Today's Topics

Previously

- Began looking at the S/SL computational model

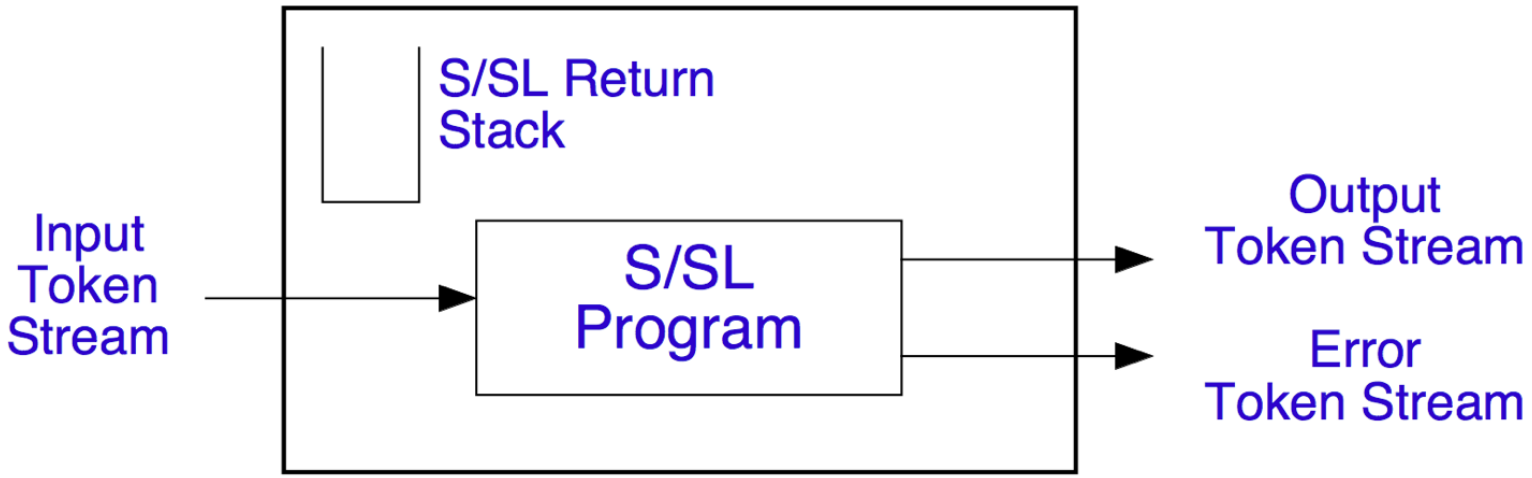
This Time

- S/SL program structure and operations
- Begin with SL (Syntax Language), S/SL without semantic mechanisms

SL - S/SL Without Mechanisms

Syntax Language

- Without semantic mechanisms, SL can only recognize input tokens, push and pop the return stack and generate output and error tokens



SL - S/SL Without Mechanisms

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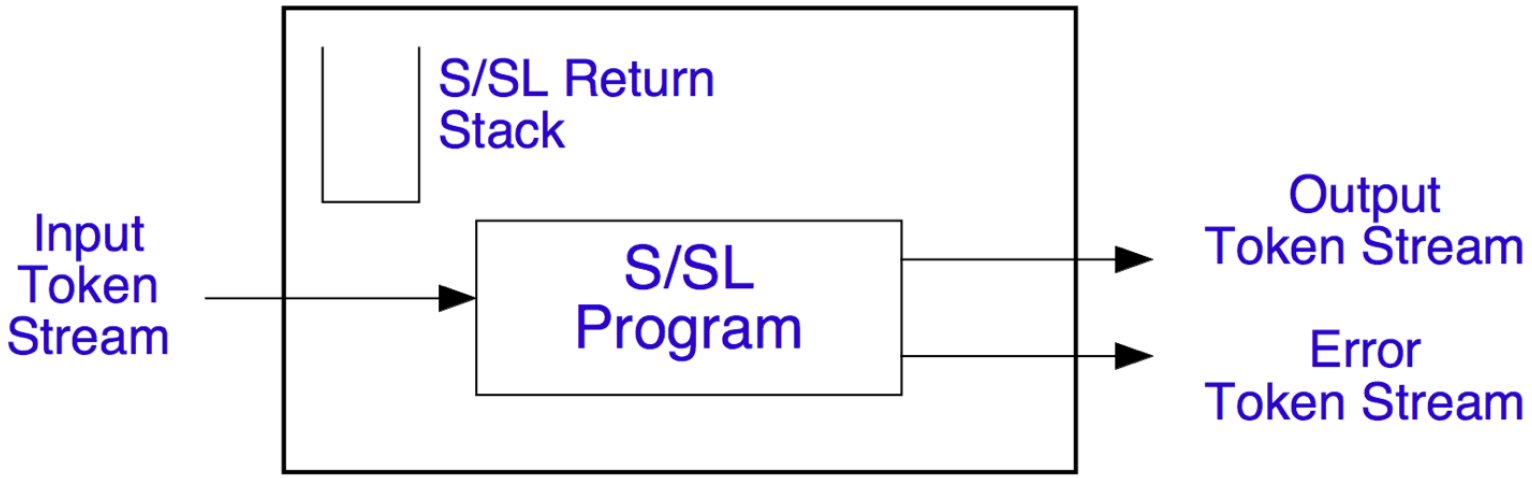
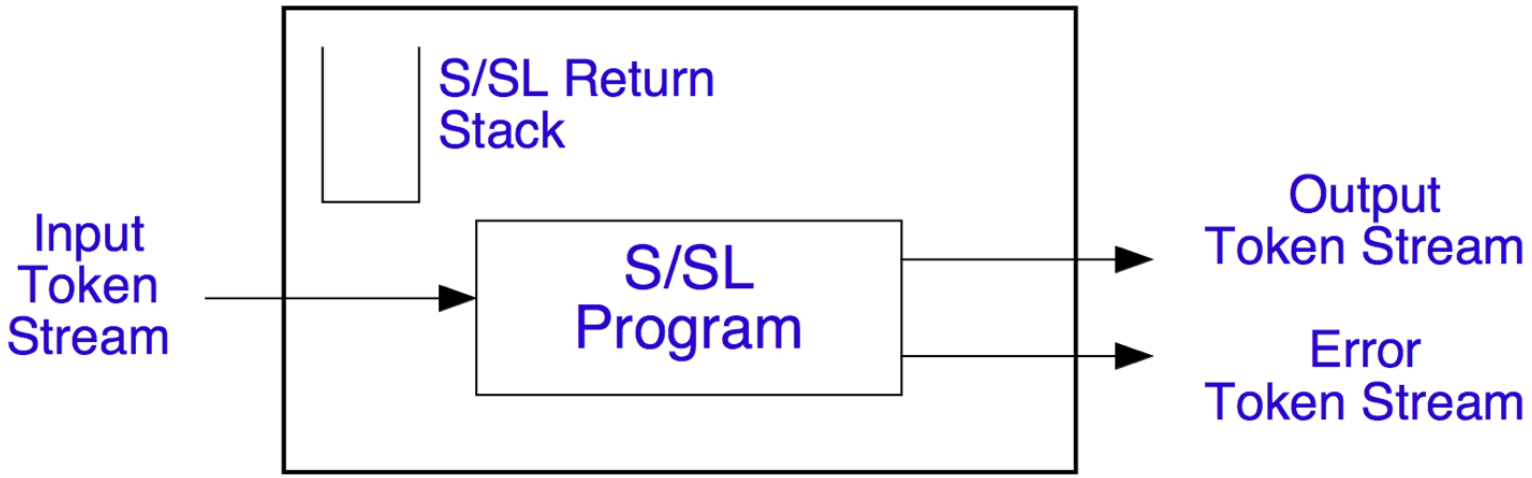
- Mathematically equivalent to a push down transducer



SL - S/SL Without Mechanisms

Syntax Language

- Without semantic mechanisms, SL can only recognize input tokens, push and pop the return stack and generate output and error tokens
- Mathematically equivalent to a push down transducer
- Therefore grammar class: context-free languages



S/SL Syntax

Chicken Scratchings

- S/SL is a very terse language, and looks a lot like "chicken scratchings" (until you get used to it)
- Most statements and operations are represented by single characters such as:

`:`	declaration
`{ }`	loop statement
`>`	loop exit
`[ ]`	case/if statement
`|`	case/if alternative
`@`	call statement
`>>`	return statement

- Comments use the `%` to end-of-line convention, like `//` in Java

```
% This is a comment
```

S/SL Program Structure

Program Structure

- S/SL programs have two main sections: definitions and rules
- Definitions give the names of tokens, types and constants used in the program
- Rules are a set of subprograms defining the actions of the S/SL program
- Execution begins with the first rule
- We will look at rules first, then definitions

S/SL Program Structure

```
% Generic S/SL program
input:
    input token definitions;
output:
    output token definitions;
type Type:
    type constant definitions;
mechanism Mechanism:
    semantic mechanism operation definitions;
rules
FirstRule:
    actions ;
OtherRules:
    actions ;
end
```

S/SL Rules

Rules and Actions

- S/SL "rules" (subprograms) have one of two forms:

```
name :                          % procedure rule
   actions ;

name >> type :                  % "choice" rule (function)
   actions ;
```

- S/SL "actions" correspond to statements in other languages

S/SL Rules

Rule Call and Return

- Rules are called using the action @
- Rules return using the >> action, or by falling off the end of the rule

```
ProcedureDef:
    @ProcedureHeader
    @ProcedureBody;

DoStuff:
    @DoFirstThing
    >>
    @DoOtherThing;

Foo >> SymbolKind:
    @Bar
    >> sVar;

DoNothing:
    ;
```

SL Actions

Actions

- The SL subset of S/SL has 8 actions

Call	@	- call
Return	>>	- return
Input	x	- recognize an input token (implicit)
Emit	.x	- generate an output token
Error	#x	- generate an error token
Cycle	{ }	- repeat a sequence of actions (loop)
Exit	>	- exit a cycle (loop)
Choice	[ ]	- choose between sets of actions (if/case/switch)

SL Input Action

Input in S/SL

- The input action is implicit - there is no action symbol for it
- To require a particular token as input, we just write it as an action
- Means that the next token in the input must be the one named (i.e., we are "expecting" it as the next input token)
- The token may be specified in one of three forms:
  - a symbolic name (e.g. pColonEquals)
  - a string synonym (e.g. ':=', the text of the token in quotes)
  - a wildcard that matches any next input token (?)

```
Assign:
 pIdentifier pColonEquals pInteger pSemicolon;

Assign:
 pIdentifier ':=' pInteger ';' ;
```

- If the next input token does not match, S/SL generates an error and syntax error recovery is invoked

SL Emit Action

Output in S/SL

- The emit (token output) action is indicated using a period character (.) followed by the token to be output
- The specified output token is emitted to the output stream

```
Expr:
    @Term '+' @Term .sAdd;

Term:
    pInt .sIntLit '*' pInt .sIntLit .sMult;
```

- Example:

```
pInt(3) * pInt(5) + pInt(7) * pInt(8)
    →
sIntLit(3) sIntLit(5) sMult sIntLit(7) sIntLit(8)
sMult sAdd
```

- That is:

```
3 * 5 + 7 * 8  →  3 5 * 7 8 * +
```

SL Error Action

Reporting Errors from S/SL

- The error (emit error token) action is indicated using a # followed by the token to be emitted
- Examples:

```
#eMissingSemicolon

#eTypeMismatch
```

- Emits the specified error token to the error output stream

SL Cycle and Cycle Exit Actions

Loops in S/SL

- Cycles specify repetition (looping)

```
{
    actions
}
```

- Actions within the cycle are repeated until the cycle is exited (using an exit action >) or the rule is exited (using a return action >>)
- Cycles may be nested, and the exit action terminates only the innermost cycle containing the exit

```
{
    {
        >          % still an infinite loop
    }
}
```

SL Choice Action

Decisions in S/SL

- The choice action implements conditional flow of control, like an if, case or switch statement in other languages

```
[ selector
  | labels :
      actions
  | labels :
      actions
  ...

  | * :
      actions
]
```

- The optional *selector* can be a choice rule (function) call, or nothing
- If the *selector* is absent, the choice is made on the next input token in the input stream
- If no alternative label matches, S/SL generates an error and syntax error recovery is invoked

SL Actions - An Example

```
AssignOrCall:
   pIdentifier
   @OptionalSubscript
   [
     | ':=':
        @Expression
     |*:
   ] ';' ;

OptionalSubscript:
   [
     | '(':
        @Expression ')'
     |*:
   ];
```

```
Expression:
   [
      | pIdentifier:
         @OptionalSubscript
      | pInteger:
   ];
```

```
A(J) := 1;
B :=1;
```

```
P(6);
X := J(6);
```

```
A(B(C));
```

SL Actions - Another Example

```
SomeRule:
    [@CommaOrParenthesis
      | true:
         actions
      | false:
         actions
    ];

CommaOrParenthesis >> Boolean:
    [
      | ',':
         >> true
      | ')':
         >> false
    ];
```

SL Actions - Another Example

```
SomeRule:
   [@CommaOrParenthesis
     | true:
        actions
     | false:
        actions
   ];

CommaOrParenthesis >> Boolean:
   [
     | ',':
        >> true
     | ')':
        >> false
   ];
```

```
SomeRule:
   [
     | ',':
       actions
     | ')':
       actions
   ];
```

S/SL Definitions

Declarations in S/SL

- Definitions in S/SL play the role of type and constant declarations in other languages
- Specify the names of input, output, and error tokens as well as other user-defined types

```
input:
   pIdentifier
   pInteger
   pPlus              '+'
   pColonEquals       ':='
    ...
   pSemicolon         ';';

output:
   sInteger
   sAdd
    ...
   sSubtract;

error:
   eMissingSemicolon;
```

S/SL Type Definitions

Types in S/SL

- User-defined types are returned by choice rules and used to communicate with semantic mechanisms
- They specify an ordered set of named values, much like an enumerated type ("enum") in C++

```
type Boolean:
   true
   false;

type SymbolKind:
   syVariable
   syConstant
   syType
   syProcedure;
```

Implementation of S/SL Types

Host Language Representation

- The enumerated values are represented in the host language (in our case PT Pascal) as integer constants

S/SL

```
output:
   sInteger
   sAdd
   sSubtract;

type SymbolKind:
   syVariable
   syConstant
   syType
   syProcedure;
```

PT Pascal

```
const
   sInteger = 0;
   sAdd = 1;
   sSubtract = 2;

const
   syVariable = 0;
   syConstant = 1;
   syType = 2;
   syProcedure = 3;
```

Controlling Values of S/SL Types

Host Language Representation

- We can explicitly control the values used to represent tokens by optionally providing a value to be used
- This has no effect on the S/SL program, but constrains the implementation to encode the token using the given value (usually for external reasons)

S/SL

```
input:
   pIdentifier = 7
   pInteger    = 33
   pPlus '+'   = 24;

type number:
   zero = 0
   one = 1
   two = 2
   eight = 8;
```

PT Pascal

```
const
   pIdentifier = 7;
   pInteger = 33;
   pPlus = 24;

const
   zero = 0;
   one = 1;
   two = 2;
   eight = 8;
```

Summary

The S/SL Language

- Syntax based on single character actions
- SL subset equivalent to pushdown transducer (i.e., context-free parser)
- Input, output, cycle, choice, call, return actions used in subprograms called rules
- Only constant values, specified as enumerated types

Next

- Semantic mechanisms, whole S/SL programs, and implementation details