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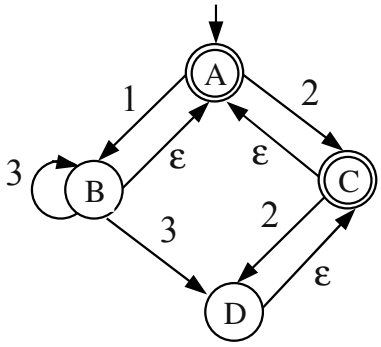
Compilers

Surname, Name	
Curriculum	

1. After generating the DFA equivalent to the following NFA, specify the BNF expressing the regular language relevant to the DFA.



2. Given the following grammar **G** in BNF notation,

$A \rightarrow B$ **a** $C \mid C$
$B \rightarrow C$ **b** $\mid$ **b**
$C \rightarrow A$ **b** $\mid$ **a**

we ask to:

- Transform **G** into a non left-recursive grammar **G'** (equivalent to **G**);
- Generate the complete LL(1) parsing table of **G'**.
- Based on the parsing table, establish whether **G'** is LL(1), providing relevant explanation.

3. After constructing the complete parsing automaton for grammar **G** introduced in point 2, determine whether **G** is SLR(1), providing relevant explanation.

4. Given the following BNF, relevant to a language for logical expressions,

expr $\rightarrow$ *expr* **or** *term* $\mid$ *term*
term $\rightarrow$ *term* **and** *factor* $\mid$ *factor*
factor $\rightarrow$ **not** *expr* $\mid$ **(** *expr* **)** $\mid$ **id** $\mid$ **true** $\mid$ **false**

we ask to codify in *Yacc* the code generator of logical expressions for a P-machine. The P-code shall be generated as strings of characters (`define YYSTYPE *char`). The following auxiliary functions are provided:

- `char* code(char* operator, char* argument)`, generating the string containing the single P-code statement "`operator argument`", where `argument` may be empty;
- `char* concode(char* pcode1, char* pcode2 ...)`, generating the string containing the catenation of two or more strings of code (separated by a newline) "`pcode1 \n pcode2 ...`".

The lexical string relevant to **id** is assumed to be assigned by the lexical analyzer (not to be codified) in the *Yacc* variable `char* lexval`. Operator **and** is evaluated in short circuit, while operator **or** is fully evaluated.

The P-machine includes the following set of instructions:

- `LDC` *const*: load boolean constant *const*;
- `LOD` *var*: load value of boolean variable *var*;
- `AND`: logical conjunction;
- `OR`: logical disjunction;
- `NOT`: logical negation;
- `LAB` *label*: create label;
- `GOF` *label*: conditional (to false) jump;
- `GOT` *label*: unconditional jump.

5. Specify the (extended) attribute grammar relevant to the following BNF,

program → *def-relation* *extend-relation*
def-relation → **relation id (** *id-list* **)**
id-list → **id ,** *id-list* | **id**
extend-relation → **extend id by id** = *expr*
expr → *expr* + *term* | *expr* - *term* | *term*
term → **id** | **num**

```
relation R (a, b, c)
extend R by n = a + c - 25
```

based on the following semantic constraints:

- Attributes are implicitly of integer type;
- Names of attributes are unique,
- The operand of the `extend` is the defined relation,
- The new attribute does not belong to the relation,
- Each identifier within the expression is an attribute of the relation,

and the following requirements:

- The set of semantic attributes is { ok, name },
- A symbol table is used to catalog table attributes by means of the following functions:
  ```
  void insert(attr)
  bool lookup(attr)
  ```
- Function `lookup(name)` returns `true` if the attribute is cataloged, otherwise it returns `false`,
- A possible intermediate semantic error does not terminate the semantic analysis.

6. With reference to the BNF introduced in point 5, assuming that the syntax tree of the phrase is semi-abstract (only irrelevant lexical sugar is removed from the concrete tree) and binary (pointers: `child`, `brother`), we ask first to outline the semi-abstract syntax tree relevant to the example phrase, and then to codify a procedure for P-code generation based on the following requirements:

- Within the syntax tree, each lexical value is stored as a string in field `lexval`;
- The translation scheme of the definition of relation *relname* is composed by a first instruction `NEW` *relname* followed by several instructions `ATTR` *attrname*, one for each attribute *attrname* in the relation, terminated by the instruction `END`;
- The translation scheme of the extension of relation *relname* with new attribute *attrname* is composed by a first instruction `EXT` *relname attrname*, followed by the translation of the attribute-value expression, terminated by the instruction `END`;
- The set of instructions for the P-machine also includes `ADD`, `SUB`, `LDC`, and `LOD`, with the usual meaning.
- The auxiliary function `emit(string ...)` , with one or more string operands, is used to print an instruction of the P-machine.