CS 160 Compilers

Lecture 5: Lexical Analysis

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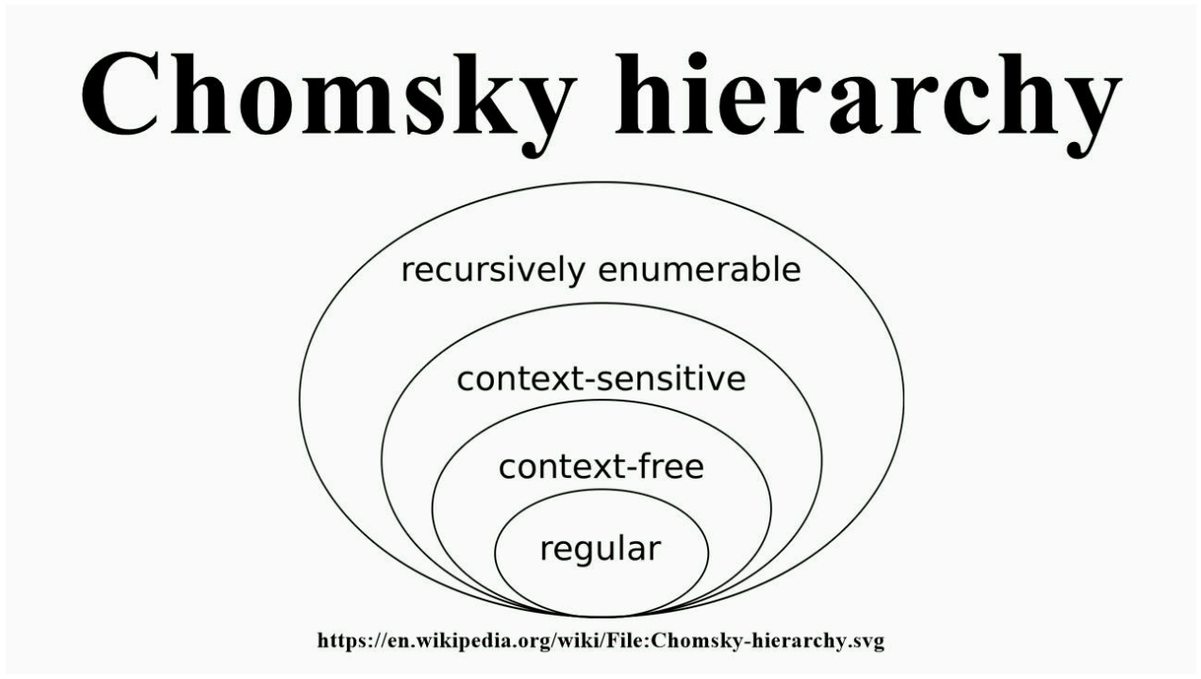
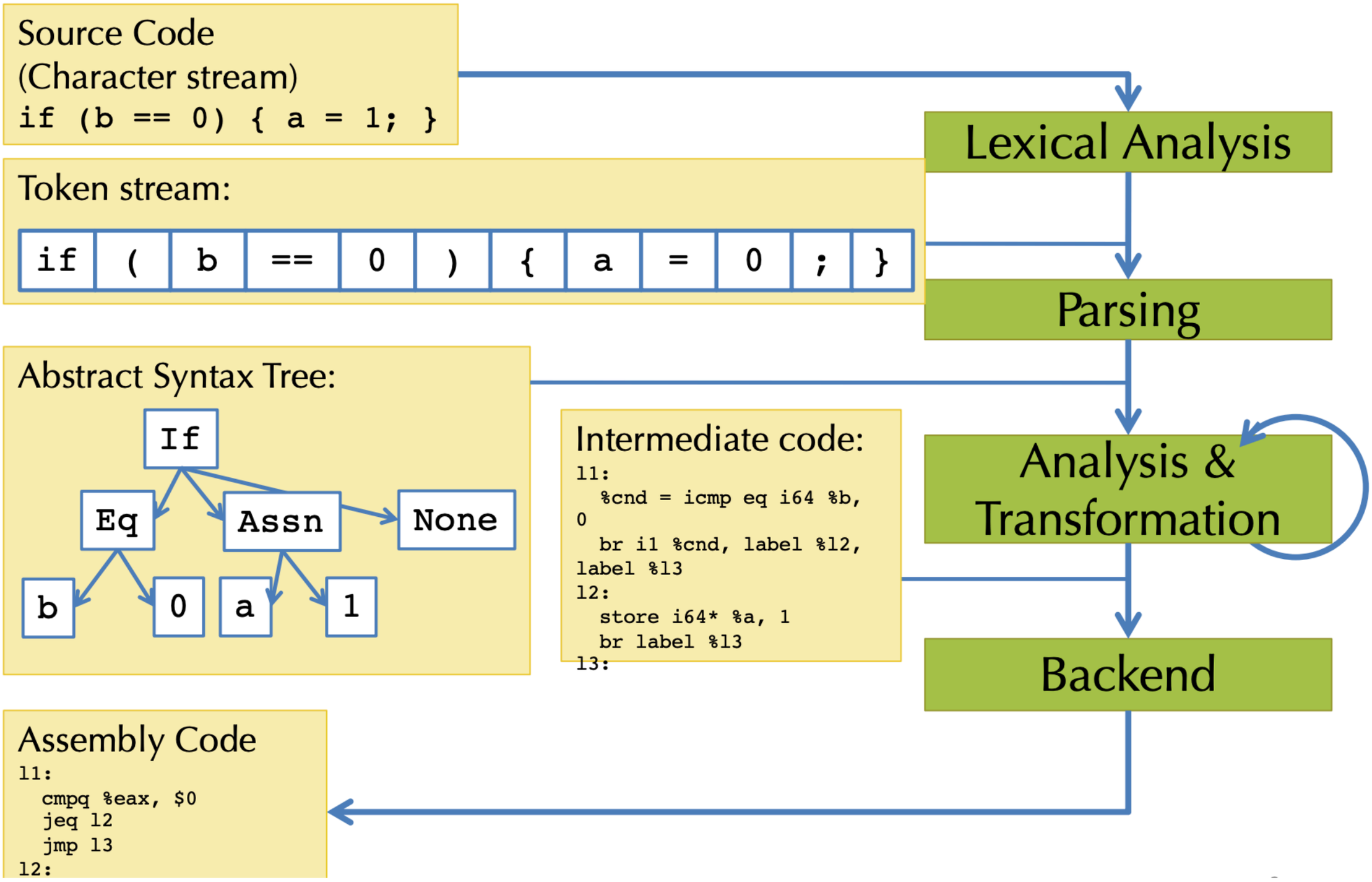
A typical flow of a compiler



A typical flow of a compiler



Lexical analysis

- Main Question: How to give structure to strings
- Analogy: Understanding an English sentence
  - First, we separate a string into words
  - Second, we understand sentence structure by diagramming the sentence
- Separating a string into words is called ***lexing***
- Note that lexing is not necessarily trivial

Lexical analysis

- Consider the following Patina program:

```
if x > y

then 10

else 8
```

- This program is just a string of characters

```
if x > y\nthen\t10\nelse\t8
```

- Goal: Portion the input string into substrings where the substrings are ***tokens***

What is a Token?

- Token is a syntactic category
- Example in English: noun, verbs, adjectives,...
- In a programming language: constants, identifiers, keywords, whitespaces…

Tokens in Patina

- Tokens correspond to sets of strings
- Identifier: strings of letters, digits and ’_’ starting with a letter
- Integer: a non-empty string of digits
- Keywords: “let”, “if”, ...
- Whitespace: a non-empty sequence of blanks, newlines, and tabs

What are tokens for?

- Classify program substrings according to their role
- Output of lexical analysis is a stream of tokens...
- ...which is input to the parser
- Parser relies on token distinction
  - An identifier is treated different than a keyword

Regular language/expressions

- We could specify tokens in many ways
- Regular Languages are the most popular
- Simple and useful theory
- Easy to understand
- Efficient to implement

Languages

- Definition: Let Σ be a set of characters, A language over Σ is a set of strings from characters drawn from Σ

- Alphabet: English characters => Language: English sentences

- Languages are sets of strings

- Need some notation for specifying which sets we want

- The standard notation for regular languages is regular expressions

Regular expressions

- Atomic Regular Expressions
  - Single character: c= {“c”}
  - Epsilon: ε = {“”}
- Compound Regular Expressions
  - Union:A+B={s | s∈A or s∈B}
  - Concatenation: AB = {ab | a ∈ A and b ∈ B}
  - Iteration: $A^* = \bigcup_{i \geq 0} A^i$ where $A^i = A...i$ times A

Regular expressions

- The regular expressions over Σ are the smallest set of expressions including
- ε
- $'c'$ where $c \in \Sigma$
- $A + B$ where A, B are regular expressions over Σ
- AB where A, B are regular expressions over Σ
- A^* where A is a regular expression over Σ
- Regular expressions are simple, but very useful

Example: Integers

- Integer: non-empty string of digits.
- digit = ‘0’+ ‘1’+’2’+’3’+’4’+’5’+’6’+ …
- integer = digit digit*
- Abbreviation: A^{+}= AA*

Example: Identifier

- Identifier: strings of letters or digits, starting with a letter
- letter = ’A’+...+’Z’+’a’+...’z’+’_’
- identifier = letter (letter + digit)*
- How about (letter*+ digit*)?

Example: Whitespace

- Whitespace: a non-empty sequence of blanks, newlines and tabs

- Whitespace = (’ ’ + ’\n’ + ’\t’)$^{+}$

Last example: email

- Consider UCSB cs emails: anyone@cs.ucsb.edu format
- Σ= letters $\cup$ {. , @}
- name = letter^{+}
- address = name ’@’ name ’.’ name ’.’ name

TODOs by next lecture

- Come to the discussion session or office hour if you have questions

- Continue with your good work on HW1