CMSC 124

Design and Implementation of Programming Languages

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Lexical Analysis

done by the
lexical analyzer (scanner)

groups the sequence
of *characters into lexemes*

Lexeme

smallest syntactic unit

the lexical analyzer also
identifies the type of each lexeme

Token

a data structure containing
the lexeme and its type


```
printf("Age is ", age);
```



```
printf("Age is ", age);
```

LEXEME	TYPE	LEXEME	TYPE
printf	function identifier	**,**	separator
(	delimiter_oparen	**age**	variable identifier
"	delimiter_str	**)**	delimiter_cparen
Age is	string literal	**;**	delimiter_end
"	delimiter_str		

Symbol Table

a data structure used to store tokens and the information about these tokens


```
printf("Age is ", age);
```

LEXEME	TYPE	VALUE	REFERENCING ENVIRONMENT
"	variable identifier		
,	separator		
age	variable identifier		
)	delimiter_cparen		
;	delimiter_scol		

the lexical analyzer finds each lexeme by using *pattern matching*

lexemes follow a specific pattern based on their type

the lexical analyzer will *match the patterns* for each type of lexeme *to a string of characters*

if a *string did not match* with any of the patterns, an *error will be produced*


```
 124
   2.2534
-100
  -5.55
    .2
   0.751
   -.0006
```



```
12-30-1995
18-02-1997
2015-05-26
07-18-93
96-08-23
```


Ways of Matching Strings

1. State-transition diagrams
2. Regular Expressions

1. State-transition Diagrams

1. State-transition diagrams

aka *state diagrams*;
they are used to give an abstract
description of the behavior of a system

1. State-transition diagrams

lexical analyzers use
the state diagram
called *finite automata*

1. State-transition diagrams

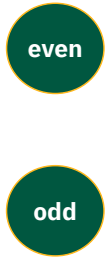
state diagrams are
just *directed graphs*

1. State-transition diagrams

nodes in a state diagram
are called *states*

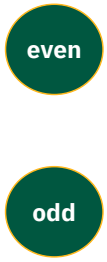
1. State-transition diagrams

usually represented
by a *circle containing
the name of the state*



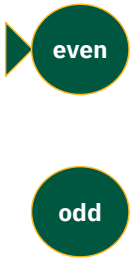
1. State-transition diagrams

one of the states
will be the *start state*
which will be *where
the pattern must start*



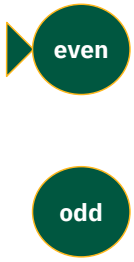
1. State-transition diagrams

the start state has
an *inverted triangle*
drawn on its side



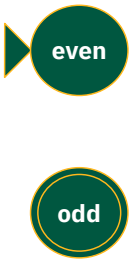
1. State-transition diagrams

some states can also
be a *final state*, which
are the states that
accepts the input string



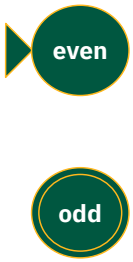
1. State-transition diagrams

they are drawn using
concentric circles



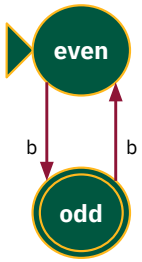
1. State-transition diagrams

arcs on state diagrams
are also called *transitions*



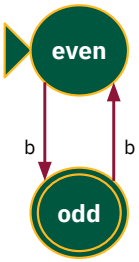
1. State-transition diagrams

drawn using *arrows*,
and must have
an *assigned symbol*



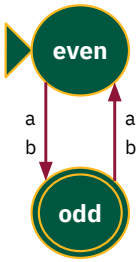
1. State-transition diagrams

the symbol assigned to a
transition is needed to
move from one state to another



1. State-transition diagrams

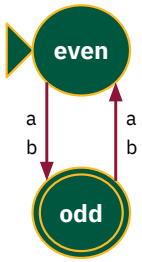
if *multiple transitions* exist
for the same source and
destination state, *all symbols*
can be written in the same arrow



1. State-transition diagrams

What does this
finite automata do?

What strings does it accept?



Example

```
 124
   2.2534
-100
  -5.55
    .2
   0.751
   -.0006
```

1. may start with a negative sign
2. may have a decimal point
3. if it has a decimal point, it must be followed by at least one digit
4. may have numbers at the left of the decimal point

2. Regular Expressions

2. Regular Expressions

aka *regex*;
set of *characters* that
formally defines a pattern

2. Regular Expressions

more info here!

SYMBOL	DESCRIPTION	EXAMPLE	SYMBOL	DESCRIPTION	EXAMPLE
^	string starts with	^car	{n}	occurs exactly n times	a{3}
$	string ends with	ry$	{n,}	occurs n times or more	a{2,}
|	or operator	pas(s|t)	{n,m}	occurs n-m times	a{2,3}
[]	one of these characters	[axy]	.	any one character	err.rs
+	one or more consecutive occurrences	bar+	\	escape character	u\.
*	zero or more consecutive occurrences	bar*	[^]	not any of these characters	[^a]
?	optional; may or may not occur in the string	t?rust	\d	digits	\d{3}

Example

```
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1. may start with a negative sign
2. may have a decimal point
3. if it has a decimal point, it must be followed by at least one digit
4. may have numbers at the left of the decimal point

Lexical Analysis

Which is better?
State-diagrams or regular expressions?

Lexical Analysis

They are equal in capabilities.

If you have a regex,
you can create a finite automaton for it.

If you have a finite automaton,
you can create a regex for it.

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