Left Recursion, Left Factoring, FIRST, FOLLOW

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Left Recursion

Definition: Left recursion occurs when a non-terminal references itself as the first symbol in its production.

Drawback in LL(1) Parsing:

- LL(1) parsers rely on a single token lookahead, and left recursion leads to infinite recursion, making parsing impossible.
- Must be eliminated for LL(1) grammar.

Example (Left Recursive Grammar):

$$A \to A\alpha \mid \beta$$

Removing Left Recursion:

$$A \to \beta A'$$
$$A' \to \alpha A' \mid \varepsilon$$

Left Factoring

Definition: Left factoring is used when a grammar has two or more productions that share a common prefix.

Drawback in LL(1) Parsing:

- LL(1) parsers require a single unique lookahead token to decide the production.
- If multiple productions share a common prefix, the parser cannot determine which rule to apply.

Example (Before Left Factoring):

$$A \to \alpha\beta \mid \alpha\gamma$$

After Left Factoring:

$$A \to \alpha A'$$
$$A' \to \beta \mid \gamma$$

FIRST Set Definition and Rules

FIRST(A): The set of terminals that can appear at the start of any string derived from **A**. If **A** can derive ε, include ε in FIRST(A).

Rules:

- If **A** is a terminal, FIRST(A) = $\{A\}$.
- If **A** $\rightarrow \varepsilon$, then $\varepsilon \in$ FIRST(A).
- If **A** $\rightarrow X_1 X_2 \ldots X_n$:
  - Add FIRST(X_1) (excluding ε) to FIRST(A).
  - If X_1 can derive ε, check X_2, and so on.
  - If all X_i can derive ε, add ε to FIRST(A).

Example for FIRST Set

Grammar:

$$A \rightarrow aB \mid \varepsilon$$
$$B \rightarrow b \mid c$$

FIRST Sets:

- FIRST(A) = { a, ε }
- FIRST(B) = { b, c }

FOLLOW Set Definition and Rules

FOLLOW(A): The set of terminals that can appear immediately after **A** in some derivation.

Rules:

- If **S** is the start symbol, FOLLOW(S) includes $.
- If **A** $\rightarrow \alpha B \beta$, then:
  - Add FIRST(β) (excluding ε) to FOLLOW(B).
  - If β can derive ε, add FOLLOW(A) to FOLLOW(B).
- If **A** $\rightarrow \alpha B$, then FOLLOW(B) includes FOLLOW(A).

Example for FOLLOW Set

Grammar:

$$S \rightarrow AB$$
$$A \rightarrow a \mid \varepsilon$$
$$B \rightarrow b$$

FOLLOW Sets:

- FOLLOW(S) = { $ }
- FOLLOW(A) = { b }
- FOLLOW(B) = { $ }