Syntactic Structure & Lexical Analysis

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- ASCII set is one such alphabet for programming languages.

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- Non-tokens: Whitespaces, comments, preprocessor directives, macros etc.

Syntax: Exercise

```
fun gcd(a:int, b:int): int =
        if b = 0 then a
        else gcd(b, a mod b)
```

- Keywords:
- Identifiers:
- Constants:
- Operators:

Scanning

- Reads as input a stream of symbols and identifies *tokens* from the *lexemes*.
- In the process it removes comments and whitespaces.
- May keep meta information for error reporting (such as line number in the file etc.)
- Eg: b*b - 4*a*c is represented by a token sequence $\mathtt{name}_\mathtt{b} * \mathtt{name}_\mathtt{b} - \mathtt{number}_4 * \mathtt{name}_\mathtt{a} * \mathtt{name}_\mathtt{c}$
- Tokens are constructed from individual characters using just three kinds of formal rules

Scanning:Regular expressions

- Rules for token generation: *concatenation*, *alternation*, *repetition* (or Kleene closure)
  - **Concatenation**: Given two strings x and y, then $x.y$ or simply xy is a concatenation of the two strings. One can apply similar ideas to sets of strings.
  - **Alternation**: Given two x and y, $x|y$ is the set of strings specified by x and y.
  - **Repetition**: For any string x, we may use concatenation to create a string y with as many repetitions of y as we want. Eg: $x^0 = "", x^3 = x.x.x, x^* = \{x^n | n \geq 0\}$.

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- Example: $[A - Za - z][A - Za - z0 - 9]^*$

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$$\mathcal{L}(rs) = \mathcal{L}(r)\mathcal{L}(s)$$
- **Alternation**: Given any two regular expressions r and s, $r|s$ is the set union of the languages specified by the individual expressions r and s respectively, i.e. $\mathcal{L}(r|s) = \mathcal{L}(r) \cup \mathcal{L}(s)$.

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  - : $r^* = \epsilon | r.r^*$, $r^* = (r^*)^*, r^+ = r.r^*$

Scanning: Recognising Tokens

- Identification of tokens is usually done by a *Deterministic Finite-state automaton* (DFA).
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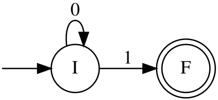

Language to represent Graphs: Dot

```
digraph G{
/* defaults */
   fontsize=12;
   ratio=compress;
   rankdir=LR;
/* Bounding box */
   size="4,4";

/* Node Definitions */
   I [shape=circle, peripheries=1];
   F [shape=circle, peripheries=2];
   "" [shape=plaintext];

/* Graph defn */
   "" -> I
   I -> I [label="0"];
   I -> F [label="1"];
}

$ dot -Tps dfa.dot > dfa.ps
```

Strengths/Power and Limitations of DFAs

- L is a regular language iff there is a regular expression r such that $L(r) = L$ iff there is a DFA M such that $L(M) = L$.
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- Question: Is the language $L = \{(^n)^n | n \geq 0\}$ regular?

Recognition Using DFA

Algorithm 1: Recognizer using DFA

Require: A string $w \in A^*$.
Ensure: Boolean

```
S := q_0
a := nextChar(w)
while a ≠ endOfString do
    S := S ∪ δ_S(a)
    a := nextChar(w)
end while
return S ∩ F ≠ ∅
```

Where $\delta_S(a) = \{q' | \exists q \in S : q \xrightarrow{a} q'\}$

An example Lexer

See exlexer.l.

- `lex exlexer.l`.This will produce the file `lex.yy.c`
- `gcc lex.yy.c`. This will produce the executable `a.out`
- Run the executable against a list of strings.