CS419 Compilers Construction

A Simple One-Pass Compiler [Chapter 2]

Lecture 6

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After generating the tokens from the lexial analyser, this stage costruct the parsing tree for the complier to understand the operations

Parsing (Semantic Analyzer)

- **Syntax-directed definition SDD** builds up a translation by attaching attributes to the nodes of the parse-tree.

Extra infomation

- **Syntax-directed translation*** **(SDT)** is a method of translating a string into a sequence of actions by attaching one action to each rule of a grammar.

operation

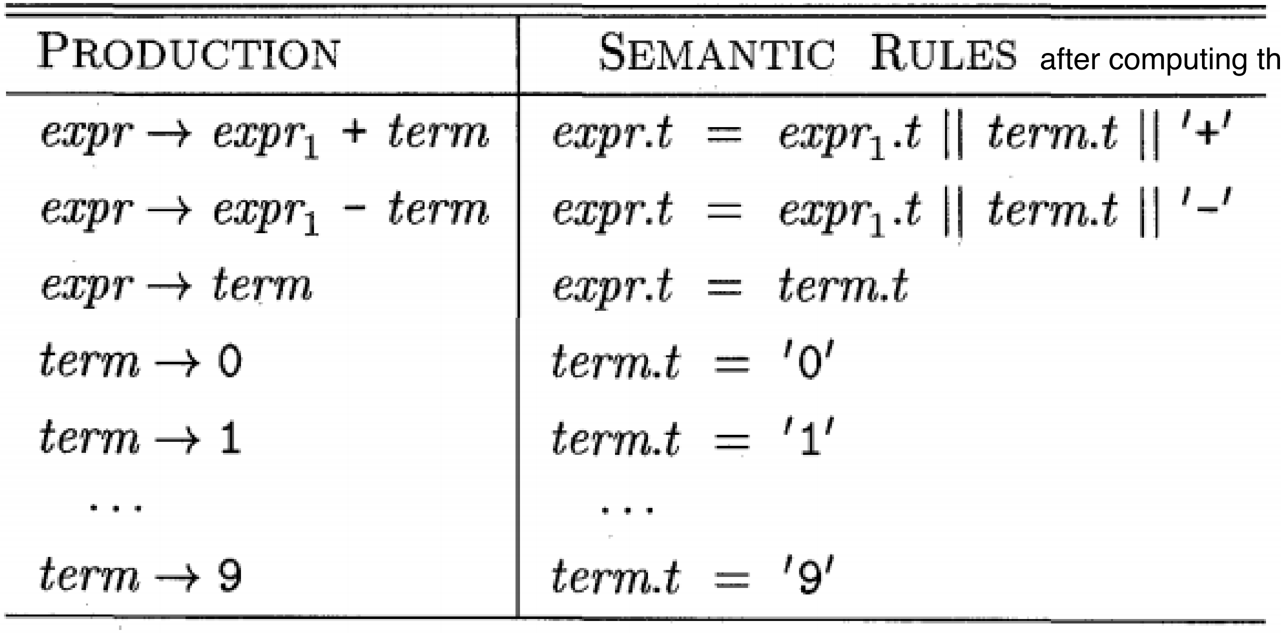
***Wikipedia**

Syntax-Directed Translation

- Associates a set of *attributes* (t) with terminals and non-terminals.
- Associates a set of *semantic rules* with each production to compute attributes’ values.
- The attributes contain the translated form of the input after computations are completed.

Attribute Grammar - Example

- Use the Syntax-directed definition SDD to translate expressions consisting of digits separated by + or – into postfix notation. So that the compiler can understand.
- The attribute t is associated with the non-terminals *expr1* and *term*.
- *expr1.t* denotes the attribute t value of expr1.
- The symbol || is the string concatenation operator.

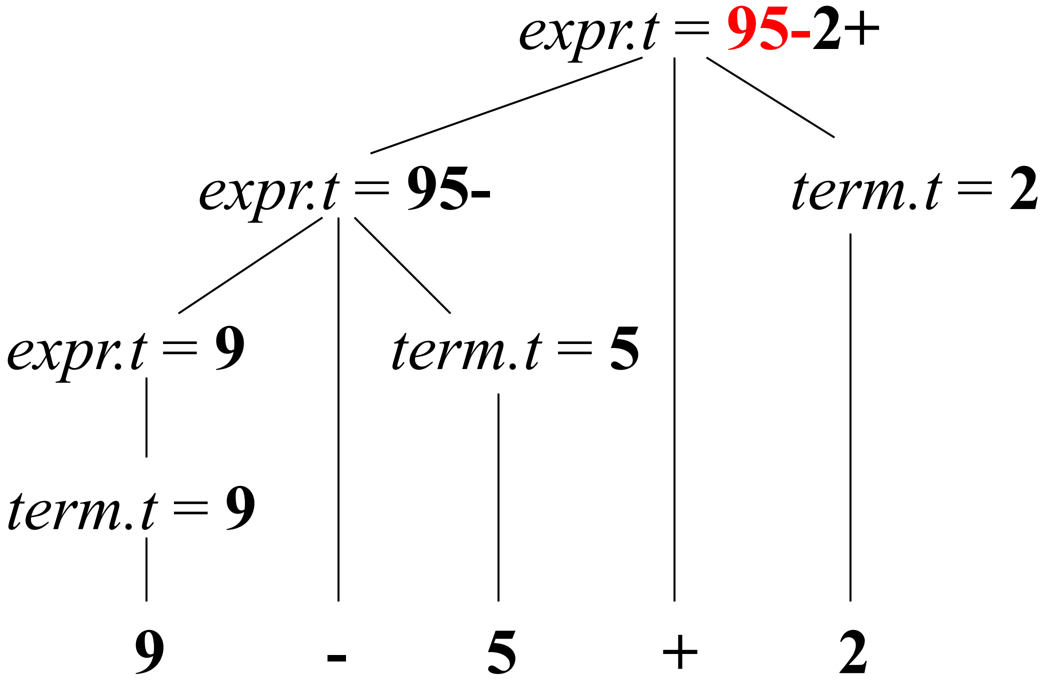


after computing the post fix notation

PRODUCTION	SEMANTIC RULES
$expr \rightarrow expr_1 + term$	$expr.t = expr_1.t \;\|\|\; term.t \;\|\|\; '+'$
$expr \rightarrow expr_1 - term$	$expr.t = expr_1.t \;\|\|\; term.t \;\|\|\; '-'$
$expr \rightarrow term$	$expr.t = term.t$
$term \rightarrow 0$	$term.t = '0'$
$term \rightarrow 1$	$term.t = '1'$
...	...
$term \rightarrow 9$	$term.t = '9'$

Annotated Parse Tree - Example

- **Annotated parse tree:** A parse tree showing the attribute values at each node.
- Example: the annotated parse tree of the expression 9-5+2 is described as follows



Synthesized and Inherited Attributes

الnode القبل اخيره

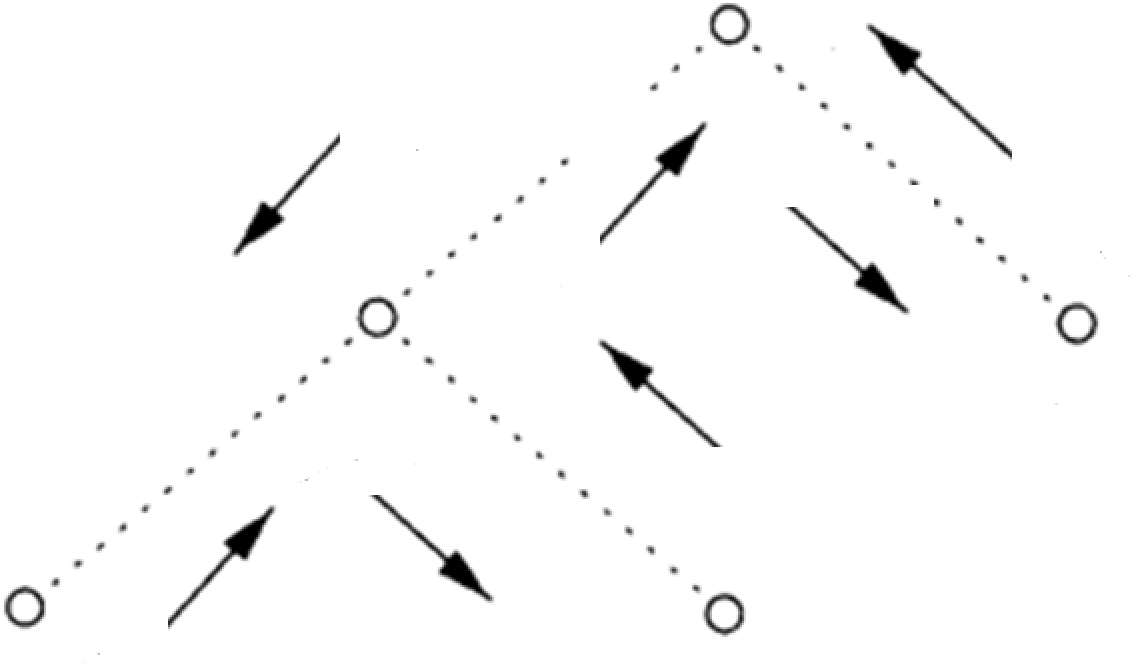
- The *Attribute is synthesized* if its value at a parse-tree node is determined from the attribute values at the children's nodes that can be evaluated during single bottom-up transversal of a parse tree.

- *The Attribute is inherited* if its value at a parse-tree node is determined by the parent (enforcing the parent’s semantic rules). This will be discussed later

Tree Transversal

- A syntax-directed definition does not require any specific order of attributes evaluation on a parse tree.
- Synthesized attributes can be evaluated using any *bottom-up* transversal

Depth-First Traversal Parse-Tree Route

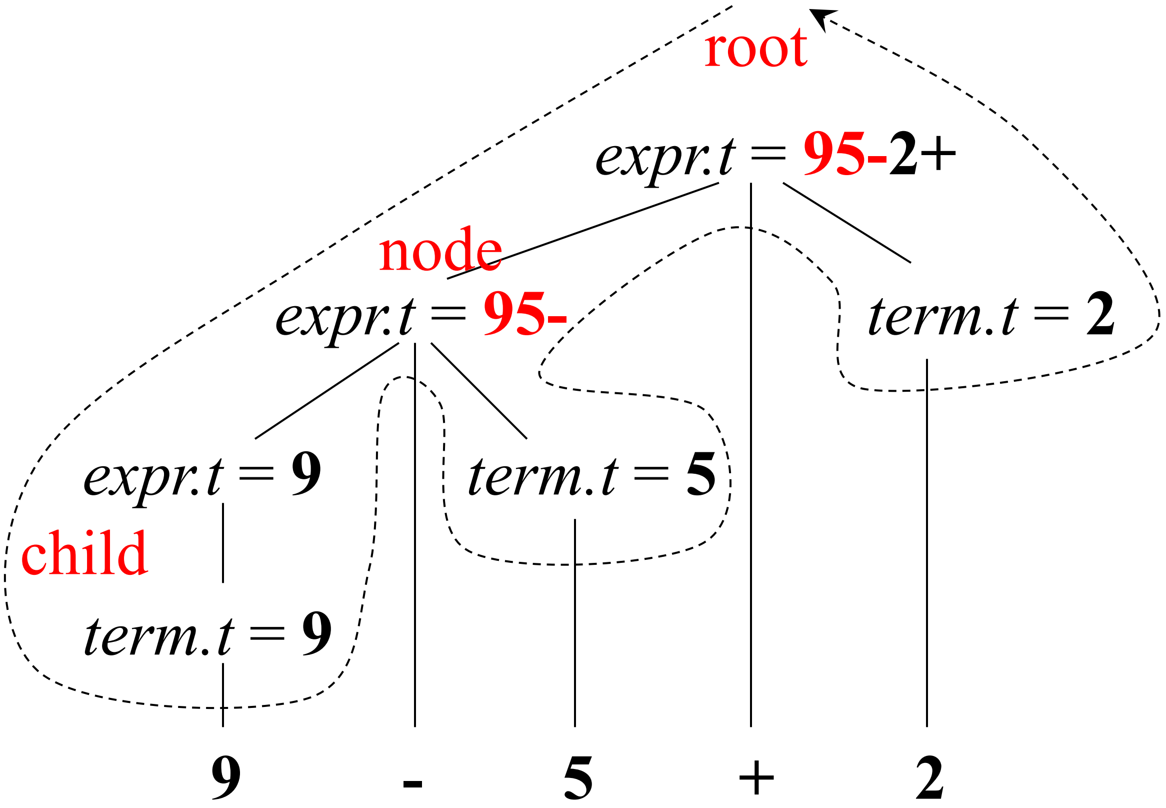


=> Starts from the root and recursively visits the children of each node in any order (here from left to right).

Depth-First Traversal Parse-Tree Pseudocode

```
procedure visit(node N)
{
   for ( each child C of N, from left to right )
      {
         visit( C);
      }
evaluate semantic rules at node N;
}
```

Depth-First Traversal Parse-Tree- Example



Note: all attributes in this example are of the synthesized type.

ما هو اثر الDFS

لازم نعرف شغلتين، اولا احنا بدنا postfix notation و

لازم نعرف انو العمليه الرياضيه تابعه للnode يلي عندها terms

فعندما نعملDPS فاحنا بناخد الterms اول بعدين مناخد الoperation بس نخلص.

Translation Schemes

- A *translation scheme* is a CF grammar embedded with *semantic actions*

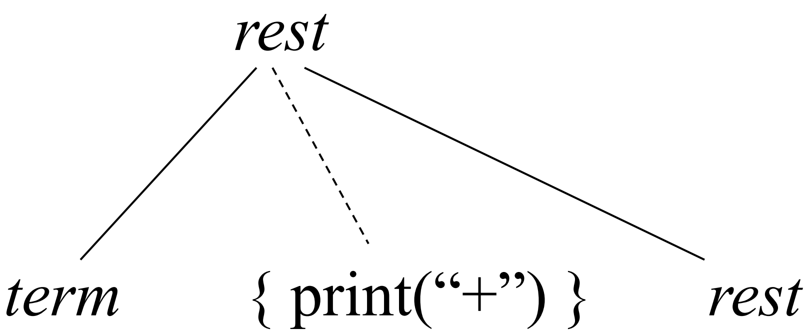
- An alternative way of translation is to use syntax-directed translation scheme that incrementally *attaches program fragments to productions* in a grammar

Attach program fragments to productions - Example

$$\mathit{rest} \rightarrow \mathit{term}\ \underbrace{\{\ \mathrm{print}(“+”)\ \}}_{\text{Embedded semantic action}}\ \mathit{rest}$$

Print is performed without the need to store attributes.

Parse-Tree



Parsing Methods

- Two methods of parsing:
- *Top-down parsing*: "constructs" a parse tree from root to leaves
    - *Recursive Descent Parsing*
    - *Predictive Parsing*
- *Bottom-up parsing*: "constructs" a parse tree from leaves to root

Recursive Descent Parsing

- *Recursive descent parsing* is a top-down parsing method:
  - Every non-terminal has one (recursive) procedure responsible for parsing the non-terminal's syntactic category of input tokens
  - When a non-terminal has multiple productions, each production is implemented in a branch of a selection (if … then …else) statement based on input look-ahead information.

Predictive Parsing

- *Predictive parsing* is a special form of recursive descent parsing where we use one lookahead (current) token to determine the parse operations.

Predictive Parser Grammar – Example

type → *simple*
| **^ id**
| **array [** *simple* **] of** *type*
simple → **integer**
| **char**
| **num dot num**

Predictive Parser - Program Code Example

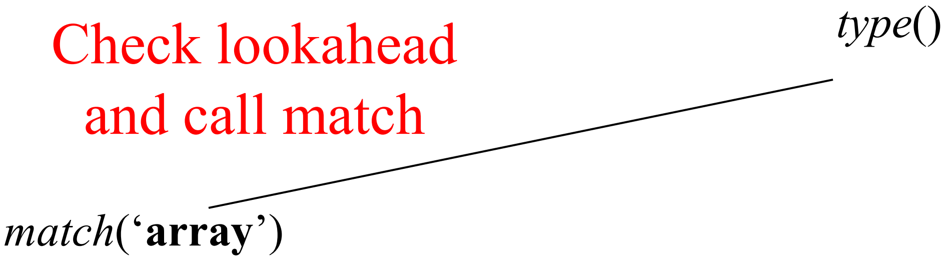
```
procedure type();
begin
    if lookahead in { ‘integer’, ‘char’, ‘num’ } then
        simple()
    else if lookahead = ‘^’ then
        match(‘^’); match(id)
    else if lookahead = ‘array’ then
        match(‘array’); match(‘[‘); simple();
        match(‘]’); match(‘of’); type()
    else error()
end;
```

```
type → simple
        | ^ id
        | array [ simple ] of type
simple → integer
        | char
        | num dot num
```

```
procedure simple();
begin
    if lookahead = ‘integer’ then
        match(‘integer’)
    else if lookahead = ‘char’ then
        match(‘char’)
    else if lookahead = ‘num’ then
        match(‘num’);
        match(‘dot’);
        match(‘num’)
    else error()
end;
```

```
procedure match(t : token);
begin
    if lookahead = t then
        lookahead := nexttoken()
    else error()
end;
```

Predictive Parser Example - Step 1

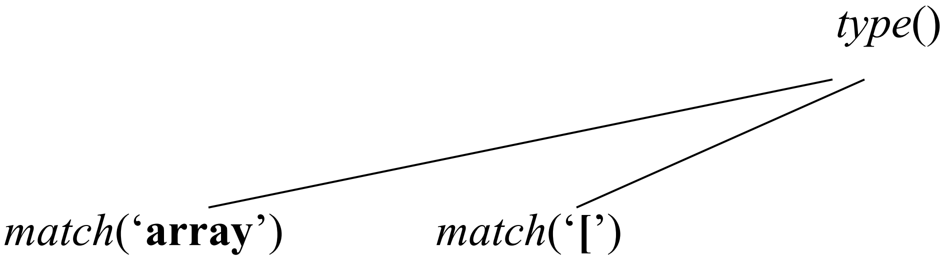


Check lookahead
and call match

<u>Input</u>: **array** **[** **num** **dot** **num** **]** **of** **integer**

↑
lookahead

Predictive Parser Example – Step 2



type()

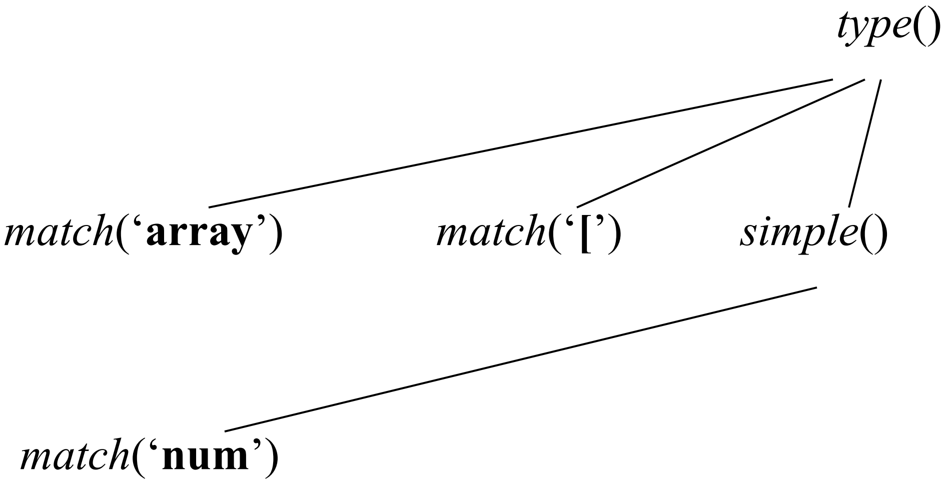
match(‘**array**’) *match*(‘**[**’)

Input: **array** **[** **num** **dot** **num** **]** **of** **integer**

↑

lookahead

Predictive Parser Example – Step 3



type()

match(‘**array**’) *match*(‘[’) *simple*()

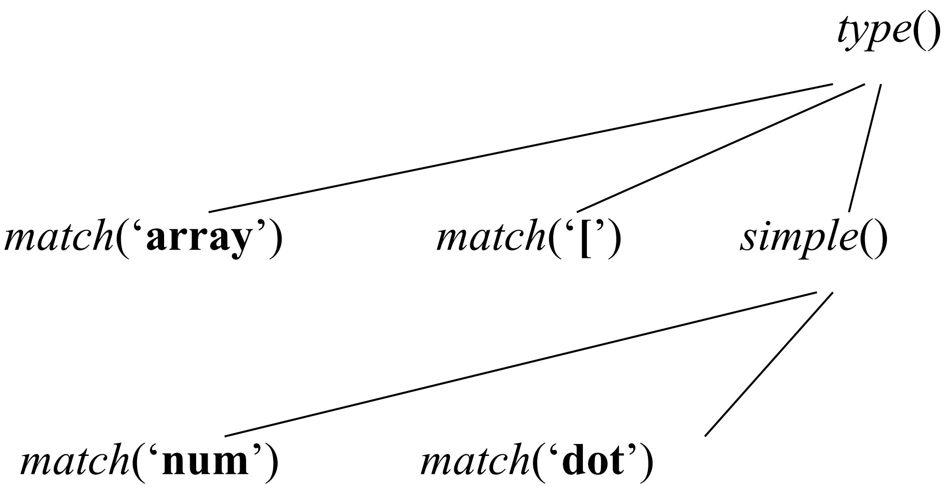
match(‘**num**’)

Input: **array** **[** **num** **dot** **num** **]** **of** **integer**

↑

lookahead

Predictive Parser Example – Step 4



type()

match(‘**array**’) *match*(‘**[**’) *simple*()

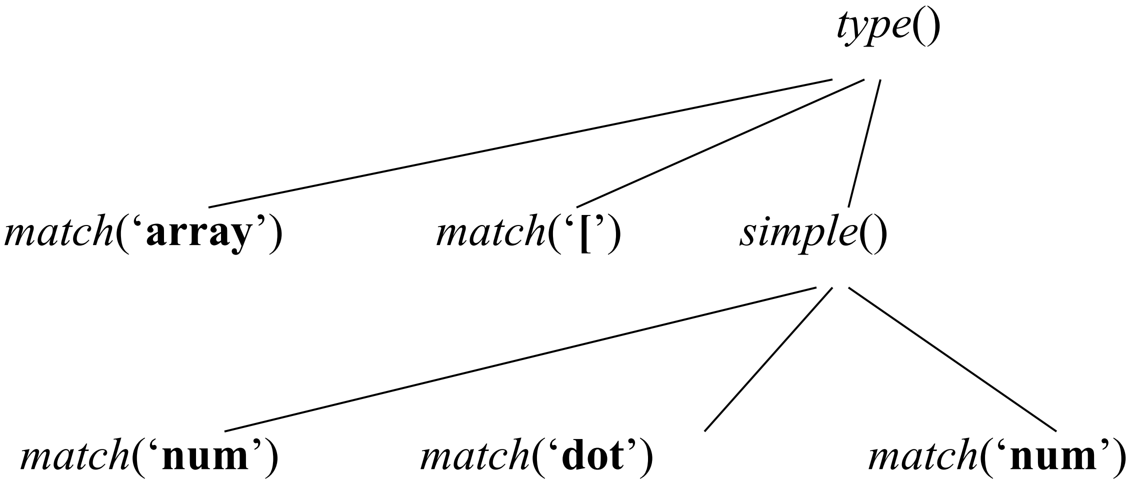
match(‘**num**’) *match*(‘**dot**’)

Input: **array** **[** **num** **dot** **num** **]** **of** **integer**

↑

lookahead

Predictive Parser Example – Step 5



type()

match(‘**array**’) *match*(‘**[**’) *simple*()

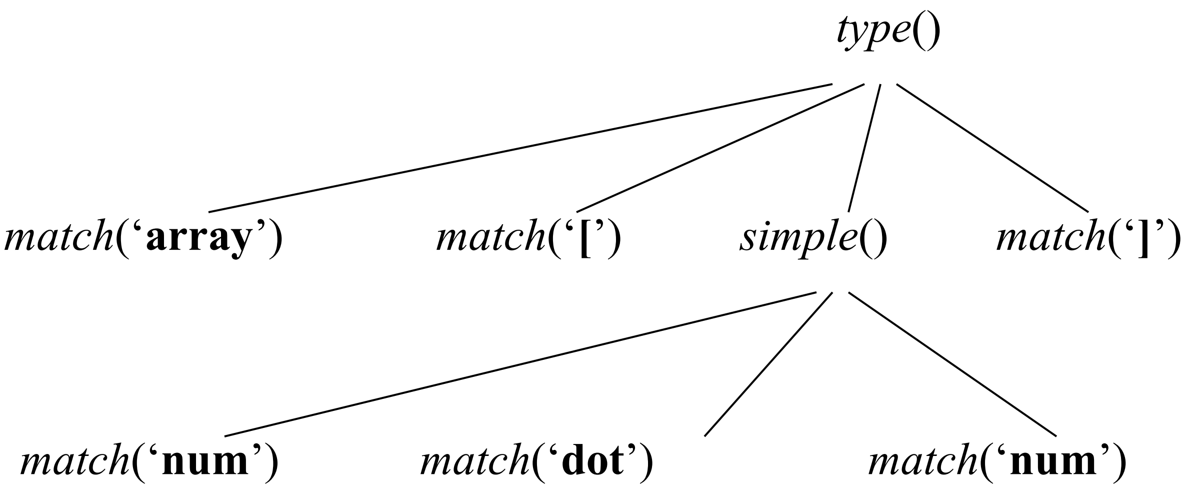
match(‘**num**’) *match*(‘**dot**’) *match*(‘**num**’)

Input: **array** **[** **num** **dot** **num** **]** **of** **integer**

↑

lookahead

Predictive Parser Example – Step 6



type()

match(‘**array**’) *match*(‘**[**’) *simple*() *match*(‘**]**’)

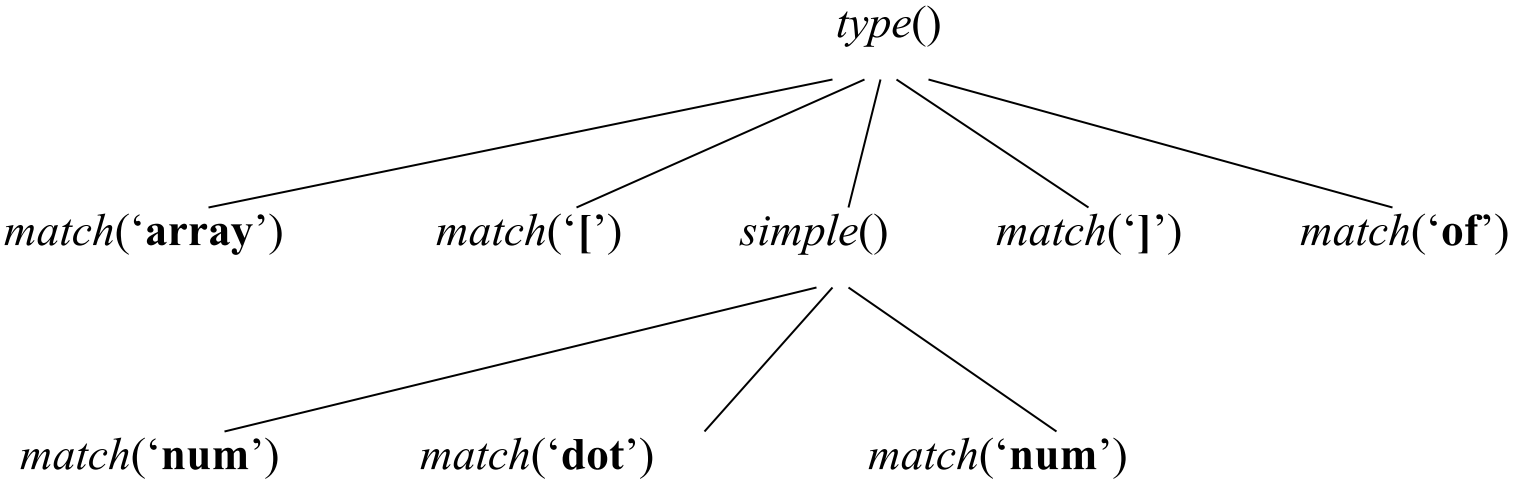
match(‘**num**’) *match*(‘**dot**’) *match*(‘**num**’)

Input: **array** **[** **num** **dot** **num** **]** **of** **integer**

↑

lookahead

Predictive Parser Example – Step 7



type()

match(‘**array**’) *match*(‘**[**’) *simple*() *match*(‘**]**’) *match*(‘**of**’)

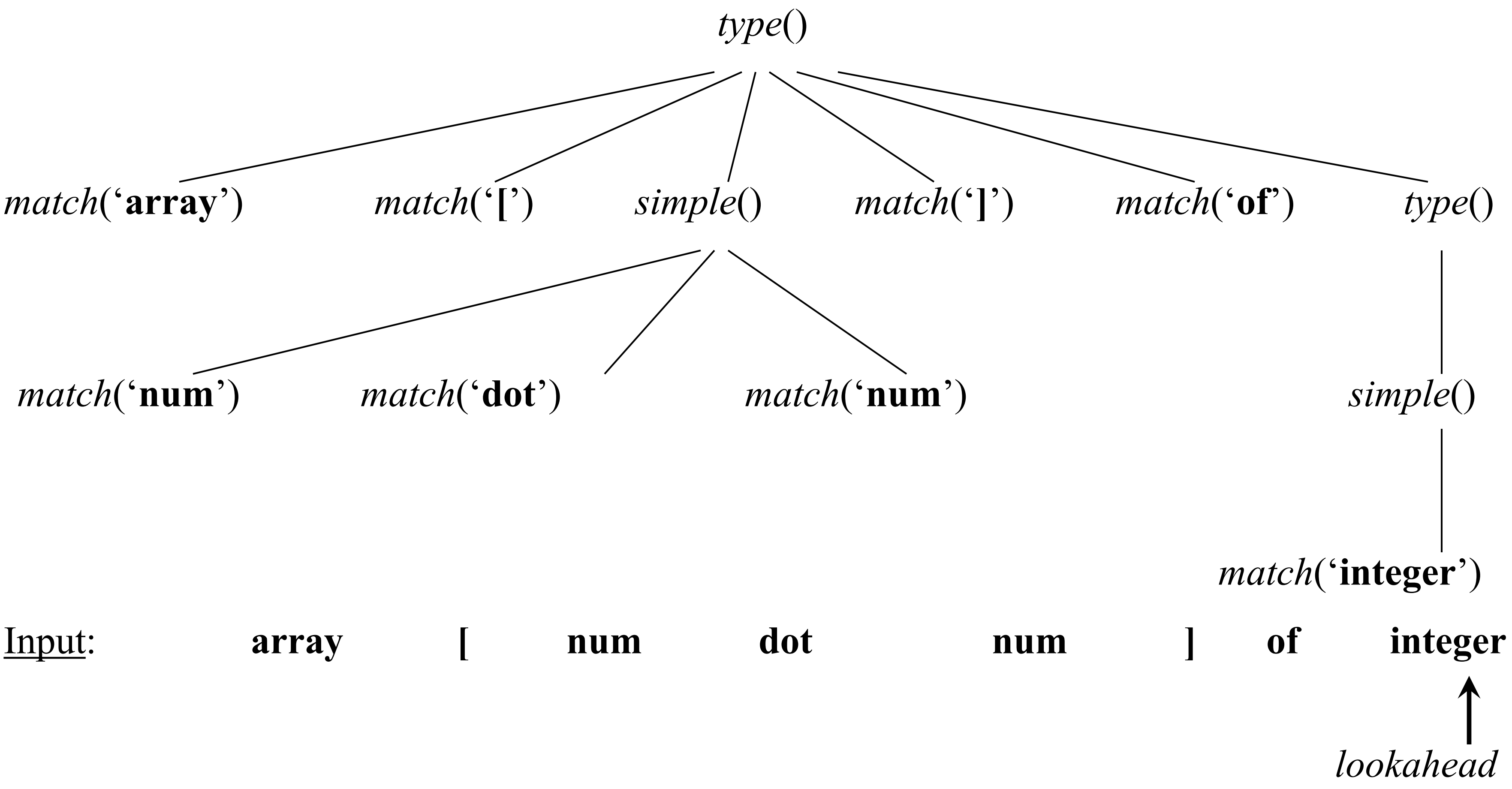
match(‘**num**’) *match*(‘**dot**’) *match*(‘**num**’)

Input: **array [num dot num] of integer**

↑

lookahead

Predictive Parser Example – Step 8



type()

match(‘**array**’) *match*(‘**[**’) *simple*() *match*(‘**]**’) *match*(‘**of**’) *type*()

match(‘**num**’) *match*(‘**dot**’) *match*(‘**num**’) *simple*()

match(‘**integer**’)

<u>Input</u>: **array** **[** **num** **dot** **num** **]** **of** **integer**

lookahead