## Design of concrete grammars

**Objectives**

The concrete grammars for **parsing**

- is parsable - fulfills the **grammar condition** of the chosen parser generator;
- specifies the **intended language** - or a small super set of it;
- is provable related to the **documented grammar**;
- can be **mapped to** a suitable **abstract grammar**.





## Grammar design for an existing language

- Take the grammar of the **language specification literally**.
- Only **conservative modifications** for parsability or for mapping to abstract syntax.
- **Describe any modification**.
  (see ANSI C Specification in the Eli system description
  http://www.uni-paderborn.de/fachbereich/AG/agkastens/eli/examples/eli_cE.html)

  - **Java** language specification (1996):
    Specification grammar is not LALR(1).
    5 problems are described and how to solve them.
  - **Ada** language specification (1983):
    Specification grammar is LALR(1)
    - requirement of the language competition
  - **ANSI C, C++**:
    several ambiguities and LALR(1) conflicts, e.g.
    „**dangling else**“,
    „**typedef problem**“:
    `A (*B);`
    is a declaration of variable **`B`**, if **`A`** is a type name,
    otherwise it is a call of function **`A`**





## Grammar design together with language design

**Read grammars** before writing a new grammar.

Apply **grammar patterns systematically** (cf. GdP-2.5, GdP-2.8)

- repetitions
- optional constructs
- precedence, associativity of operators

**Syntactic structure should reflect semantic structure**:

E. g. a range in the sense of scope rules should be represented by a single subtree of the derivation tree (of the abstract tree).

Violated in Pascal:

functionDeclaration ::= functionHeading block
functionHeading ::= ‘function‘ identifier formalParameters ‘:‘ resultType ‘;‘

formalParameters together with block form a range,
but identifier does not belong to it





## Syntactic restrictions versus semantic conditions

Express a restriction **syntactically** only if
it can be **completely covered with reasonable complexity**:

- **Restriction can not be decided syntactically**:
  e.g. type check in expressions:
  BoolExpression ::= IntExpression ‘<‘ IntExpression
- **Restriction can not always be decided syntactically**:
  e. g. disallow array type to be used as function result
  Type ::= ArrayType | NonArrayType | Identifier
  ResultType ::= NonArrayType
  If a type identifier may specify an array type,
  a semantic condition is needed, anyhow
- **Syntactic restriction is unreasonable complex**:
  e. g. distinction of compile-time expressions from ordinary expressions requires duplication of the expression syntax.

## Reasons of LALR(1) conflicts

Grammar condition does not hold:

| | | |
|---|---|---|
| **context-free** | | |
| **unambiguous** | **ambiguous** | most cases |
| **LR(k)** | **unbounded lookahead** needed | |
| **LR(1)** | **fixed length lookahead > 1** needed | |
| **LALR(1)** | **merge of LR(1) states** introduces **conflicts** | rare cases |

LALR(1) parser generator can not distinguish these cases.





## Eliminate ambiguities

**unite syntactic constructs - distinguish them semantically**

**Examples:**

- Java:
  ClassOrInterfaceType ::= ClassType | InterfaceType
  InterfaceType ::= TypeName
  ClassType ::= TypeName

  replace first production by
  ClassOrInterfaceType ::= TypeName
  semantic analysis distinguishes between class type and interface type

- Pascal:
  factor ::= variable | ... | functionDesignator
  variable ::= entireVariable | ...
  entireVariable ::= variableIdentifier
  variableIdentifier ::= identifier (**)
  functionDesignator ::= functionIdentifier (*)
  | functionIdentifer '(' actualParameters ')'
  functionIdentifier ::= identifier

  eliminate marked (*) alternative
  semantic analysis checks whether (**) is a function identifier





## Unbounded lookahead

The decision for a **reduction** is determined by a **distinguishing token** that may be **arbitrarily far to the right**:

**Example**, forward declarations as could have been defined in Pascal:

functionDeclaration ::=
'function' forwardIdent formalParameters ':' resultType ';' 'forward'

| 'function' functionIdent formalParameters ':' resultType ';' block

The distinction between forwardIdent and functionIdent would require to see the forward or the begin token.

Replace forwardIdent and functionIdent by the same nonterminal; distinguish semantically.



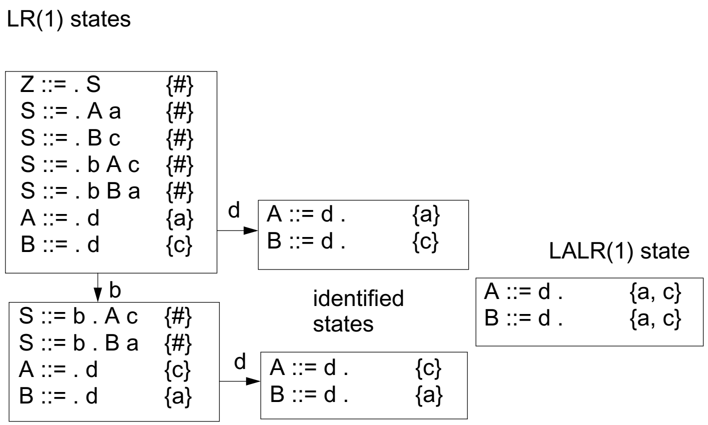


## LR(1) but not LALR(1)

**Identification of LR(1) states** causes non-disjoint right-context sets.

Artificial example:

Grammar:
Z ::= S
S ::= A a
S ::= B c
S ::= b A c
S ::= b B a
A ::= d.
B ::= d.




Avoid the distinction between A and B - at least in one of the contexts.