

## CD23 Programming Language LL(1) Grammar

NPROG        <program> ::= CD23 <id> <global> <funcs> <mainbody>

NGLOB        <globals> ::= <consts> <types> <arrays>

Special       <consts> ::= constants <initlist> | ε

NILIST        <initlist> ::= <init> <opt\_initlist>

Special       <opt\_initlist> ::= , <initlist> | ε

We applied left factoring to this rule because it wasn't LL(1)

NINIT        <init> ::= <id> is <expr>

Special       <types> ::= types <typelist> | ε

Special       <arrays> ::= arrays <arrdecls> | ε

NFUNCS       <funcs> ::= <func> <funcs> | ε

NMAIN        <mainbody> ::= main <slist> begin <stats> end CD23 <id>

NSDLST       <slist> ::= <sdecl> <opt\_slist>

Special       <opt\_slist> ::= , <slist> | ε

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NYPEL        <typelist> ::= <type> <opt\_typelist>

Special       <opt\_typelist> ::= <typelist> | ε

NRTYPE       <type> ::= <structed> is <fields> end

NATYPE       <type> ::= <typeid> is array [<expr>] of <structid> end

NFLIST        <fields> ::= <sdecl> <opt\_fields>

Special       <opt\_fields> ::= , <fields> | ε

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NSDECL       <sdecl> ::= <id> : <type>

NALIST        <arrdecls> ::= <arrdecl> <opt\_arrdecl>

Special       <opt\_arrdecl> ::= , <arrdecls> | ε

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NARRD        <arrdecl> ::= <id> : <typeid>

NFUND        <func> ::= func <id> (<plist>):<rtype> <funcbody>

Special       <rtype> ::= <stype> | void

Special       <plist> ::= <params> | ε

NPLIST        <params> ::= <param> <opt\_params>

Special       <opt\_params> ::= , <params> | ε

NSIMP        <param> ::= <sdecl>

NARRP        <param> ::= <arrdecl>

NARRC       $\langle \text{param} \rangle ::= \text{const } \langle \text{arrdecl} \rangle$

Special       $\langle \text{funcbody} \rangle ::= \langle \text{locals} \rangle \text{ begin } \langle \text{stats} \rangle \text{ end}$

Special       $\langle \text{locals} \rangle ::= \langle \text{dlist} \rangle \mid \epsilon$

NDLIST       $\langle \text{dlist} \rangle ::= \langle \text{decl} \rangle \langle \text{opt\_dlist} \rangle$

Special       $\langle \text{opt\_dlist} \rangle ::= , \langle \text{dlist} \rangle \mid \epsilon$

Special       $\langle \text{decl} \rangle ::= \langle \text{sdecl} \rangle \mid \langle \text{arrdecl} \rangle$

Special       $\langle \text{stype} \rangle ::= \text{integer} \mid \text{real} \mid \text{Boolean}$

NSTATS       $\langle \text{stats} \rangle ::= \langle \text{stat} \rangle ; \langle \text{opt\_stats} \rangle \mid \langle \text{strstat} \rangle \langle \text{opt\_stats} \rangle$

Special       $\langle \text{opt\_stats} \rangle ::= \langle \text{stats} \rangle \mid \epsilon$

Special       $\langle \text{strstat} \rangle ::= \langle \text{forstat} \rangle \mid \langle \text{ifstat} \rangle$

Special       $\langle \text{stat} \rangle ::= \langle \text{reptstat} \rangle \mid \langle \text{asgnstat} \rangle \mid \langle \text{iostat} \rangle$

Special       $\langle \text{stat} \rangle ::= \langle \text{callstat} \rangle \mid \langle \text{returnstat} \rangle$

NFORL       $\langle \text{forstat} \rangle ::= \text{for } (\langle \text{asgnlist} \rangle ; \langle \text{bool} \rangle) \langle \text{stats} \rangle \text{ end}$

NREPT       $\langle \text{reptstat} \rangle ::= \text{repeat } (\langle \text{asgnlist} \rangle) \langle \text{stats} \rangle \text{ until } \langle \text{bool} \rangle$

Special       $\langle \text{asgnlist} \rangle ::= \langle \text{alist} \rangle \mid \epsilon$

NASGNS       $\langle \text{alist} \rangle ::= \langle \text{asgnstat} \rangle \langle \text{opt\_alist} \rangle$

Special       $\langle \text{opt\_alist} \rangle ::= , \langle \text{alist} \rangle \mid \epsilon$

NIFTH       $\langle \text{ifstat} \rangle ::= \text{if } (\langle \text{bool} \rangle) \langle \text{stats} \rangle \langle \text{opt\_else} \rangle \text{ end}$

NIFTE       $\langle \text{opt\_else} \rangle ::= \text{else } \langle \text{stats} \rangle \mid \epsilon$

Special       $\langle \text{asgnstat} \rangle ::= \langle \text{var} \rangle \langle \text{asgnop} \rangle \langle \text{bool} \rangle$

NASGN       $\langle \text{asgnop} \rangle ::= =$

NPLEQ       $\langle \text{asgnop} \rangle ::= +=$

NMNEQ       $\langle \text{asgnop} \rangle ::= -=$

NSTEQ       $\langle \text{asgnop} \rangle ::= *=$

NDVEQ       $\langle \text{asgnop} \rangle ::= /=$

NINPUT       $\langle \text{iostat} \rangle ::= \text{In } \gg \langle \text{vlist} \rangle$

NOUTP       $\langle \text{iostat} \rangle ::= \text{Out } \ll \langle \text{prlist} \rangle \langle \text{opt\_line} \rangle$

Special       $\langle \text{opt\_line} \rangle ::= \epsilon$

NOUTL       $\langle \text{opt\_line} \rangle ::= \ll \text{Line}$

NOUTL       $\langle \text{iostat} \rangle ::= \text{Out } \ll \text{Line}$

NCALL       $\langle \text{callstat} \rangle ::= \langle \text{id} \rangle (\langle \text{elist} \rangle) \mid \langle \text{id} \rangle ()$

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Note that if  $\langle \text{opt\_line} \rangle$  is  $\ll \text{Line}$ , the node is NOUTL, not NOUTP

NRETN      <returnstat> ::= return void | return <expr>

NVLIST      <vlist> ::= <var> <opt\_vlist>

Special      <opt\_vlist> ::= , <vlist> | ε

We applied left factoring to NVLIST because it wasn't LL(1)

NSIMV      <var> ::= <id> <opt\_expr>

Special      <opt\_expr> ::= ε

NAELT      <opt\_expr> ::= [<expr>] <opt\_id>

Special      <opt\_id> ::= ε

NARRV      <opt\_id> ::= . <id>

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NEXPL      <elist> ::= <bool> <opt\_elist>

Special      <opt\_elist> ::= , <elist> | ε

We applied left factoring to NEXPL because it wasn't LL(1)

NBOOL      <bool> ::= <logop> <rel> <bool'> | ε

Special      <bool> ::= <rel> <bool'>

We changed NBOOL because it was left recursive

NNOT      <rel> ::= ! <expr> <relop> <expr>

Special      <rel> ::= <expr> <opt\_rel>

Special      <opt\_rel> ::= <relop> <expr> | ε

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NAND      <logop> ::= &&

NOR      <logop> ::= ||

NXOR      <logop> ::= &|

NEQL      <relop> ::= ==

NNEQ      <relop> ::= !=

NGRT      <relop> ::= >

NLSS      <relop> ::= <

NLEQ      <relop> ::= <=

NGEQ      <relop> ::= >=

Special      <expr> ::= <term> <expr'>

NADD      <expr'> ::= +<term> <expr'>

NSUB      <expr'> ::= - <term> <expr'>

Special      <expr'> ::= ε

Special      <expr> ::= <term>

Special      <term> ::= <fact> <term'>

NMUL      <term'> ::= \*<fact> <term'>

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NDIV  $\langle \text{term}' \rangle ::= / \langle \text{fact} \rangle \langle \text{term}' \rangle$

NMOD  $\langle \text{term}' \rangle ::= \% \langle \text{fact} \rangle \langle \text{term}' \rangle$

Special  $\langle \text{term}' \rangle ::= \epsilon$

Special  $\langle \text{term} \rangle ::= \langle \text{fact} \rangle$

Special  $\langle \text{fact} \rangle ::= \langle \text{exponent} \rangle \langle \text{fact}' \rangle$

NPOW  $\langle \text{fact}' \rangle ::= \wedge \langle \text{exponent} \rangle \langle \text{fact}' \rangle \mid \epsilon$

Special  $\langle \text{fact} \rangle ::= \langle \text{exponent} \rangle$

Special  $\langle \text{exponent} \rangle ::= \langle \text{var} \rangle$

NILIT  $\langle \text{exponent} \rangle ::= \langle \text{intlitt} \rangle$

NFLIT  $\langle \text{exponent} \rangle ::= \langle \text{reallitt} \rangle$

Special  $\langle \text{exponent} \rangle ::= \langle \text{fncall} \rangle$

NTRUE  $\langle \text{exponent} \rangle ::= \text{true}$

NFALS  $\langle \text{exponent} \rangle ::= \text{false}$

Special  $\langle \text{exponent} \rangle ::= (\langle \text{bool} \rangle)$

NFCALL  $\langle \text{fncall} \rangle ::= \langle \text{id} \rangle (\langle \text{elist} \rangle) \mid \langle \text{id} \rangle ()$

NPRLST  $\langle \text{prlist} \rangle ::= \langle \text{printitem} \rangle \langle \text{opt\_prlist} \rangle$

Special  $\langle \text{opt\_prlist} \rangle ::= , \langle \text{prlist} \rangle \mid \epsilon$

Special  $\langle \text{printitem} \rangle ::= \langle \text{expr} \rangle$

NSTRG  $\langle \text{printitem} \rangle ::= \langle \text{string} \rangle$

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