CPS 140 **Project 3** **Spring 2012**

Project Due: Thursday, April 19, 11:59pm
30 points

The purpose of this assignment is to write an interpretor for the MOUSECAT programming language (see the project 1 and project 2 handouts for a description of the tokens and the grammar of the MOUSECAT programming language). Your program will read in a data file containing a MOUSECAT program, and if it is a syntactically correct MOUSECAT program, then you will interpret the program and graphically interpret cats, mice, holes and movement of cats and mice.

DESCRIPTION OF YOUR PROGRAM

Given a sample MOUSECAT program, your task is to 1) scan the program and identify all its *parts* (or *tokens*) 2) parse the program using an LR parser and identify if it is syntactically correct 3) construct a syntax tree and 4) "run" the MOUSECAT program by traversing the syntax tree.

Part 1 - The Scanner

This was done in project 1.

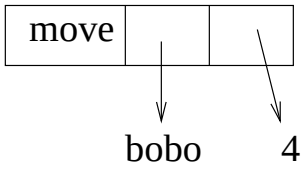
Part 2 - The Parser

This was done in project 2.

Part 3 - The Syntax Tree

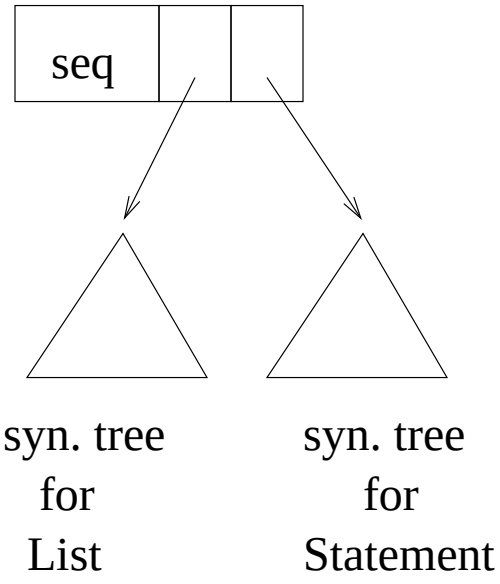
For each MOUSECAT program, you will construct a syntax tree that represents the semantics of the MOUSECAT program. The tree can be built as the MOUSECAT program is parsed.

Whenever structure is recognized in a MOUSECAT program, the parts of the structure can be put together in the form of a syntax tree. Structure is recognized when a reduce operation is encountered. For example, when "move bobo 4" is reduced to "Statement", a syntax tree can represent the fact that the cat *bobo* should move 4 spaces in the current direction. We will create a node of type "move". This node should contain a pointer to "bobo" in the symbol table.



For another example, when "List Statement ;" is reduced to "List", there already exists a syntax tree for "List" and a syntax tree for "Statement", and they are joined together into one syntax tree for the new "List" by creating a node of type "seq" (indicating a sequence of statements) containing pointers to the two syntax trees.

In order to keep track of the syntax trees, a stack called STstack will contain a *reference* to the current syntax trees and to variables in the symbol table. Whenever a reduce operation is encountered whose rewrite rule contains two nonterminals on the right hand side (representing two syntax trees that have previously been calculated), the top two references on the STstack are popped and joined together in a new syntax tree. Then the reference to this new syntax tree is placed on the stack. Whenever a reduce operation is encountered whose rewrite rule contains one



nonterminal on the right hand side, the top reference on the STstack is popped and then pushed back onto the stack. Since this results in the STstack remaining the same, the stack does not need to be manipulated in this case. Whenever a reduce operation is encountered whose rewrite rule contains just terminals on the right hand side, a syntax tree node is created, references to the nonterminal's value in the symbol table are popped off of the STstack and placed into the syntax tree node, and then the reference to the syntax tree node is pushed onto the STstack. When a MOUSECAT program is recognized as valid, there will be one reference on the STstack. This reference points to the root of a syntax tree that represents the program. NOTE: the STstack is not the same stack the LR parser uses, but the two stacks do operate in parallel.

Types of nodes for syntax trees:

- *size - size i j begin <list> halt* - This type of node represents the beginning of a MOUSECAT program and has four parts. The first part tells the type of the node, *size*, the second and third parts are references to the integers i and j in the symbol table, and the fourth part is a reference to a list of statements, either a *seq* node if there are multiple statements, or a single statement node.

- *cat v i j d* - This type of node has five parts. The first part tells the type of the node, *cat,* the second part is a reference to v in the symbol table, the third and fourth parts are references to i and j in the symbol table, and the fifth part d is the direction.

- *mouse v i j d* - This type of node is a mouse node with five parts and is similar to the cat node.

- *hole i j* - This type of node has three parts. The first part tells the type of the node, *hole,* and the second and third parts are references to i and j in the symbol table.

- *sequence* - This type of node has three parts. The first part identifies the type of node, *seq*. The second and third parts are references to syntax trees, where those statements in the second part's syntax tree should be executed before those statements in the third part's syntax tree.

- *move v i* - This type of node has three parts. The first part tells the type of the node, *move,* the second part points to the variable *v* in the symbol table, and the third part points to the integer *i* in the symbol table.
- *clockwise v* - This type of node has two parts. The first part tells the type of the node, *clockwise,* and the second part points to the variable *v* in the symbol table.
- *repeat i <stmts> end* - This type of node has three parts. The first part identifies the node as a *repeat* node, The second part is a reference to the integer *i* in the symbol table, and the third part is a reference to a syntax tree that represents the body of the do statement. The meaning of the repeat statement is to execute the statements in the body *i* times.

Consider the following MOUSECAT program.

```
// program 1
size 30 40
begin
      cat char 20 21 east ;
      move char 4 ;
halt
```

This MOUSECAT program can be derived by applying the following production rules (using the first letter of each variable):

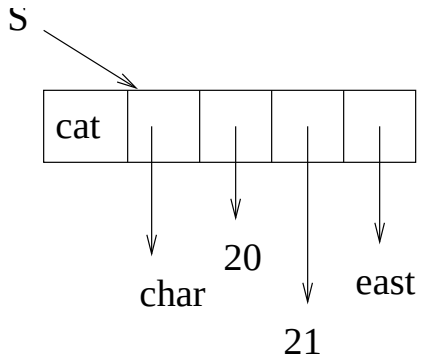
RULES	DERIVATION
P → size int int begin L halt	size 30 40 begin L halt
L → L S ;	size 30 40 begin L S ; halt
S → move var int	size 30 40 begin L move char 4 ; halt
L → S ;	size 30 40 begin S ; move char 4 ; halt
S → cat var int int D	size 30 40 begin cat char 20 21 D ; move char 4 ; halt
D → east	size 30 40 begin cat char 20 21 east ; move char 4 ; halt

If we apply the rules in the reverse order (the order an LR parser would find them) we can construct the syntax tree for this MOUSECAT program.

D → east

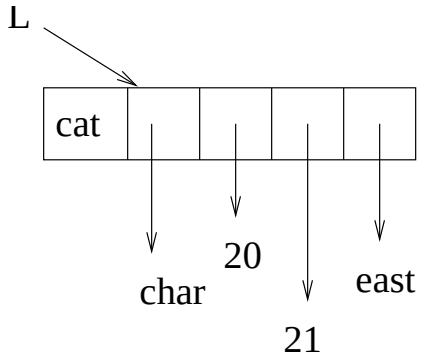
In this case, the reference to the node in the symbol table containing east is pushed on the STstack.

S → cat var int int D



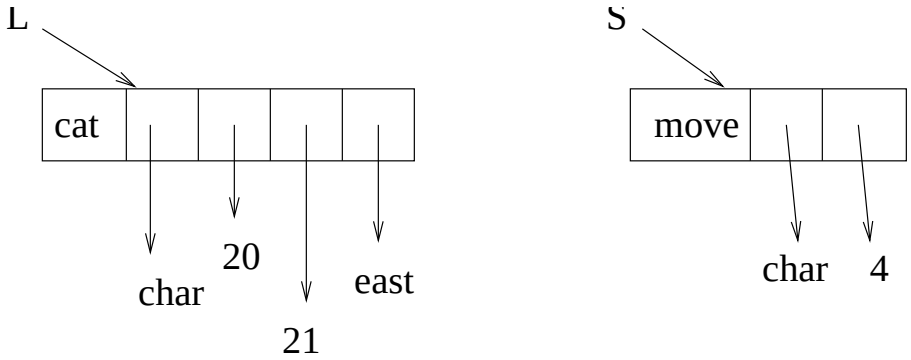
Here char, 20 and 21 would have already been shifted onto the STstack, and the direction node D is already on the STstack pointing to east. These 4 items are popped off the STstack, a cat node is made and the cat node is pushed onto the STstack.

L → S ;



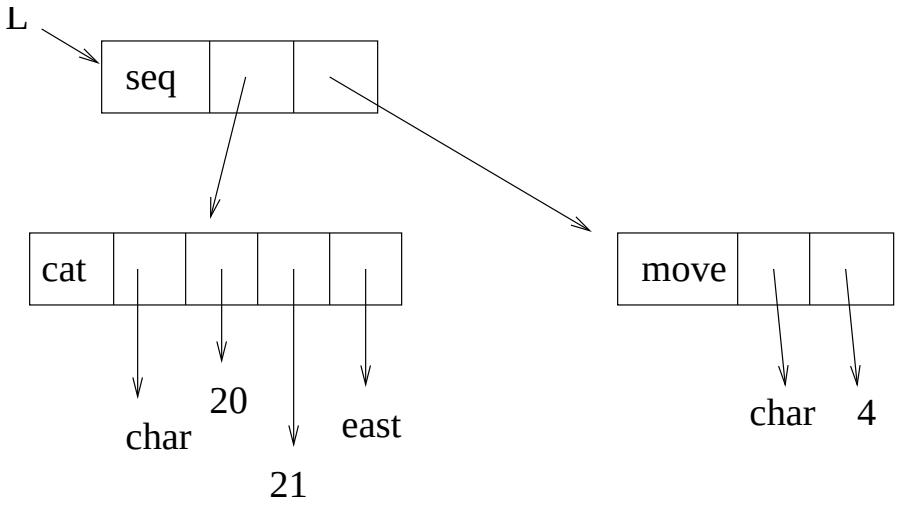
This is interpreted as the top of the STstack is popped and then pushed, or you can do nothing since the stack doesn't change in this case.

S → move var int



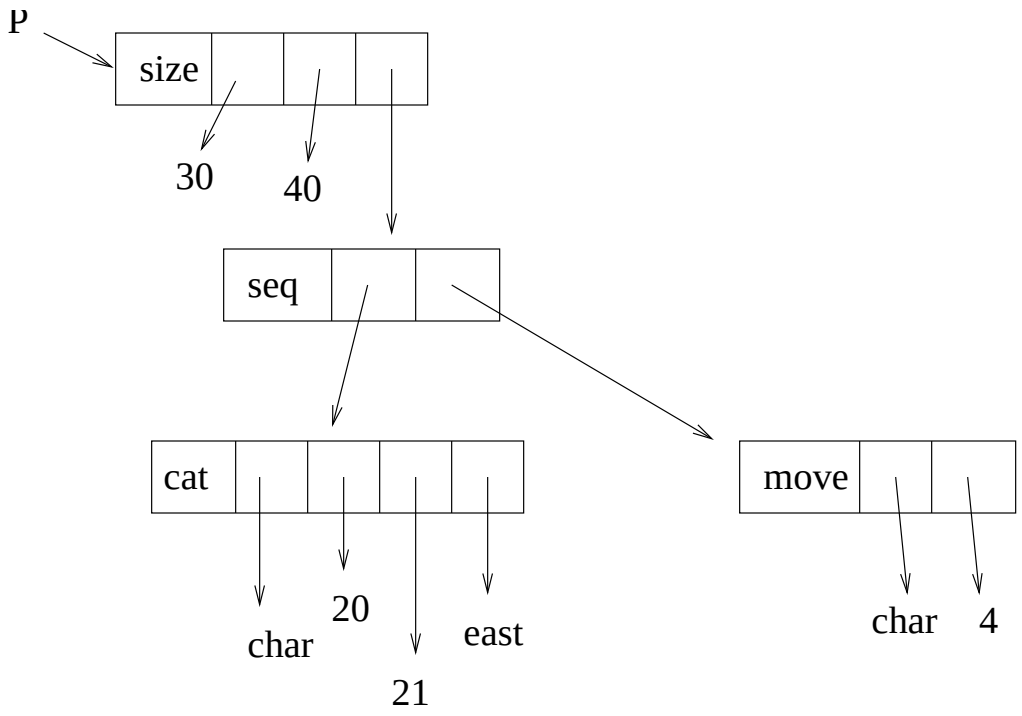
The char and 4 have already been pushed onto the STstack. They are popped off, a move node is created and pushed onto the STstack.

L → L S ;



The top two items are popped off the STstack and joined together in a sequence node, which is then pushed on the STstack.

P → size int int begin L halt



The two ints have been shifted onto the top of the STstack. Three items are popped off the stack and joined together in a size node, and then pushed back onto the stack, where it should be the only thing on the stack.

Part 4 - Execution of MOUSECAT programs

If the parser identifies that the MOUSECAT program is syntactically correct, then one can walk through the syntax tree and "run" the MOUSECAT program. When running a program, the

current value of variables are stored in the symbol table. In project 1, each variable in the symbol table had an integer value associated with it that was initially set to 0.

In the example above, one would traverse the syntax tree and 1) use graphic commands to create an initial window of size 30 by 40 2) create a cat at position (20, 21) headed in the direction east, 3) show the cat moving (cell by cell) 4 positions to the east.

Refer to project 1 that shows a graphic diagram showing the coordinates for the grid and a sample animation picture.

INPUT:

The input is a MOUSECAT program. You may assume the tokens for MOUSECAT programs are all valid. The format of the data file is the same as it was in projects 1 and 2.

OUTPUT:

Indicate whether the MOUSECAT program is syntactically correct or not. If it is syntactically correct, then run the MOUSECAT program and and produce a graphical simulation of the MOUSECAT program. If the MOUSECAT program is not syntactically correct, your program should display a text message indicating this, such as "Not syntactically correct."

Your program should follow the rules listed below, generating error messages in the animation when rules aren't followed and if multiple items are allowed on the same position, displaying the appropriate critter for that position.

RULES for Cat and Mice

- A mouse can hide in a hole, so display the hole if there is a mouse on the same position.
- Cats can walk over holes, but not go in them, so in this case display the cat until the cat is gone, then display the hole again.
- If a cat and mouse are on the same square (the mouse is not in a hole), then display the cat and assume the cat has eaten the mouse. You can remove the mouse. Any other statements that refer to the mouse are invalid, and an error message should flash in the animation.
- Two cats cannot be on the same square. This is an error. Remove the cat that entered the position last and keep the program running. It is then an error to refer to the cat that was removed. Flash an error message if this happens.
- Multiple mice can be on the same square if the square is a hole. Multiple mice cannot be on the same square otherwise. In that case, remove the mouse that entered the position last and flash error messages for any later statements that refer to that mouse.
- Display (flash) an error message in the window if an object (cat, mouse or hole) has coordinates outside of the window.

Graphics

The focus of this assignment is to learn about how parsing works. Graphics added are an extra bells and whistle.

AT THE MINIMUM, you should store the grid in a 2d array with different symbols representing the mouse, the path of the mouse, the cats, the path of the cats and the hole. Then print out all

error messages and the 2d array after the simulation is complete. (note you must indicate the path the mouse and cat moved with appropriate symbols). Each symbol used and what it represents should be described in your README file.

EXTRA CREDIT (5 pts)

EXTRA CREDIT: Create an animation of the program with simple graphical objects for the cats, mice and holes such as blue circle, red square, etc. Here errors should be displayed in the graphics.

THE PROGRAM AND ITS SUBMISSION

Your program should be written in Java and use Eclipse.

Your program will be graded on style as well as content. Style will count for 20% of your grade.

Appropriate style for this course includes:

- *Modularity* - Your program should be divided into classes. Comments should describe each part of the classes.
- *Liberal use of comments* - In addition to the comment for each class part, each nontrivial section of code (for example a loop) should have a comment describing its purpose. Comments should not merely echo the code.
- *Readability* - Your program should use the indentation and spacing appropriately to make it easily readable. Your comments should be clearly distinguishable from the code.
- *Appropriate variable names* - Give appropriate names that describe their function for variables, methods and classes.
- *Understandable output* - Your program should indicate its input as well as its output in a clear and readable manner. Remember, the output from your program is the only indication that it works!

The remaining part of your grade is based on meeting the specifications of the assignment. If you do not get your program correctly running, for partial credit you may generate output that identifies which part (functions) of your program are correctly working. This output must also be clearly understandable or no credit will be given!

You should create a file called README that contains your name, the amount of time the project took, and anyone you received help from.

Programs should be submitted by the due date. You should read your mail regularly after submitting your project in case the grader cannot compile your program.

LATE PENALTIES

Late programs are subject to a 10% penalty. No late programs will be accepted after Monday, April 23 8am!