Lecture 16 - July 8

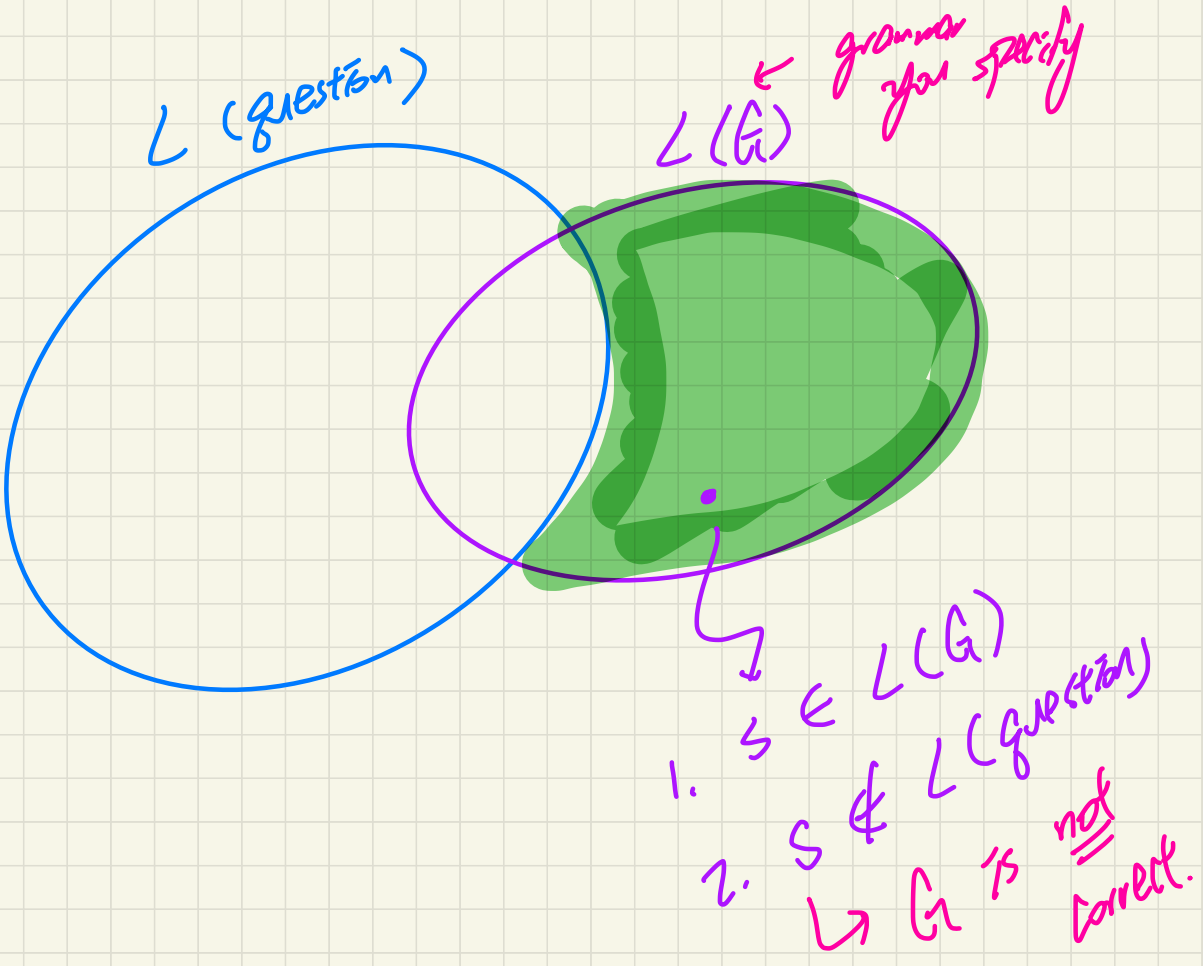
Syntactic Analysis

Comparing Two Versions of CFGs
Witness String of CFG Ambiguity
RE to CFG, DFA to CFG

Announcements/Reminders

- ProgTest result released
- Makeup lecture released
- Project Milestone ~~2~~ 1 released
  - ↳ Wed 6pm
  - ↳ Thu. midnight

Written test
↳ to be confirmed
guide by Thursday's class.


L (question)
L(G)
← grammar you specify
1. $s \in L(G)$
2. $s \notin L(\text{question})$
↳ G is not correct.

Discussion: Compare Two CFGs

Expression	→	*IntegerConstant*
	|	*BooleanConstant*
	|	*BinaryOp*
	|	*UnaryOp*
	|	(*Expression*)
IntegerConstant	→	*Digit*
	|	*Digit IntegerConstant*
	|	-*IntegerConstant*
Digit	→	0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
BooleanConstant	→	`TRUE`
	|	`FALSE`

mix diff. semantic ops. under the same variable

v1

BinaryOp	→	*Expression* + *Expression*
	|	*Expression* − *Expression*
	|	*Expression* ⋆ *Expression*
	|	*Expression* / *Expression*
	|	*Expression* && *Expression*
	|	*Expression* || *Expression*
	|	*Expression* => *Expression*
	|	*Expression* == *Expression*
	|	*Expression* /= *Expression*
	|	*Expression* > *Expression*
	|	*Expression* < *Expression*
UnaryOp	→	! *Expression*

separate of diff. categories of semantic ops. to diff. variables

v2

ArithmeticOp	→	*ArithmeticOp* + *ArithmeticOp*
	|	*ArithmeticOp* − *ArithmeticOp*
	|	*ArithmeticOp* ⋆ *ArithmeticOp*
	|	*ArithmeticOp* / *ArithmeticOp*
	|	(*ArithmeticOp*)
	|	*IntegerConstant*
RelationalOp	→	*ArithmeticOp* == *ArithmeticOp*
	|	*ArithmeticOp* /= *ArithmeticOp*
	|	*ArithmeticOp* > *ArithmeticOp*
	|	*ArithmeticOp* < *ArithmeticOp*
LogicalOp	→	*LogicalOp* && *LogicalOp*
	|	*LogicalOp* || *LogicalOp*
	|	*LogicalOp* => *LogicalOp*
	|	! *LogicalOp*
	|	(*LogicalOp*)
	|	*RelationalOp*
	|	*BooleanConstant*

Context-Free Grammar (CFG): Example Version 1

Expression	→	*IntegerConstant*
	|	*BooleanConstant*
	|	*BinaryOp*
	|	*UnaryOp*
	|	(*Expression*)
IntegerConstant	→	*Digit*
	|	*Digit IntegerConstant*
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Digit	→	0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
BooleanConstant	→	TRUE
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BinaryOp	→	*Expression* + *Expression*
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	|	*Expression* && *Expression*
	|	*Expression* || *Expression*
	|	*Expression* => *Expression*
	|	*Expression* == *Expression*
	|	*Expression* /= *Expression*
	|	*Expression* > *Expression*
	|	*Expression* < *Expression*
UnaryOp	→	! *Expression*

Example: (1 + 2) => (5 / 4)

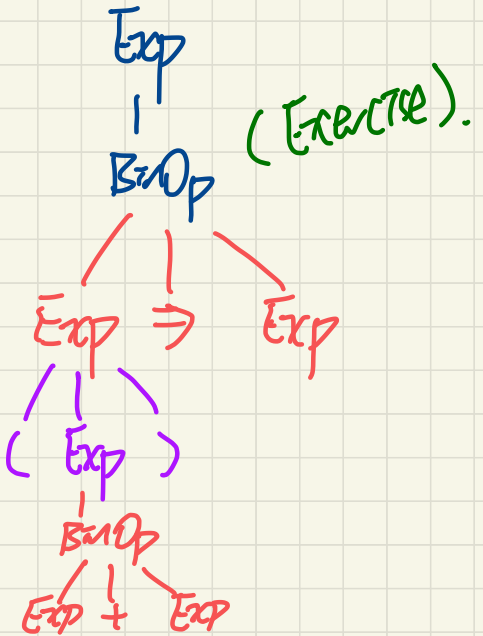
Int Int

has a PT, meaning syntactically/grammatically correct

Pros: single variable for all possible ops.

Cons: allows expressions that are not type-correct

some checking by model classes expected.



Context-Free Grammar (CFG): Example Version 1

Expression	→	*IntegerConstant*
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	|	*BinaryOp*
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BooleanConstant	→	`TRUE`
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BinaryOp	→	*Expression* + *Expression*
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	|	*Expression* > *Expression*
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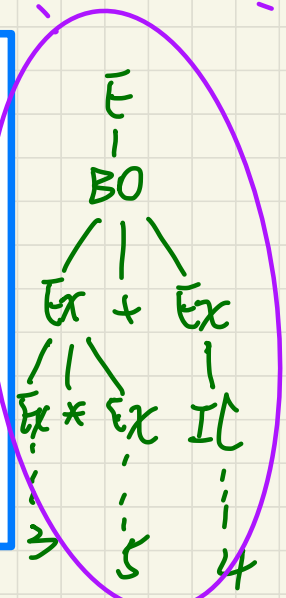
UnaryOp	→	! *Expression*

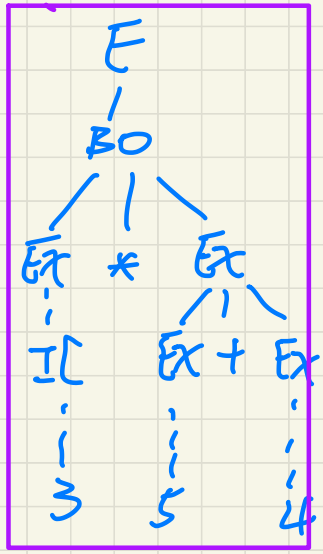
Example: 3 * 5 + 4

↳ Interpretations : ① (3 * 5) + 4 — Exp + Exp rule used first

② 3 * (5 + 4) — Exp * Exp rule used first

having two distinct PTs for the same string ⇒ grammar is ambiguous





To show that a grammar is ambiguous, give a witness string s.t. more than one PTs.

Q.

Expression	→	*IntegerConstant*
	|	*BooleanConstant*
	|	*BinaryOp*
	|	*UnaryOp*
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	|	*Expression* > *Expression*
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UnaryOp	→	! *Expression*

(T) 1. Grammar is ambiguous and can be proved using "3 + 5 * 4".

(F) 2. Grammar is ambiguous and (T) can be proved using "(3 + 5) * 4"

↳ false :(it has a unique PT!

Context-Free Grammar (CFG): Example Version 2

Expression	→	*ArithmeticOp*
	|	*RelationalOp*
	|	*LogicalOp*
	|	(*Expression*)
IntegerConstant	→	*Digit*
	|	*Digit IntegerConstant*
	|	*−IntegerConstant*
Digit	→	0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
BooleanConstant	→	`TRUE`
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ArithmeticOp	→	*ArithmeticOp* + *ArithmeticOp*
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	|	*ArithmeticOp* / *ArithmeticOp*
	|	(*ArithmeticOp*)
	|	*IntegerConstant*
RelationalOp	→	*ArithmeticOp* == *ArithmeticOp*
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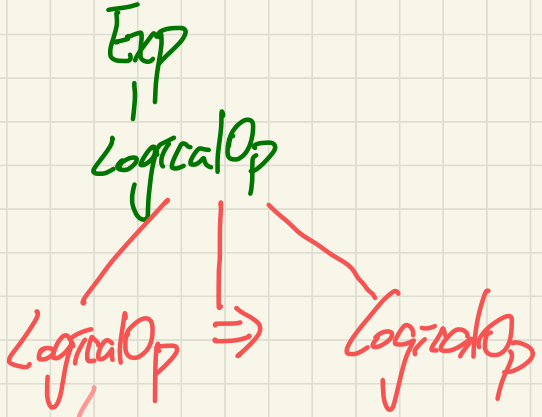
LogicalOp	→	*LogicalOp* && *LogicalOp*
	|	*LogicalOp* || *LogicalOp*
	|	*LogicalOp* => *LogicalOp*
	|	! *LogicalOp*
	|	(*LogicalOp*)
	|	*RelationalOp*
	|	*BooleanConstant*

Example: (1 + 2) => (5 / 4)

Is this syntactically correct? No.

Pros.
- expressions not type-correct rejected at the parsing level

Cons.
- to perform semantic on the input → need to be done in the non-model classes.



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	|	(*LogicalOp*)
	|	*RelationalOp*
	|	*BooleanConstant*

Q: No semantic analysis at all for Version 2 grammar?

Example: (1 + 2) => (5 - (2 + 3))

Context-Free Grammar (CFG): Example Version 2

Example: 3 * 5 + 4

also ambiguous (Exercise)

Expression	→	*ArithmeticOp*
	|	*RelationalOp*
	|	*LogicalOp*
	|	(*Expression*)
IntegerConstant	→	*Digit*
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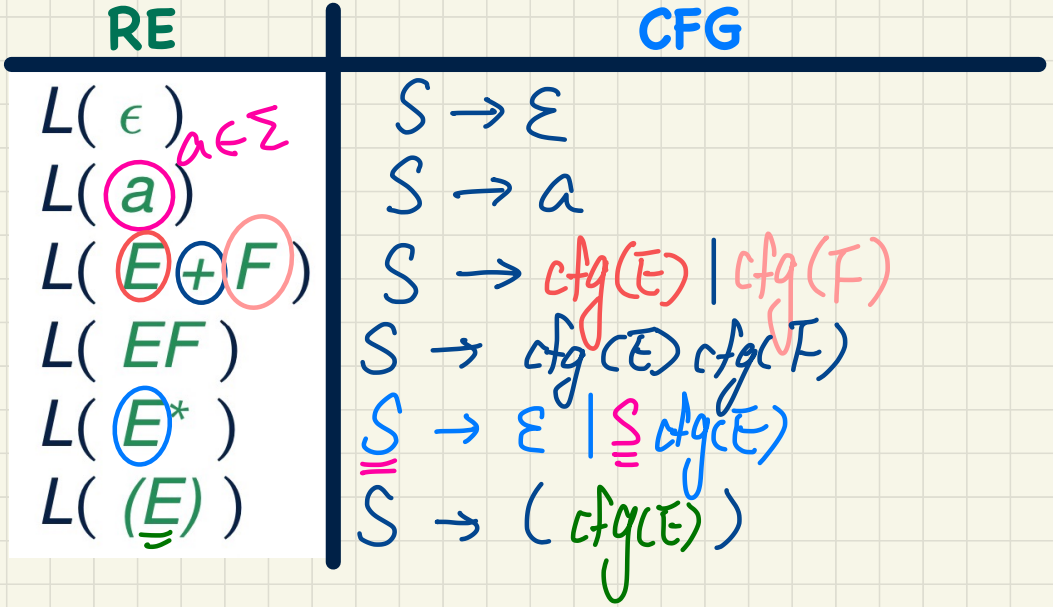
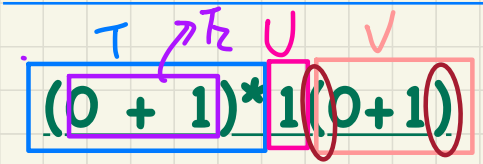
	|	(*LogicalOp*)
	|	*RelationalOp*
	|	*BooleanConstant*

Context-Free Grammar (CFG): from RE (1)



Context-Free Grammar (CFG): from RE (2)



$S \to T\,U\,V$

$T \to \varepsilon \mid T\,T_2$

$T_2 \to 0 \mid 1$

$U \to 1$

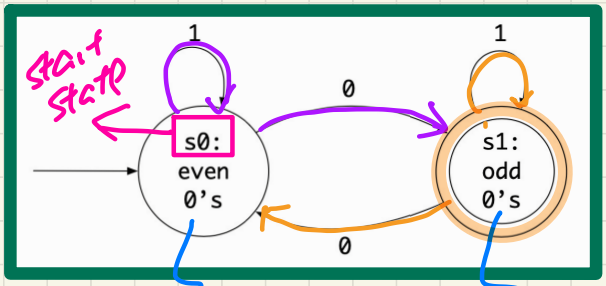
$V \to 0 \mid 1$

$\notin \Sigma = \{0, 1\}$

Exercise

$(00 + 1)^* + (11 + 0)^*$

Context-Free Grammar (CFG): from DFA (Exercise)



S_0 S_1

start var.

$S_0 \rightarrow 0S_1 \mid 1S_0$

$S_1 \rightarrow 1S_1 \mid 0S_0 \mid \varepsilon$

base case of derivation.