCS(r1, r2);
      } else {
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            string p1 = LCS(s1, r2);
            string p2 = LCS(r1, s2);
            if (p1.length() > p2.length()) {
                  return p1;
            } else {
                  return p2;
            }
      }
}
```

Recursion vs backtracking

- Multiple recursive calls at every level of the function call
- Backtracking is about finding and weighing your options

```
string LCS(string &s1, string &s2) {
      if (s1 == “” || s2 == “”) return “”;
      if (s1[0] == s2[0]){
            string r2 = s2.substr(1);
            string r2 = s2.substr(1);
            return s1[0] + LCS(r1, r2);
      } else {
            string r1 = s1.substr(1);
            string r2 = s2.substr(1);
            string p1 = LCS(s1, r2);
            string p2 = LCS(r1, s2);
            if (p1.length() > p2.length()) {
                  return p1;
            } else {
                  return p2;
            }
      }
}
```

Types of recursion & backtracking

Determine whether a solution exists

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Find the best solution

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Find the best solution

Count the number of solutions

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Find the best solution

Count the number of solutions

Print/find all the solutions

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Find the best solution

Count the number of solutions

Print/find all the solutions

See midterm review slides for more detail!

Classes

Interface

```
// Person.h

class Person {
     public:
          // constructor(s)
          Person(string name)
          /*
           * Write sick (and public)
           * code prototypes here
           */
     private:
          string name;
          /*
           * Write sick (and secret)
           * code prototypes here
           * /
}
```

Source

```
// Person.cpp

Person::Person(string name) {
     this->name = name;
}

Person::string getName(){
     return this->name;
}
```

Interface

```
// Person.h

class Person {
     public:
          // constructor(s)
          Person(string name)
          /*
           * Write sick (and public)
           * code prototypes here
           */
     private:
          string name;
          /*
           * Write sick (and secret)
           * code prototypes here
           * /
}
```

Source

```
// Person.cpp

Person::Person(string name) {
     this->name = name;
}

Person::string getName(){
     return this->name;
}
```

Another file, far far away (or not)

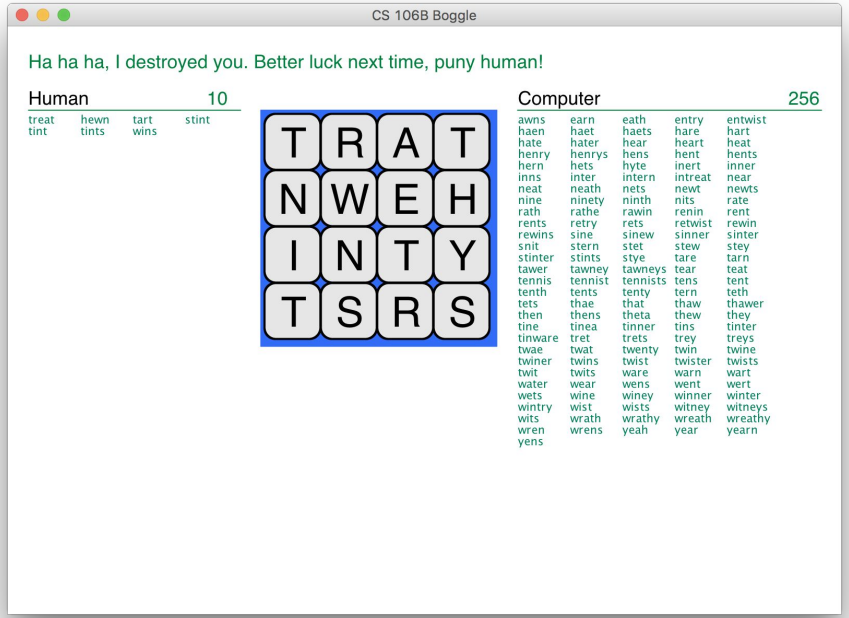
```
Person me = Person(“Brahm”);

cout << me.getName() << endl; //“Brahm”
```

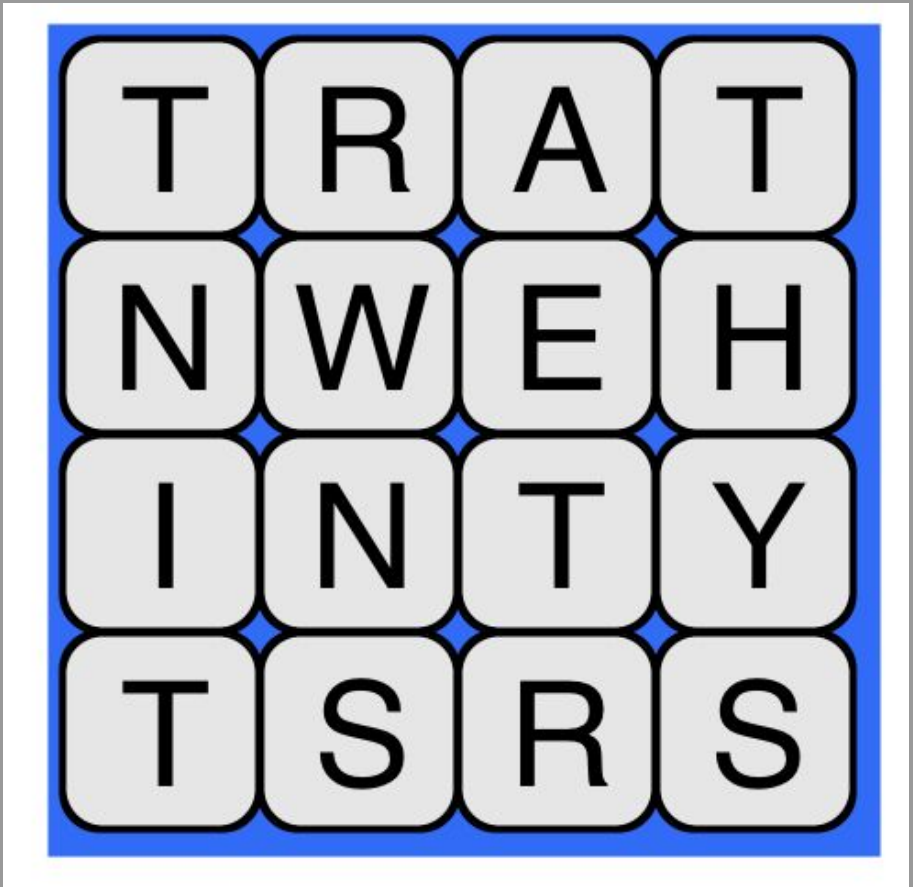
Boggle!

Logistics:

- Due May 10
- Pair programming allowed!
  - Partner needs to be in the same section



The Rules



Starter code structure

`boggleplay.cpp`

> "Client to perform console UI and work with your Boggle class to play a game"
>
> "...not meant to be the place to store the majority of the game's state, logic or algorithms..."
>
> "...no recursion or backtracking should take place in boggleplay..."

`Boggle.h & Boggle.cpp`

> "files for a Boggle class representing the state of the current Boggle game"
>
> "the majority of your code"
>
> "...required members..."

Starter code structure

`boggleplay.cpp`

"Client to perform console UI and work with your Boggle class to play a game"

"...not meant to be the place to store the majority of the game's state, logic or algorithms..."

"...no recursion or backtracking should take place in boggleplay..."

`Boggle.h & Boggle.cpp`

"files for a Boggle class representing the state of the current Boggle game"

"the majority of your code"

"...required members..."

Also `boggleui.h`, but worry about this last!

Game Setup

- Drawing the board
  - Custom board
  - Shaking the cubes
    - Representing the cubes
    - Representing the board
    - Random locations and faces

```
#include “shuffle.h”

     shuffle(array, length);

#include random.h

     randomInteger(0,6);

#include <<cctype>

     isalpha(ch);

#include “simpio.h”

     getYesOrNo(prompt, reprompt);
```

Get a word from the user...

Make sure to error check!

Human Word Search

_ _ _

- Find where the word you're searching for can start
- Recursively explore from this point
    - Is the public method enough, or do you need a helper function?

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Find the best solution

Count the number of solutions

Print/find all the solutions

Human Word Search

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- Find where the word you're searching for can start
- Recursively explore from this point
  - Is the public method enough, or do you need a helper function?
- An example (courtesy of previous YEAH hours)

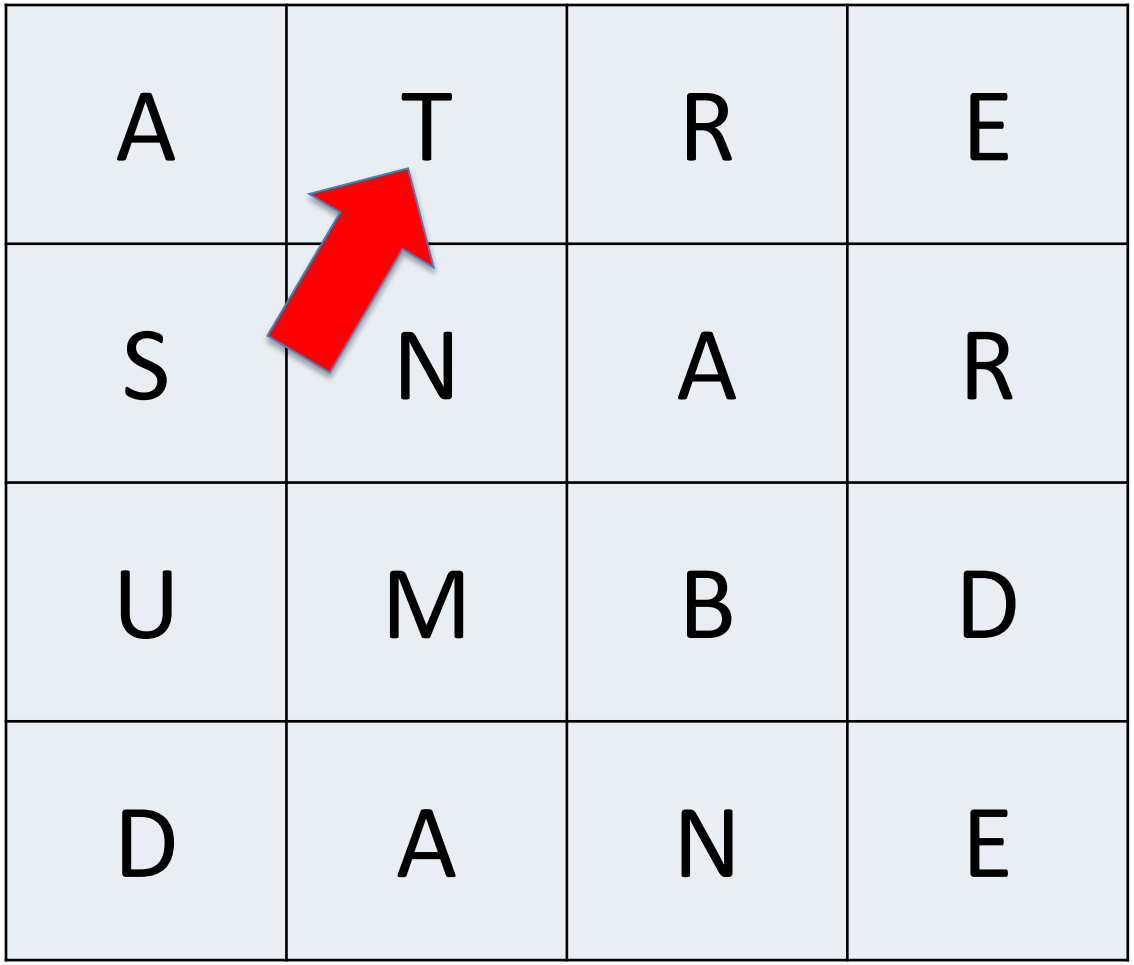
`humanWordSearch` Demo

word = “smart”

A	T	R	E
S	N	A	R
U	M	B	D
D	A	N	E

`humanWordSearch` Demo

word = “smart”



`humanWordSearch` Demo

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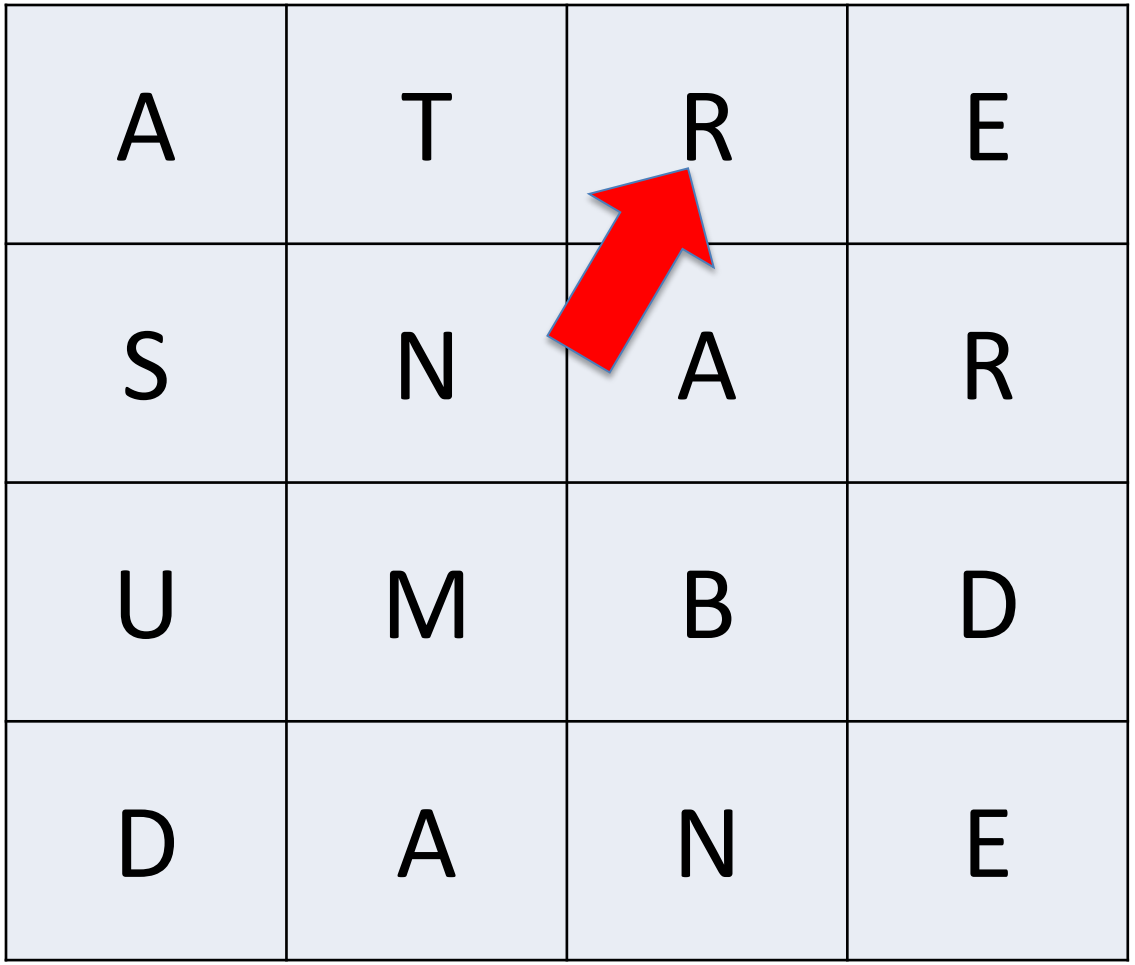

`humanWordSearch` Demo

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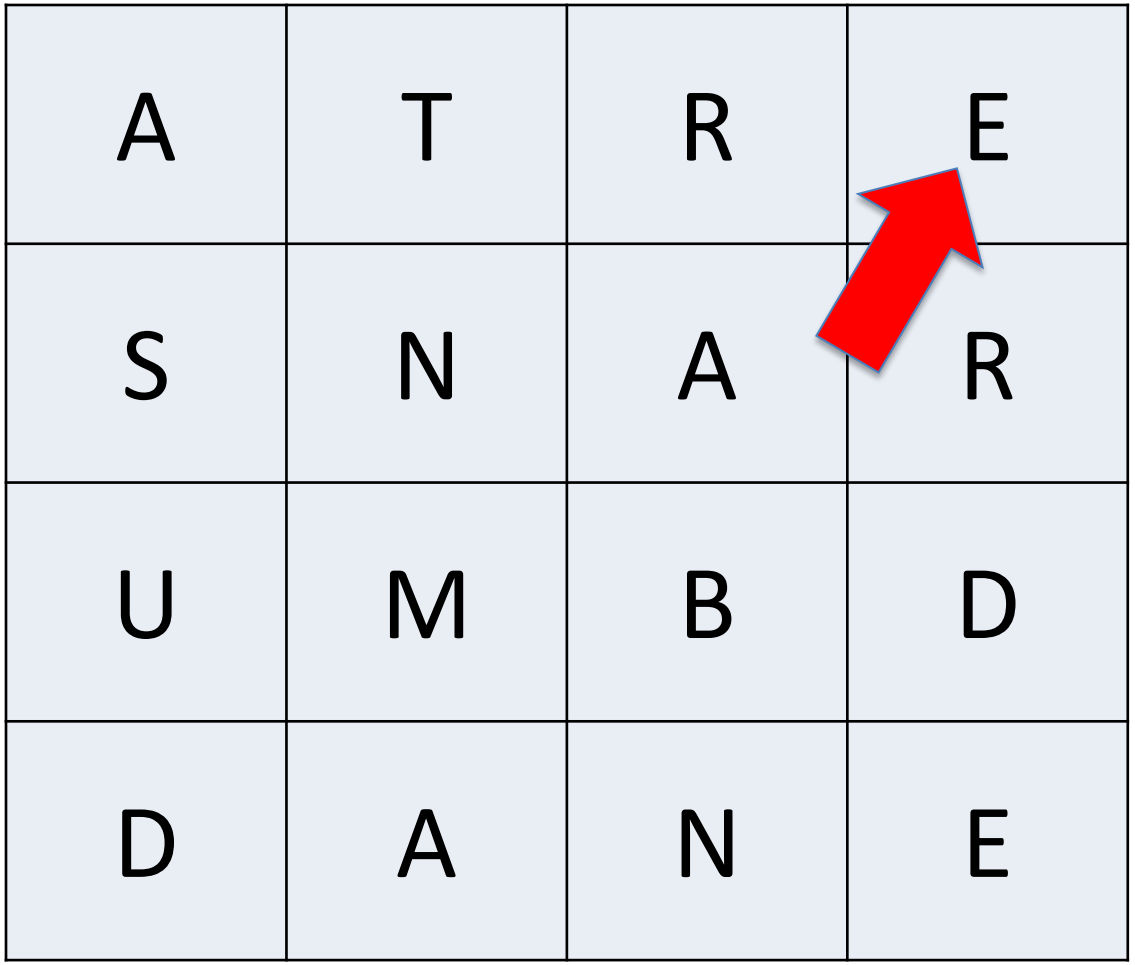

`humanWordSearch` Demo

word = “smart”

A	T	R	E
S	N	A	R
U	M	B	D
D	A	N	E

- We found the first letter
  - Mark it as used
    - Why?
  - Explore the rest of the word

`humanWordSearch` Demo

word = “mart”

A	T	R	E
S	N	A	R
U	M	B	D
D	A	N	E

- We found the first letter
  - Mark it as used
    - Why?
  - Highlight square
  - Look at its neighbors for the second letter.

`humanWordSearch` Demo

word = “mart”

A	T	R	E
Marked As Used	N	A	R
U	M	B	D
D	A	N	E

- We found the first letter
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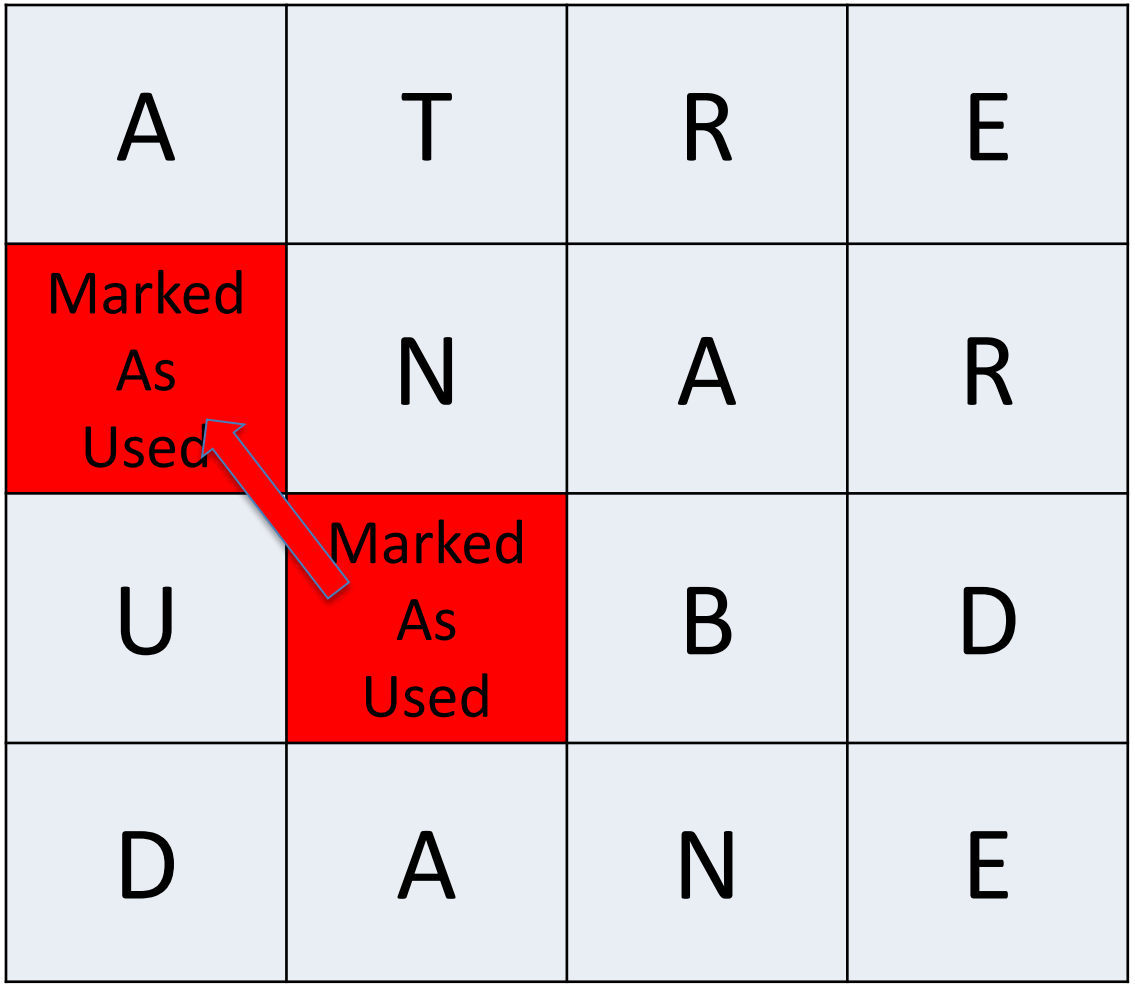
A	T	R	E
Marked As Used	N	A	R
U	M	B	D
D	A	N	E

- We found the first letter
  - Mark it as used
    - Why?
  - Highlight square
  - Look at its neighbors for the second letter.
- **Found it, now do it again.**

`humanWordSearch` Demo

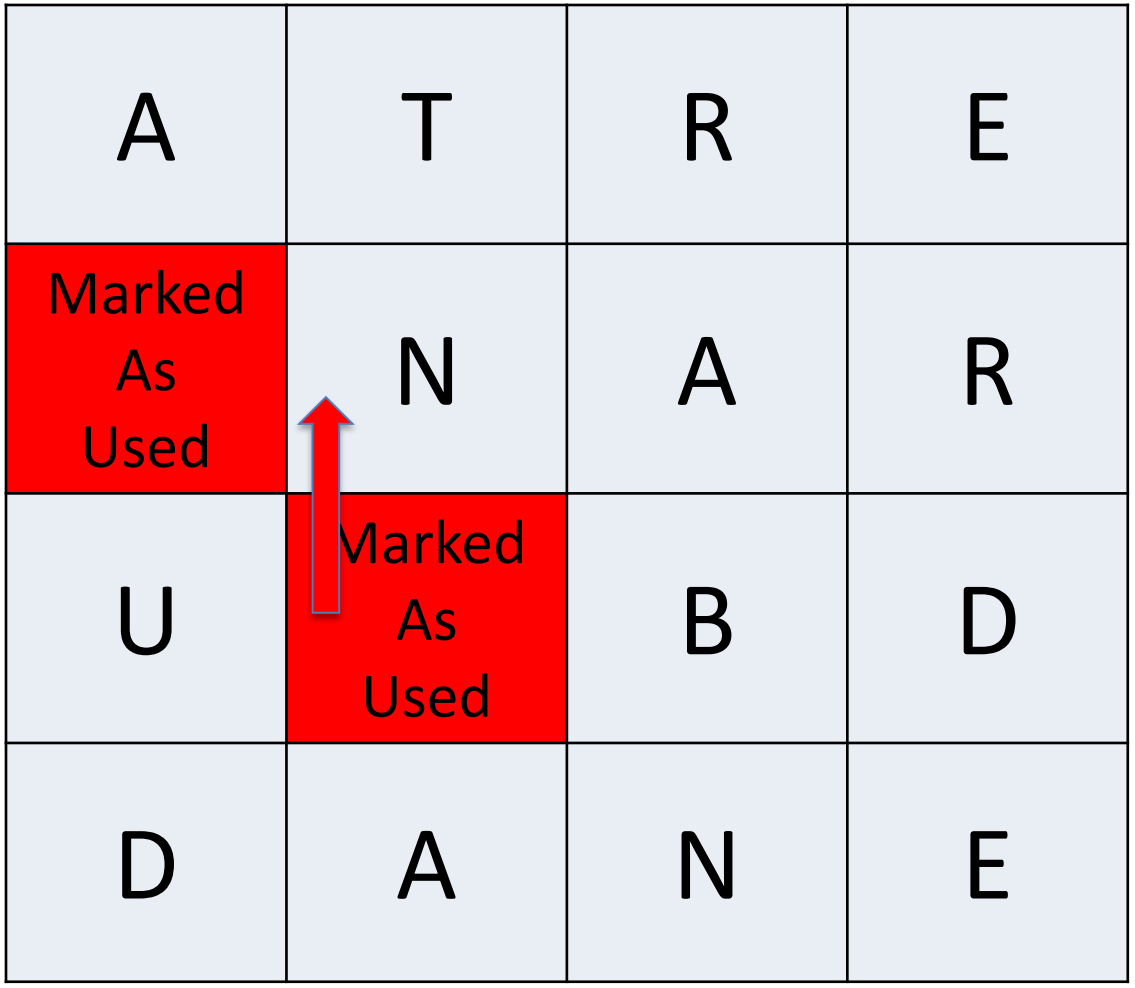
word = “art”



- We found the first letter
  - Mark it as used
    - Why?
  - Highlight square
  - Look at its neighbors for the second letter.

`humanWordSearch` Demo

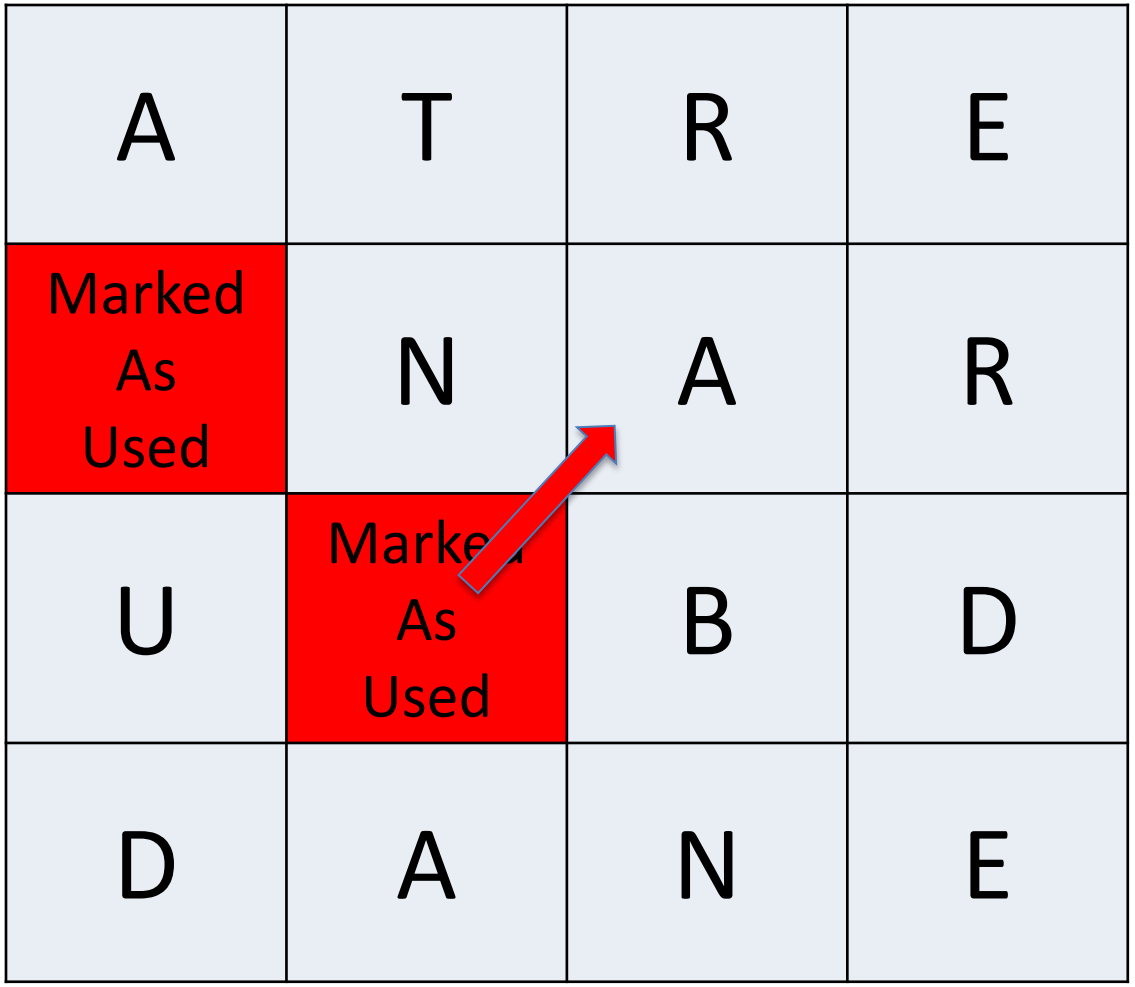
word = “art”



- We found the first letter
  - Mark it as used
    - Why?
  - Highlight square
  - Look at its neighbors for the next letter.

`humanWordSearch` Demo

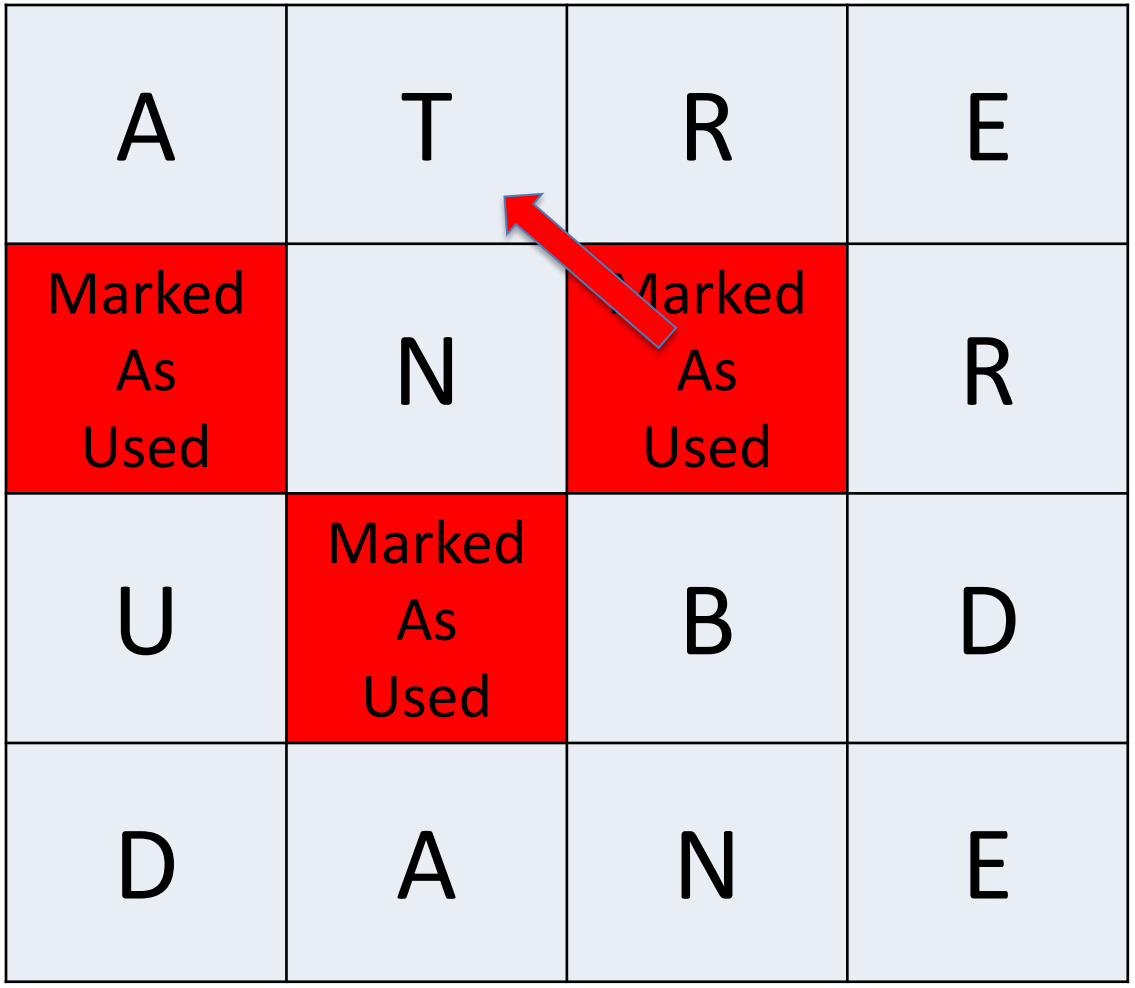
word = “art”



- We found the first letter
  - Mark it as used
    - Why?
  - Highlight square
  - Look at its neighbors for the next letter.
- **Found the next letter! Let’s do it again.**

`humanWordSearch` Demo

word = “rt”



- We found the first letter
  - Mark it as used
    - Why?
  - Highlight square
  - Look at its neighbors for the next letter.

`humanWordSearch` Demo

…a few steps later

A	T	R	E
S	N	A	R
U	M	B	D
D	A	N	E

- How do we know when we are here?
  - That's our base case
- *What if that first "S" did not work out?*
  - Keep looking

The user ends their turn...

(by pressing enter)

Computer Word Search

– – –

- Find all the words on the board
- Also backtracking

Types of recursion & backtracking

Determine whether a solution exists

Find a solution

Find the best solution

Count the number of solutions

Print/find all the solutions

Computer Word Search

- Find all the words on the board
- Also backtracking
- When do you stop?
  - It can't be when you find a word
  - Once you've found "ban", you can still find "banter"

```
lexicon.containsPrefix(pre);

// pre is a possible string prefix
```

Computer Word Search

- Find all the words on the board
- Also backtracking
- When do you stop?
  - It can't be when you find a word
  - Once you've found "ban", you can still find "banter"
- An example (courtesy of previous YEAH hours)

```
lexicon.containsPrefix(pre);

// pre is a possible string prefix
```

`computerWordSearch()` Demo

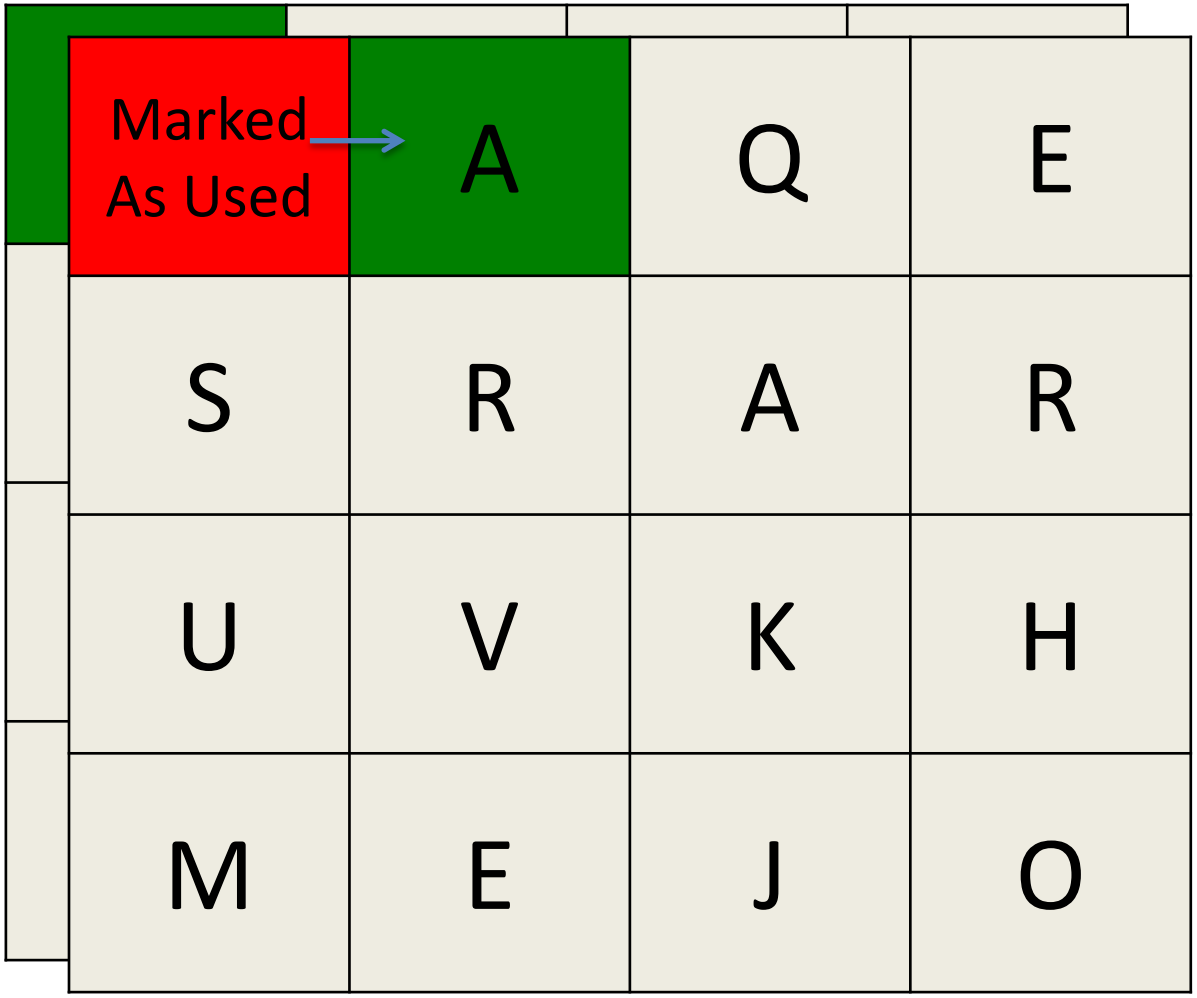
word so far: “E”

E	A	Q	E
S	R	A	R
U	V	K	H
M	E	J	O

Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

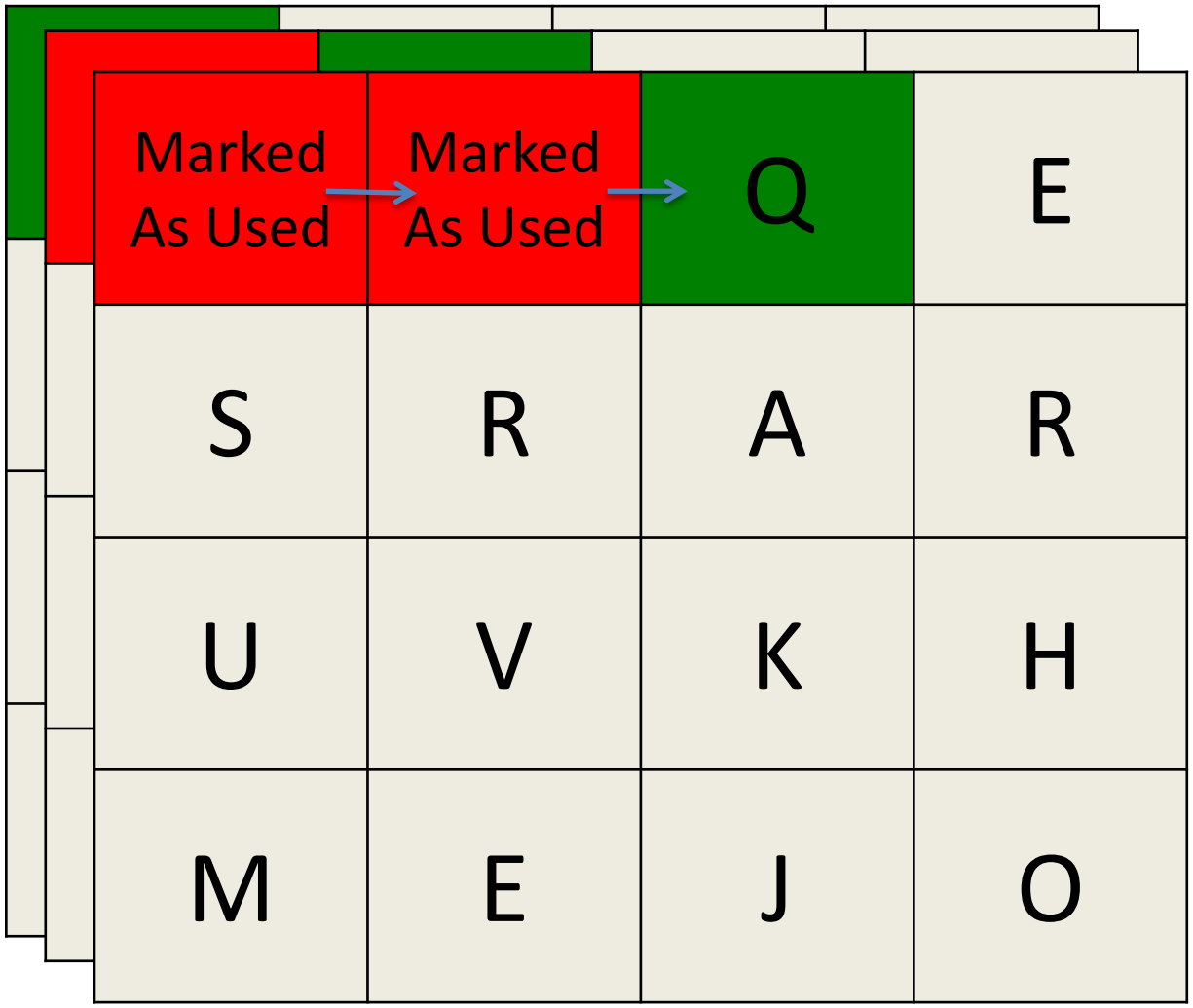
word so far: "EA"



Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

word so far: “EAQ”

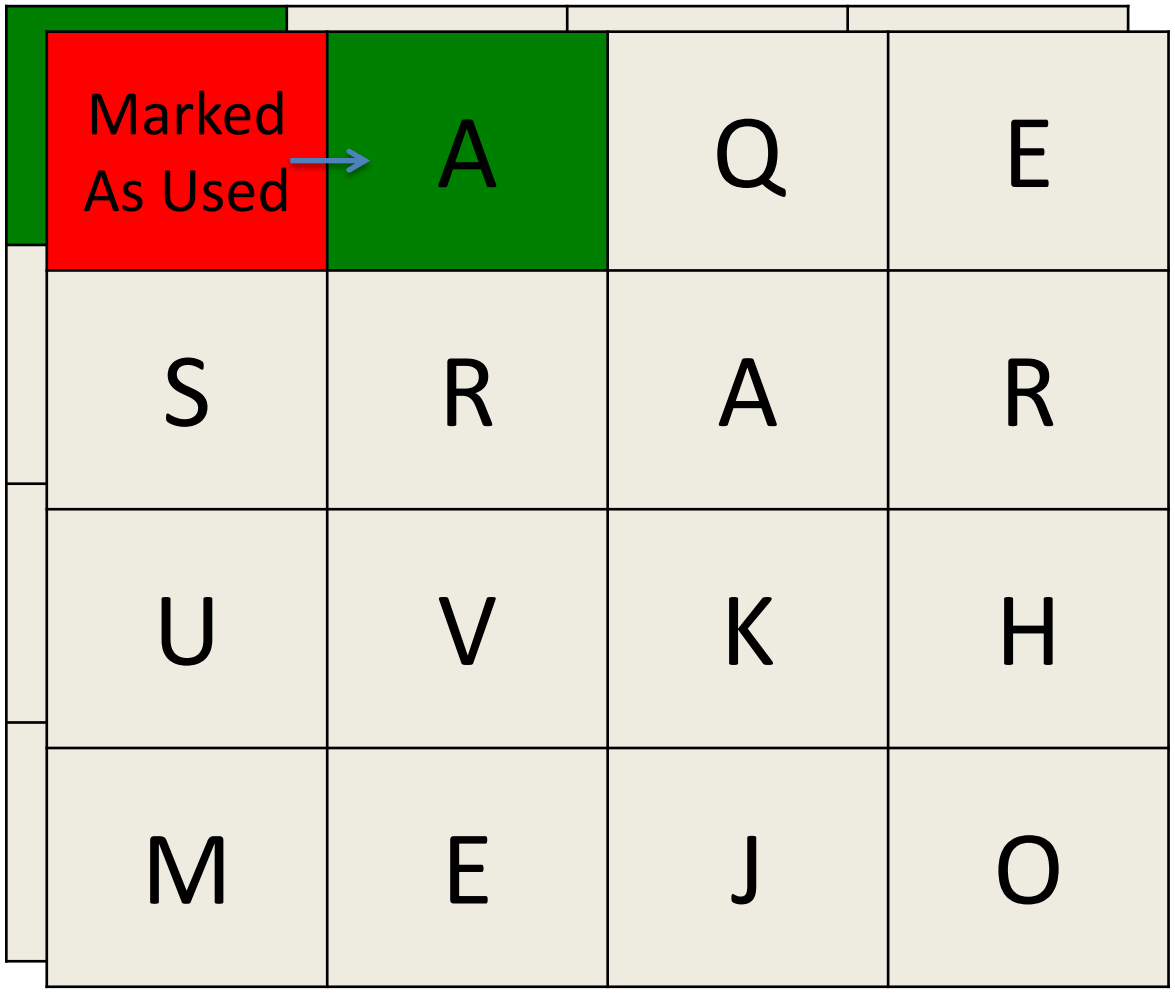


Select each neighbor in turn and recurse down.

BUT WAIT! EAQ is not the start of any english word! So should we continue??

`computerWordSearch()` Demo

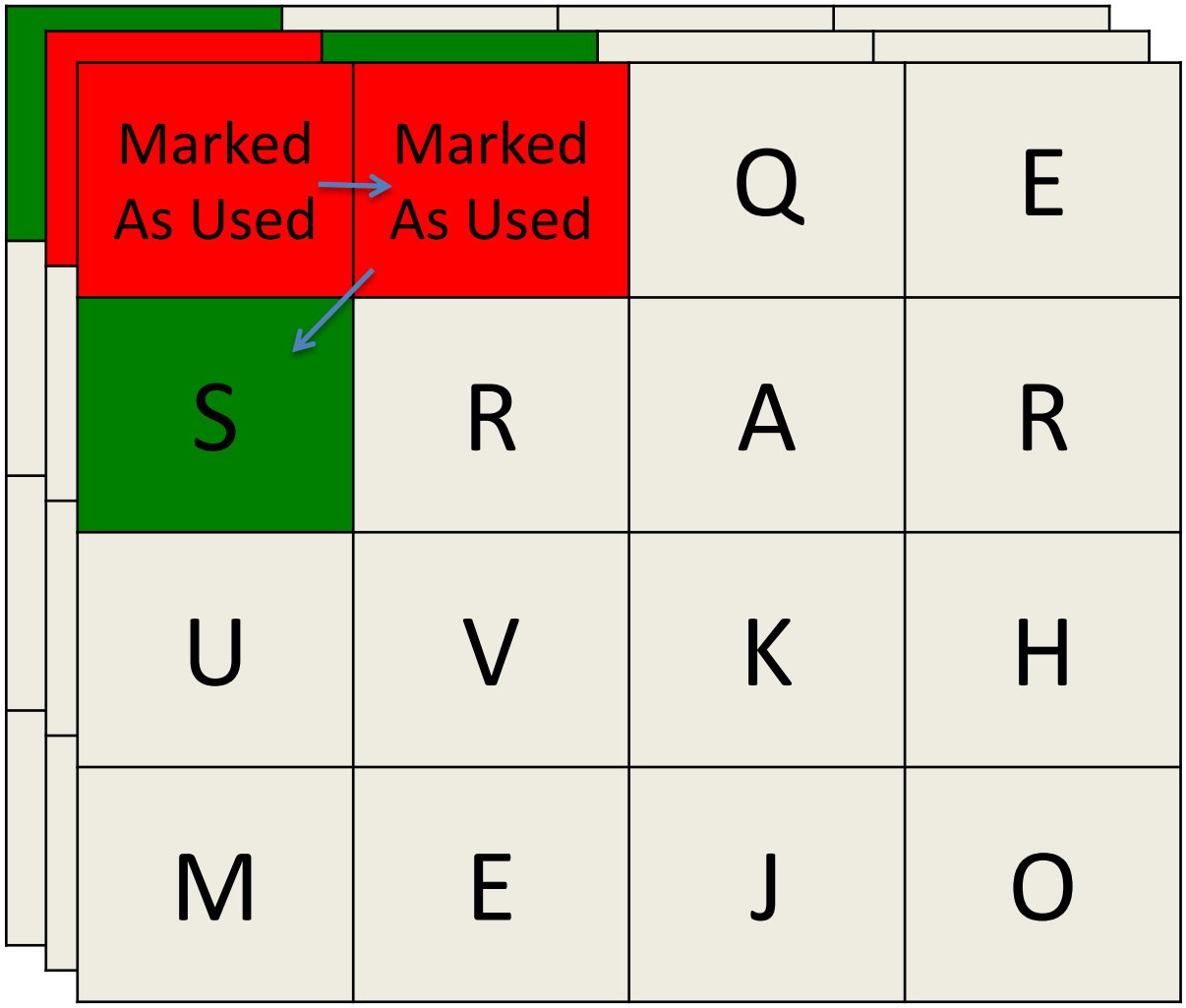
word so far: “EA”



Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

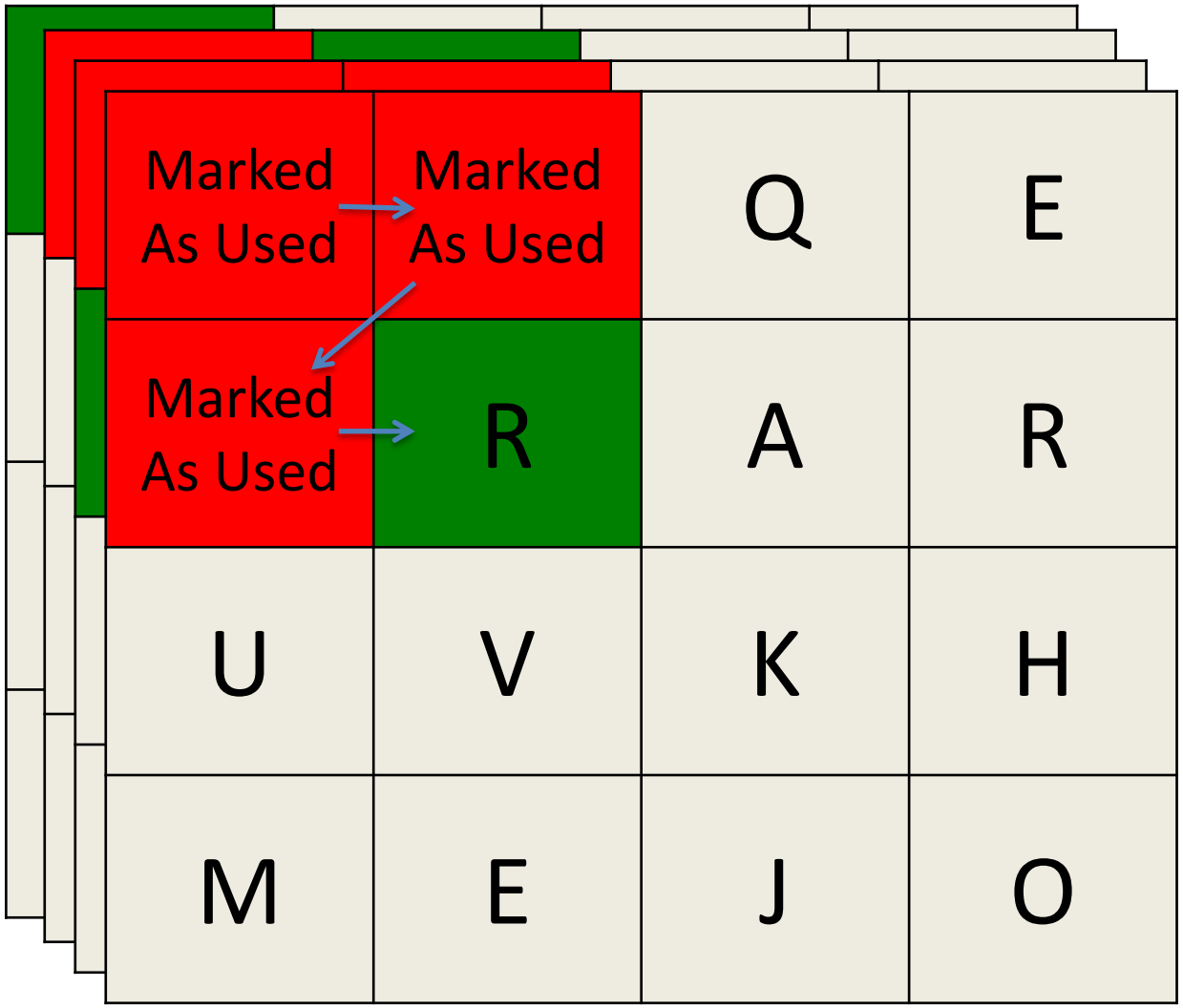
word so far: “EAS”



Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

word so far: “EASR”

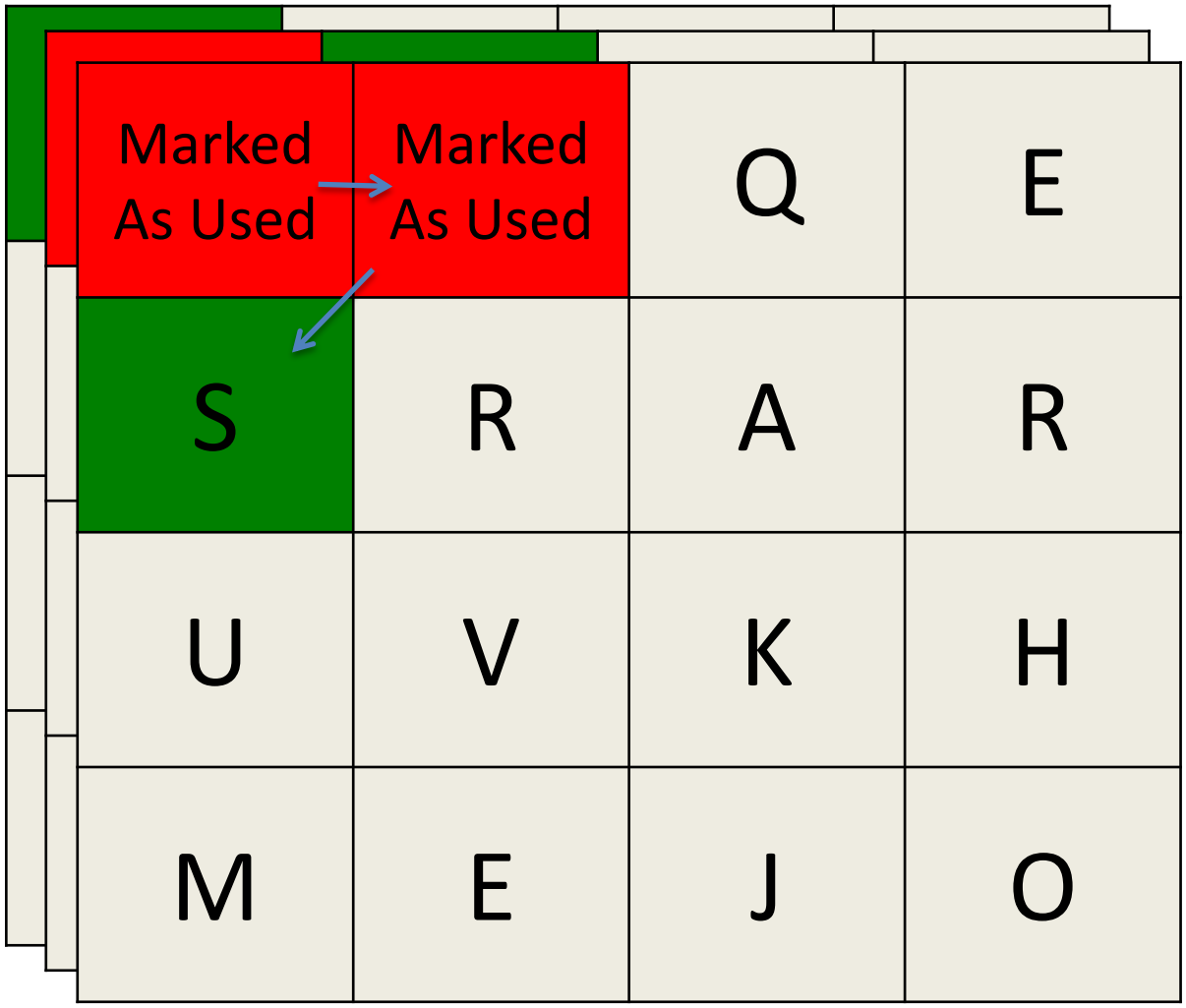


Select each neighbor in turn and recurse down.

But wait, no word begins with EASR!

`computerWordSearch()` Demo

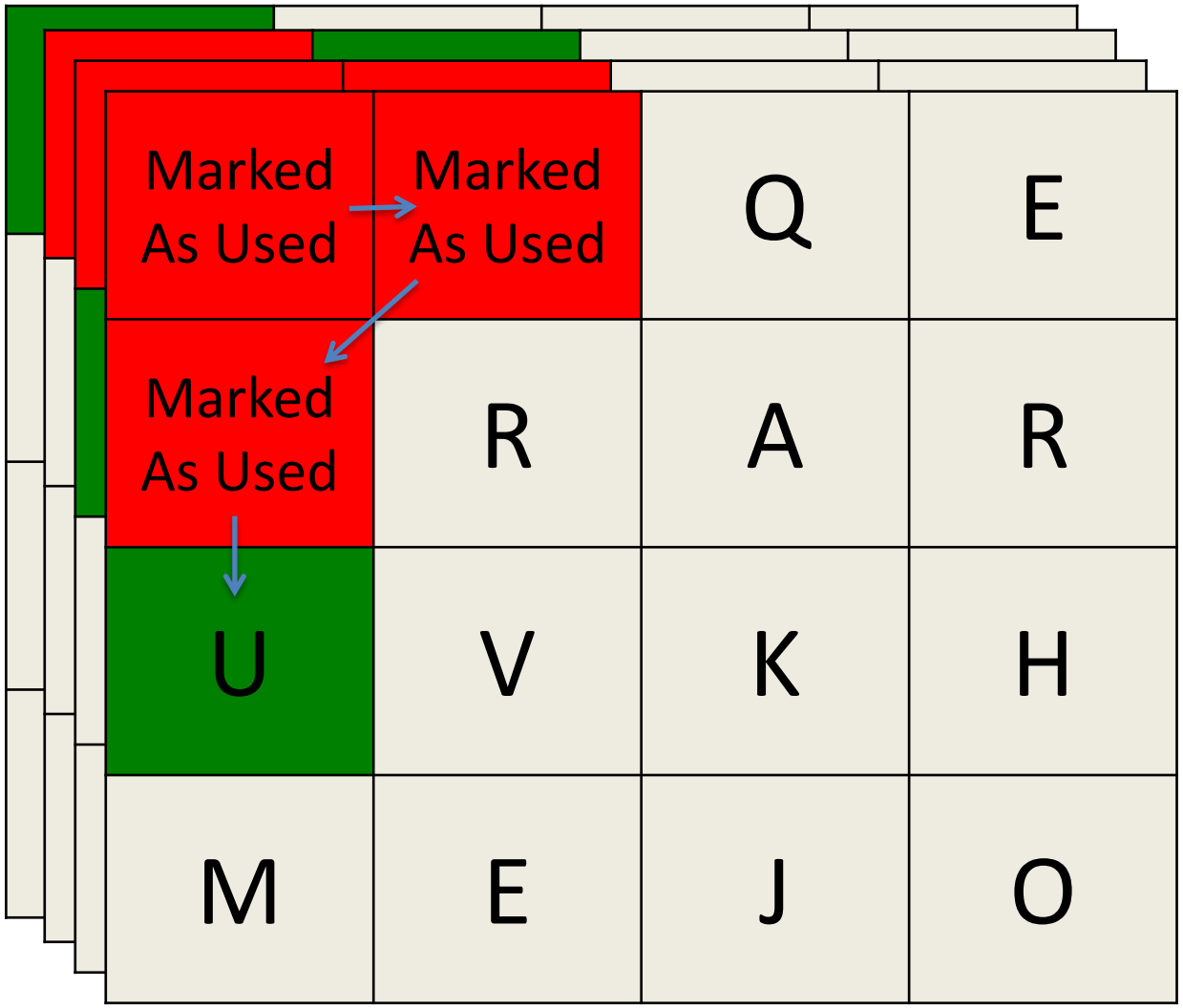
word so far: “EAS”



Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

word so far: “EASU”

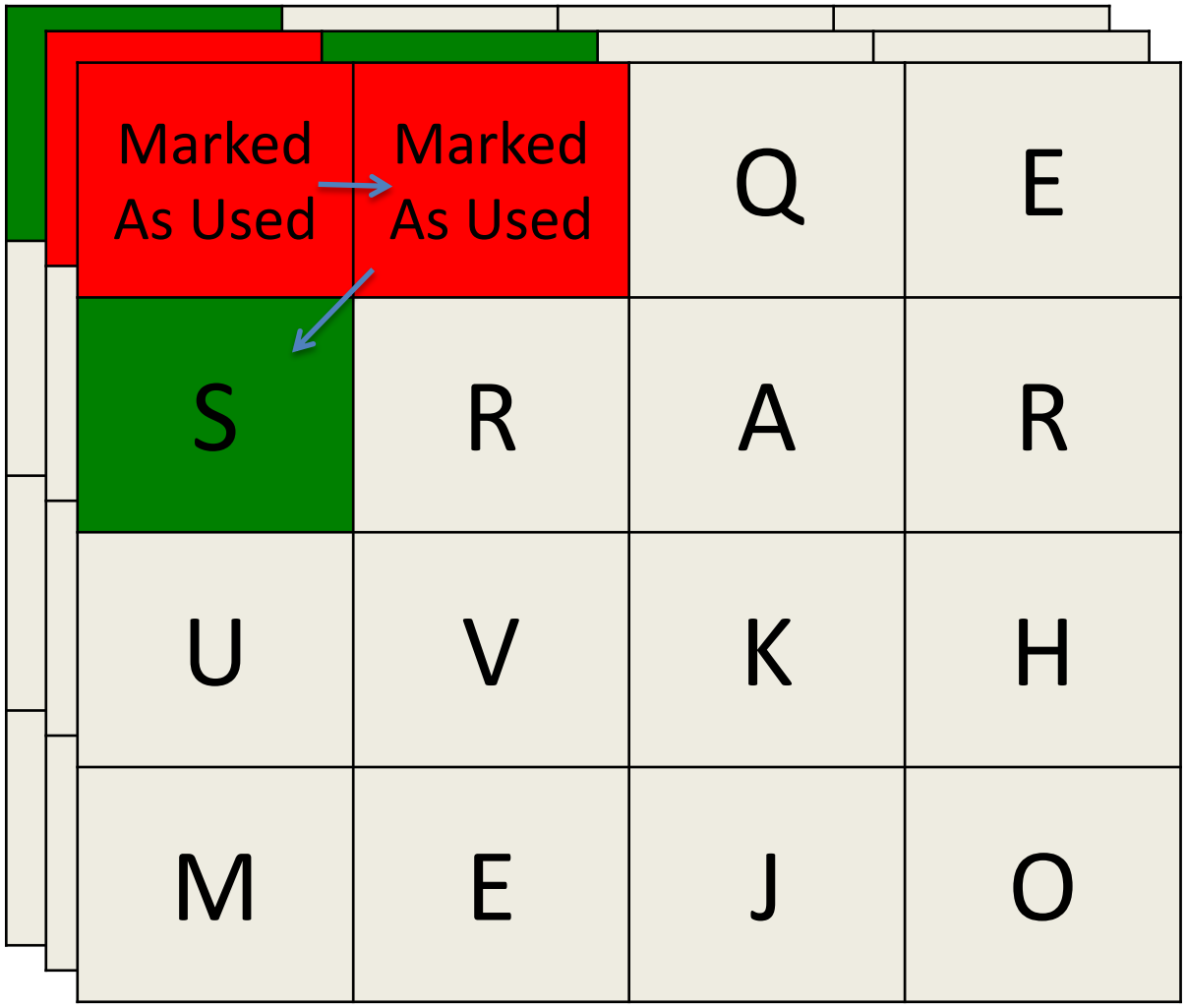


Select each neighbor in turn and recurse down.

But wait, no word begins with “EASU”!

`computerWordSearch()` Demo

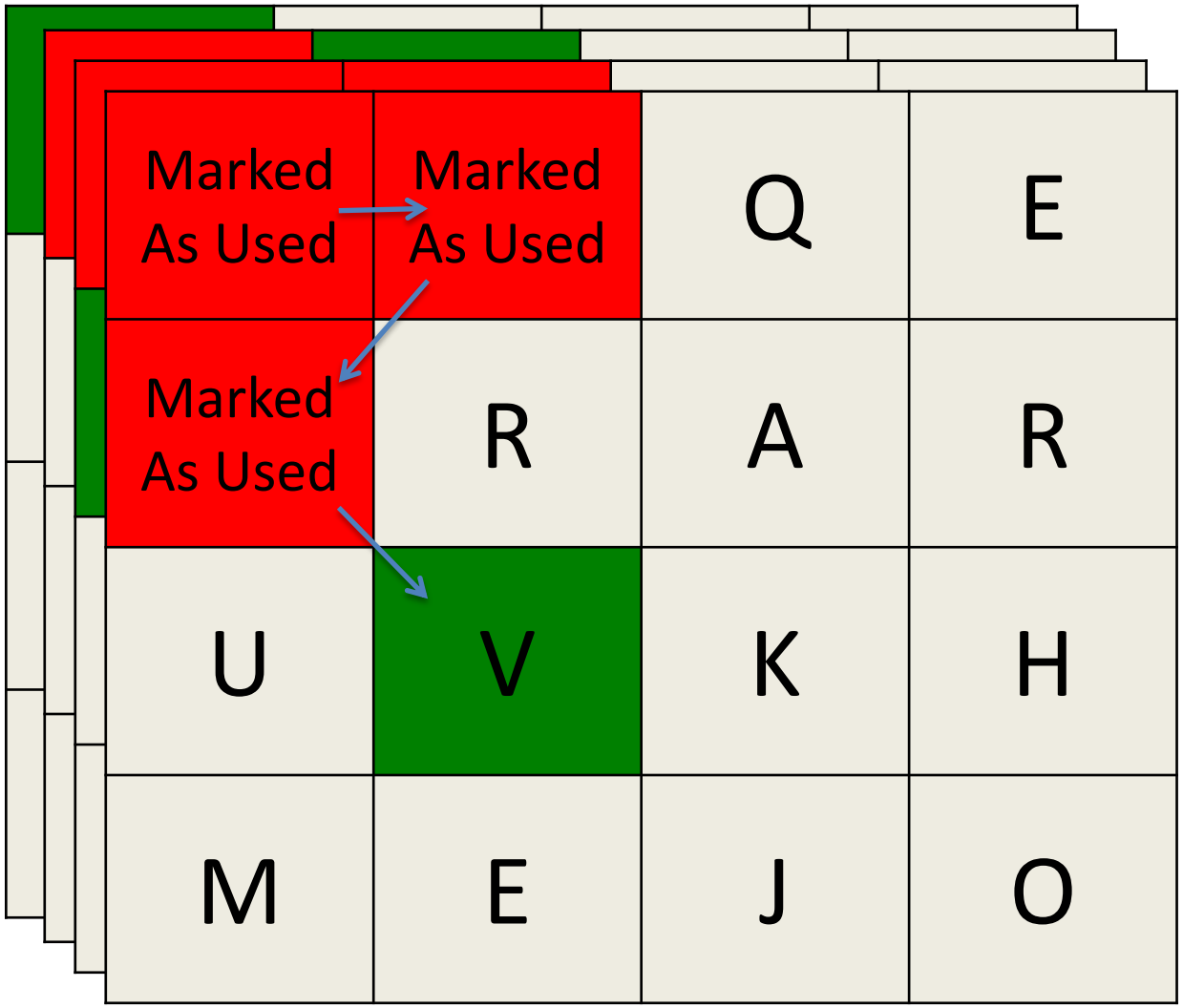
word so far: “EAS”



Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

word so far: “EASV”

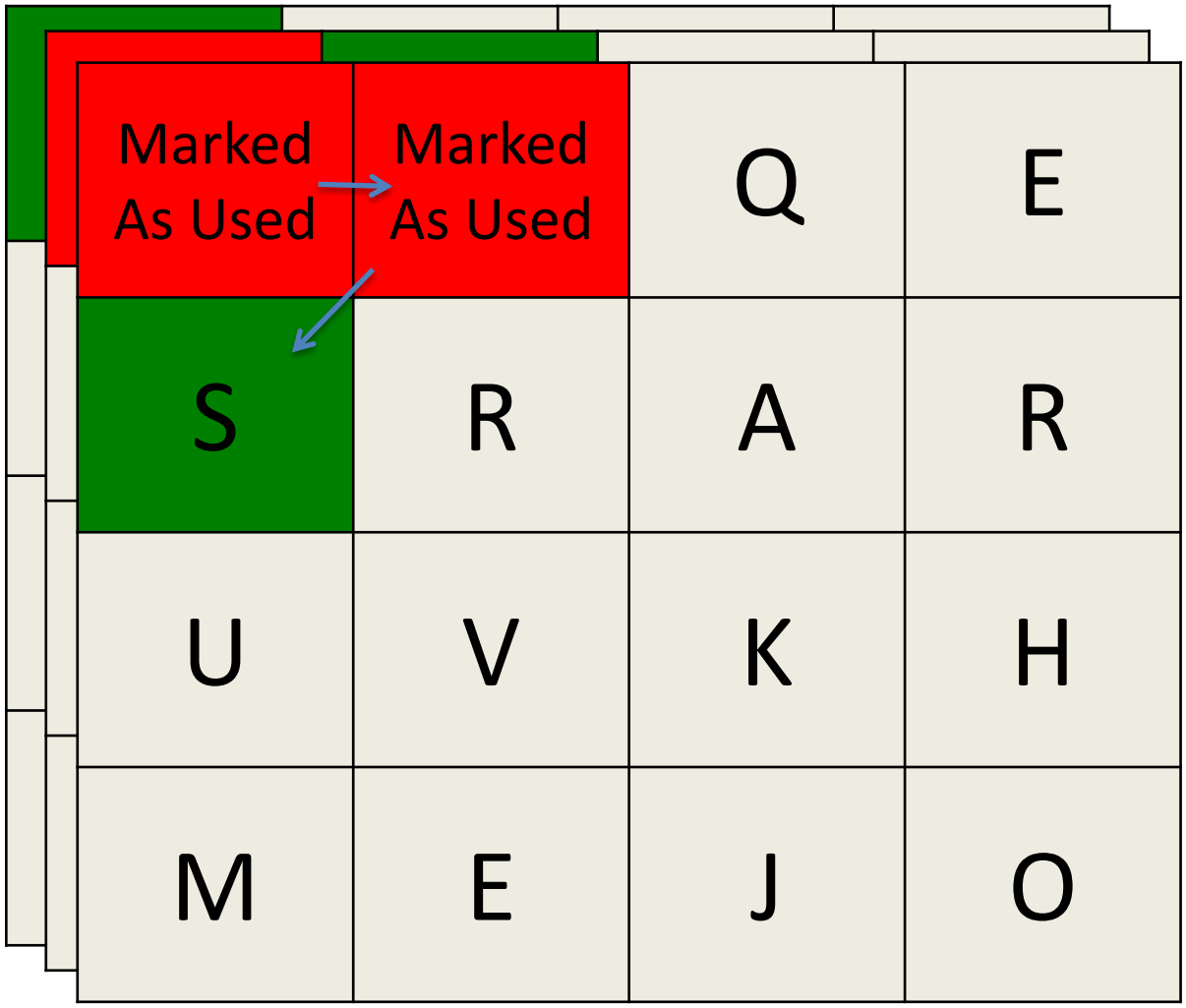


Select each neighbor in turn and recurse down.

STOP! No words start with “EASV”!

`computerWordSearch()` Demo

word so far: “EAS”

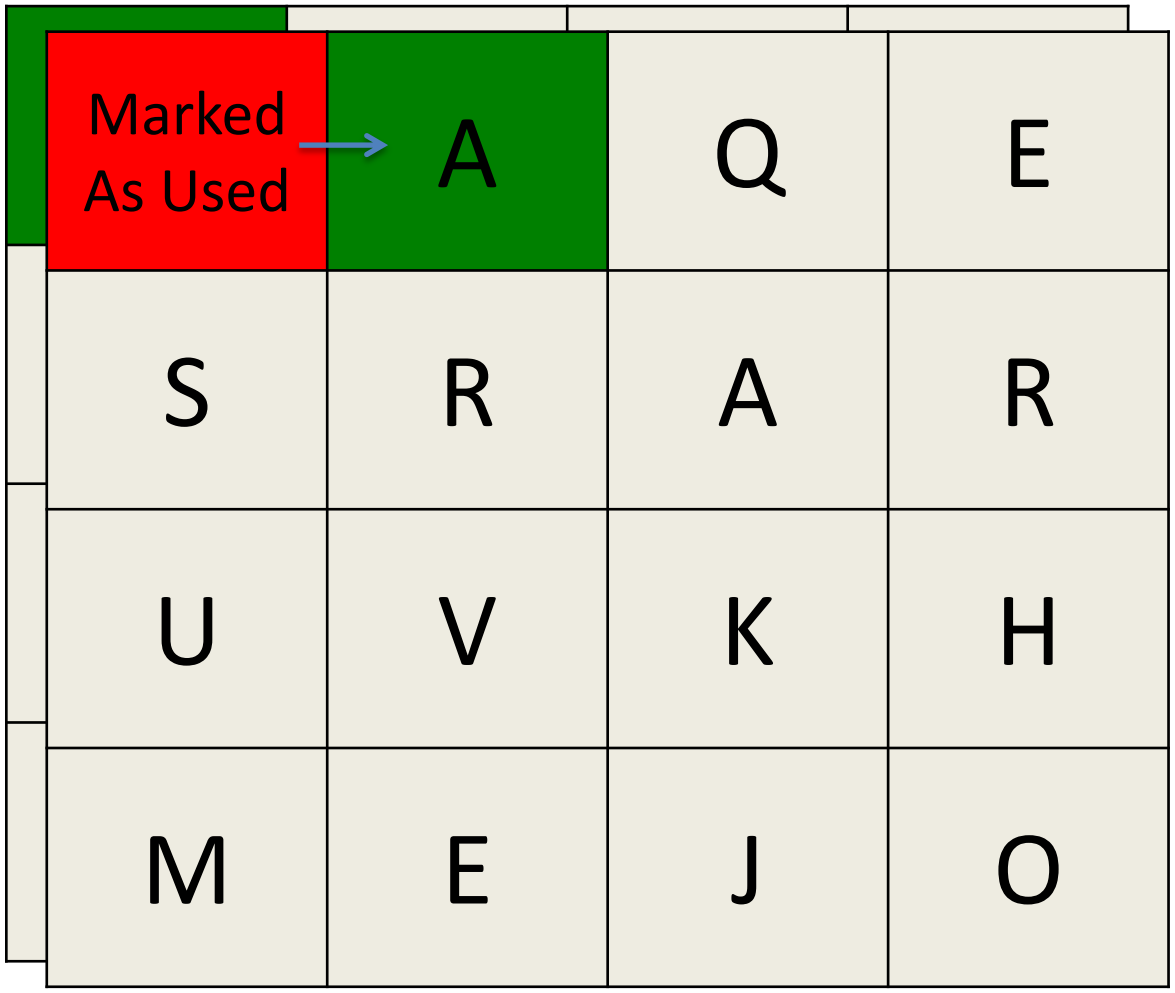


Select each neighbor in turn and recurse down.

We have looked at all of S’s neighbors, so we will head back up.

`computerWordSearch()` Demo

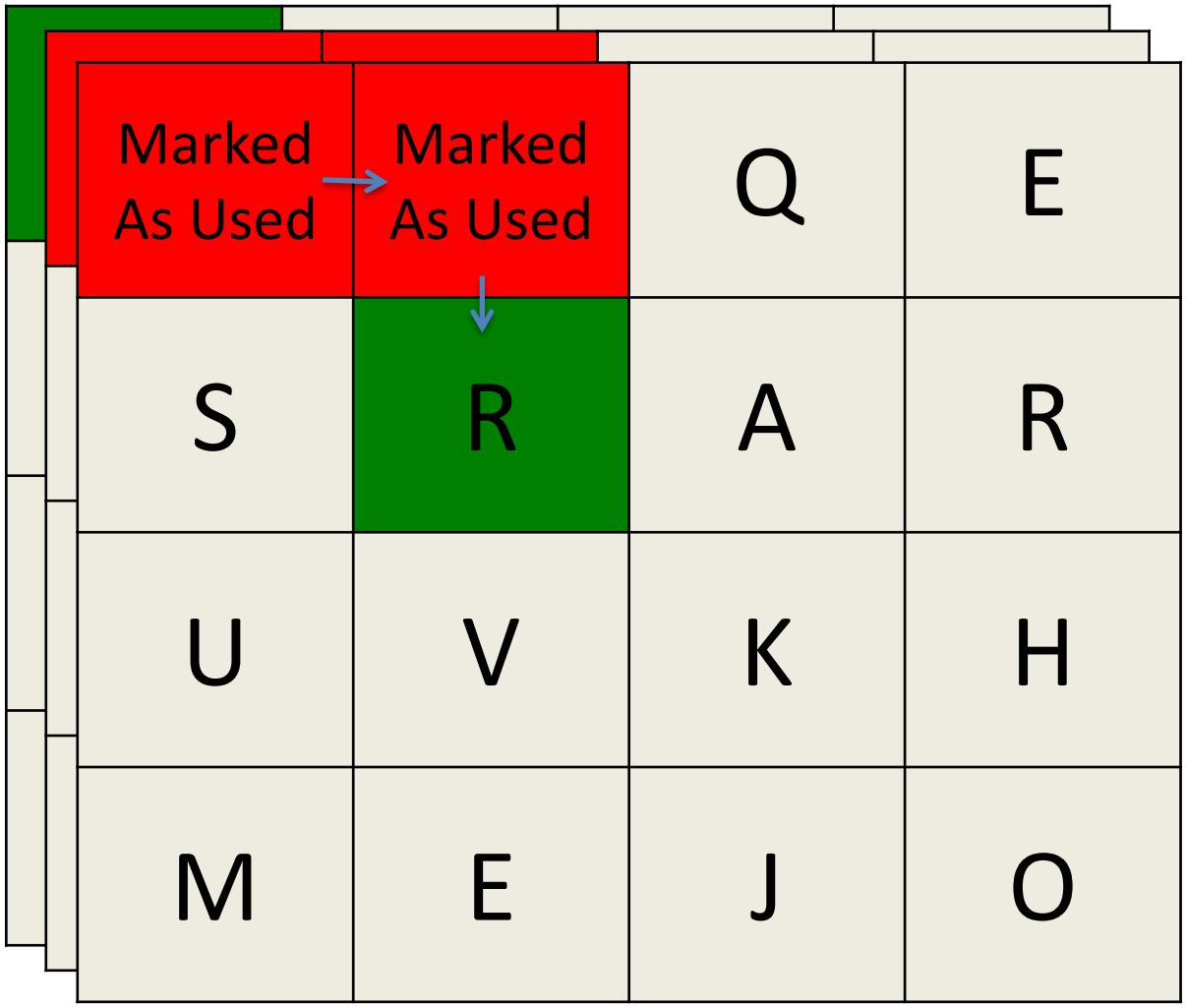
word so far: “EA”



Select each neighbor in turn and recurse down.

`computerWordSearch()` Demo

word so far: "EAR"

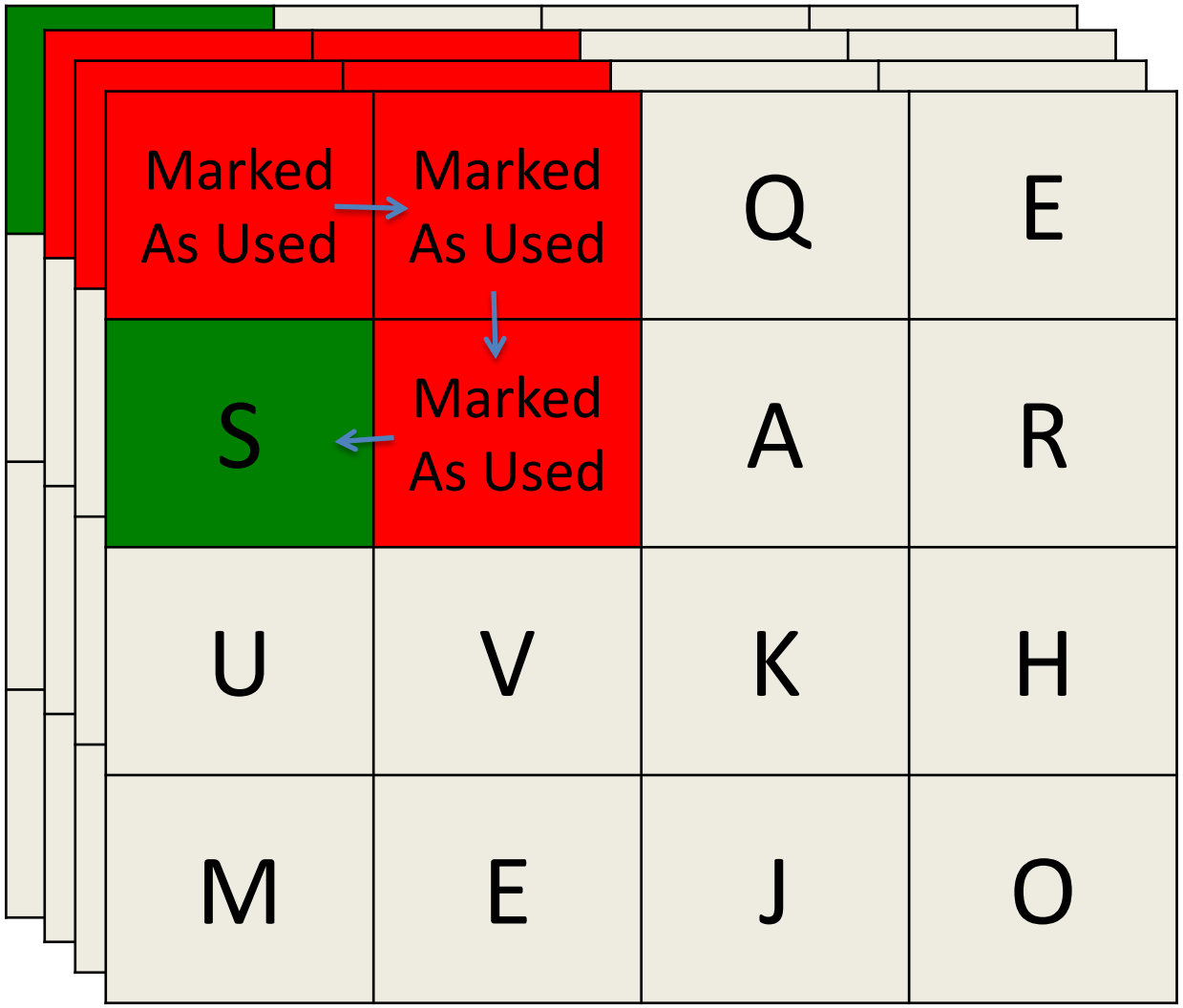


Select each neighbor in turn and recurse down.

"EAR" is a word, *but it is not 4 letters*.

`computerWordSearch()` Demo

word so far: “EARS”



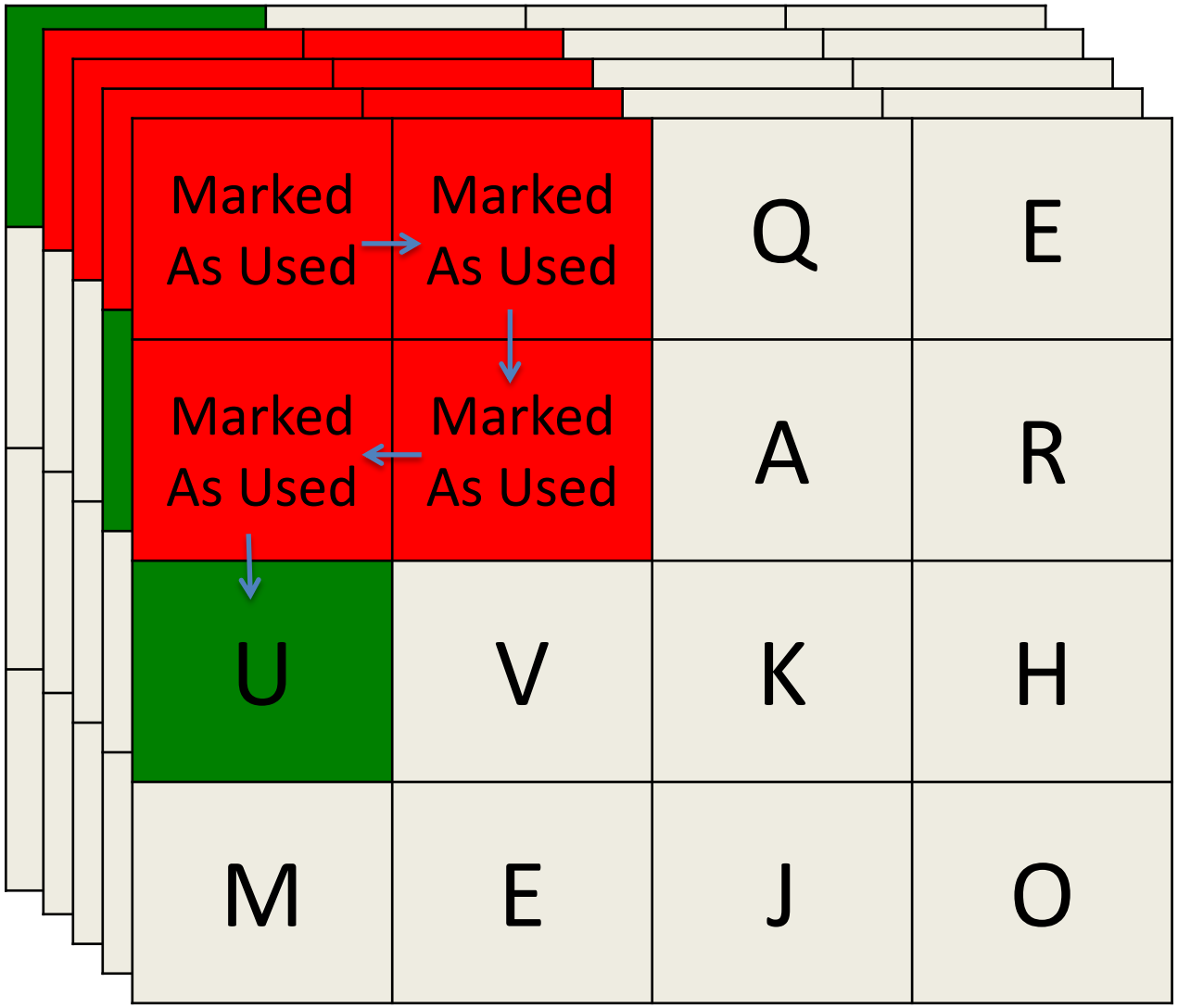
Select each neighbor in turn and recurse down.

“EARS”! Hey, that’s a word and it’s 4 letters at least.

Let’s add it to our set, and **keep looking**!

`computerWordSearch()` Demo

word so far: “EARSU”



Select each neighbor in turn and recurse down.

Time for the GUI!

Figure out what each function in `boggleui.h` does and how/when to use it.

`BoggleGUI::initialize(row, col)` if you want to call `initialize(row, col)`

```
endl;
//questions?
```