Lecture 10

Syntax Analysis

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Take aways from the last class

- Example of Shift-Reduce parsing

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- Issuses in bottom-up parsing

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- Handle

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- Conflicts

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- Conflicts
- Configuration of LR parser

Parser states

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- Summarize all possible stack prefixes α as a parser state
- Parser state is defined by a DFA state that reads in the stack α
- Accept states of DFA are unique reductions

Constructing parse table

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- Viable prefixes

There are two reasons for augmenting the grammar -
1. it ensures that there is only one accept state in DFA.
2. Input is terminated by $. Let S -> ab | bc | ca.
Then all the three will be modified as ab$, bc$, ca$,
which involves modification of the grammar.
To avoid it, we add another production S' -> S

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    - ★ $\alpha.w$ is a configuration of the shift reduce parser
  - As long as the parser has viable prefixes on the stack no parser error has been seen
  - The set of viable prefixes is a regular language
  - Construct an automaton that accepts viable prefixes

that's why, we are able to
represent parser using FSM only.

LR(0) items

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- An item indicates how much of a production has been seen at a point in the process of parsing
  - Symbols on the left of "." are already on the stacks
  - Symbols on the right of "." are expected in the input

Start State

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  - Added items have "." located at the beginning

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- Closure of a state adds items for all productions whose LHS occurs in an item in the state, just after "."
  - Set of possible productions to be reduced next
  - Added items have "." located at the beginning
  - No symbol of these items is on the stack as yet

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- Intuitively $A \rightarrow \alpha.B\beta$ indicates that we might see a string derivable from $B\beta$ as input
- If input $B \rightarrow \gamma$ is a production then we might see a string derivable from γ at this point

Example

- Consider the grammar
  $E' \to E$
  $E \to E + T | T$
  $T \to T * F | F$
  $F \to (E) | id$

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- I_4 : $goto(I_0, ()$

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  $T \rightarrow F.$
- $I_4 : goto(I_0, ()$
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  $F \rightarrow .(E)$
  $F \rightarrow .id$
- I_1 : $goto(I_0, E)$
  $E \rightarrow E.$
  $E \rightarrow E. + T$
- I_2 : $goto(I_0, T)$
  $E \rightarrow T.$
  $T \rightarrow T. * F$
- I_3 : $goto(I_0, F)$
  $T \rightarrow F.$
- I_4 : $goto(I_0, ()$
  $F \rightarrow (.E)$
  $E \rightarrow .E + T$
  $E \rightarrow .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- I_5 : $goto(I_0, id)$

Example

- Grammar:
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- $I_0 : closure(E' \to .E)$
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  $F \to .(E)$
  $F \to .id$
- $I_1 : goto(I_0, E)$
  $E \to E.$
  $E \to E. + T$
- $I_2 : goto(I_0, T)$
  $E \to T.$
  $T \to T. * F$
- $I_3 : goto(I_0, F)$
  $T \to F.$
- $I_4 : goto(I_0, ()$
  $F \to (.E)$
  $E \to .E + T$
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  $T \to .T * F$
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  $F \to .(E)$
  $F \to .id$
- $I_5 : goto(I_0, id)$
  $F \to id.$

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- Grammar:
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  $E \rightarrow .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- I_1 : $goto(I_0, E)$
  $E \rightarrow E.$
  $E \rightarrow E. + T$
- I_2 : $goto(I_0, T)$
  $E \rightarrow T.$
  $T \rightarrow T. * F$
- I_3 : $goto(I_0, F)$
  $T \rightarrow F.$
- I_4 : $goto(I_0, ()$
  $F \rightarrow (.E)$
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  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- I_5 : $goto(I_0, id)$
  $F \rightarrow id.$

Example

- $I_6 : goto(I_1, +)$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
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- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
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  $E \rightarrow E + .T$
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  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
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- $I_7 : goto(I_2, *)$
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- $I_8 : goto(I_4, E)$
  F $\rightarrow (E.)$
  $E \rightarrow E. + T$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  F $\rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  F $\rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  $\mathrm{F} \rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  $\mathrm{F} \rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  $\mathrm{F} \rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  $\mathrm{F} \rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$

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- $goto(I_4, T) is \quad I_2$
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- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
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  $T \rightarrow T * .F$
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- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$
- $goto(I_6, () is \quad I_4$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
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  $F \rightarrow .(E)$
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  $E \rightarrow E + T.$
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- $goto(I_6, id) is \quad I_5$

Example

- $I_6 : goto(I_1, +)$
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  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  $\mathrm{F} \rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$
- $goto(I_6, () is \quad I_4$
- $goto(I_6, id) is \quad I_5$

- $I_{10} : goto(I_7, F)$
  $T \rightarrow T * F.$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  F $\rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$
- $goto(I_6, () is \quad I_4$
- $goto(I_6, id) is \quad I_5$

- $I_{10} : goto(I_7, F)$
  $T \rightarrow T * F.$
- $goto(I_7, () is \quad I_4$
  $goto(I_7, id) is \quad I_5$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  F $\rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$
- $goto(I_6, () is \quad I_4$
- $goto(I_6, id) is \quad I_5$

- $I_{10} : goto(I_7, F)$
  $T \rightarrow T * F.$
- $goto(I_7, () is \quad I_4$
  $goto(I_7, id) is \quad I_5$
- $I_1 1 : goto(I8,))$
  $F \rightarrow (E).$

Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  F $\rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$
- $goto(I_6, () is \quad I_4$
- $goto(I_6, id) is \quad I_5$

- $I_{10} : goto(I_7, F)$
  $T \rightarrow T * F.$
- $goto(I_7, () is \quad I_4$
  $goto(I_7, id) is \quad I_5$
- $I_1 1 : goto(I8,))$
  $F \rightarrow (E).$
- $goto(I_8, +) is \quad I_6$

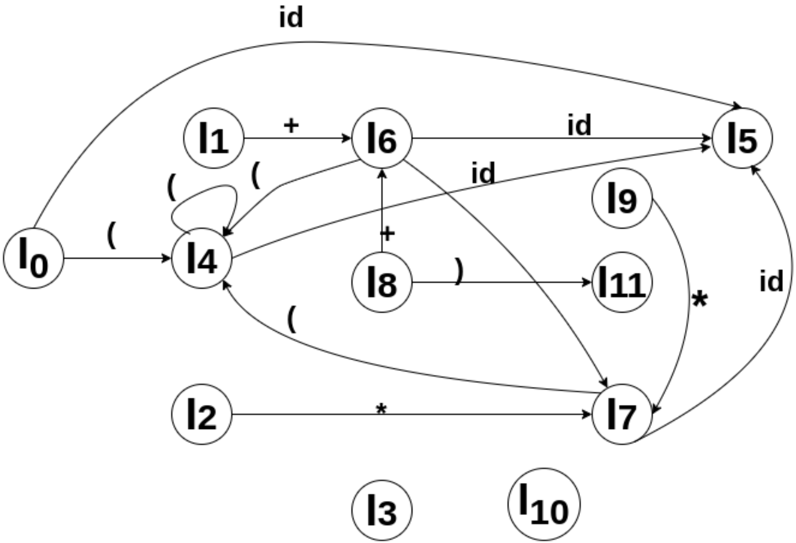
Example

- $I_6 : goto(I_1, +)$
  $E \rightarrow E + .T$
  $T \rightarrow .T * F$
  $T \rightarrow .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_7 : goto(I_2, *)$
  $T \rightarrow T * .F$
  $F \rightarrow .(E)$
  $F \rightarrow .id$
- $I_8 : goto(I_4, E)$
  $\mathrm{F} \rightarrow (E.)$
  $E \rightarrow E. + T$

- $goto(I_4, T) is \quad I_2$
- $goto(I_4, F) is \quad I_3$
- $goto(I_4, () is \quad I_4$
- $goto(I_4, id) is \quad I_5$
- $I_9 : goto(I_6, T)$
  $E \rightarrow E + T.$
  $T \rightarrow T. * F$
- $goto(I_6, F) is \quad I_3$
- $goto(I_6, () is \quad I_4$
- $goto(I_6, id) is \quad I_5$

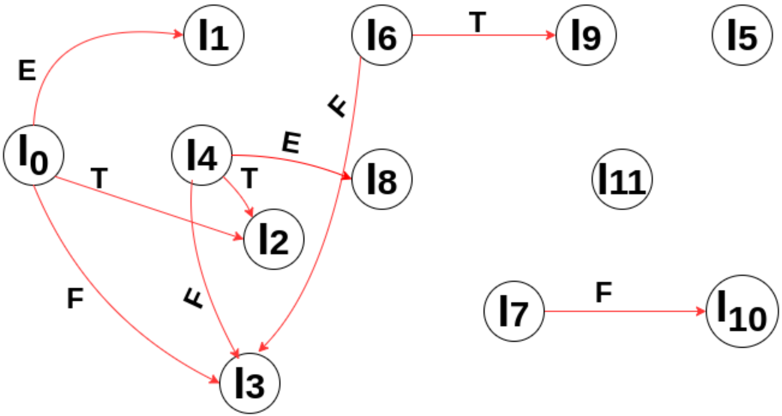
- $I_{10} : goto(I_7, F)$
  $T \rightarrow T * F.$
- $goto(I_7, () is \quad I_4$
  $goto(I_7, id) is \quad I_5$
- $I_1 1 : goto(I8,))$
  $F \rightarrow (E).$
- $goto(I_8, +) is \quad I_6$
- $goto(I_9, *) is \quad I_7$

Example



transitions corresponding to terminals => action table

Example



transitions corresponding to non-terminals => goto table