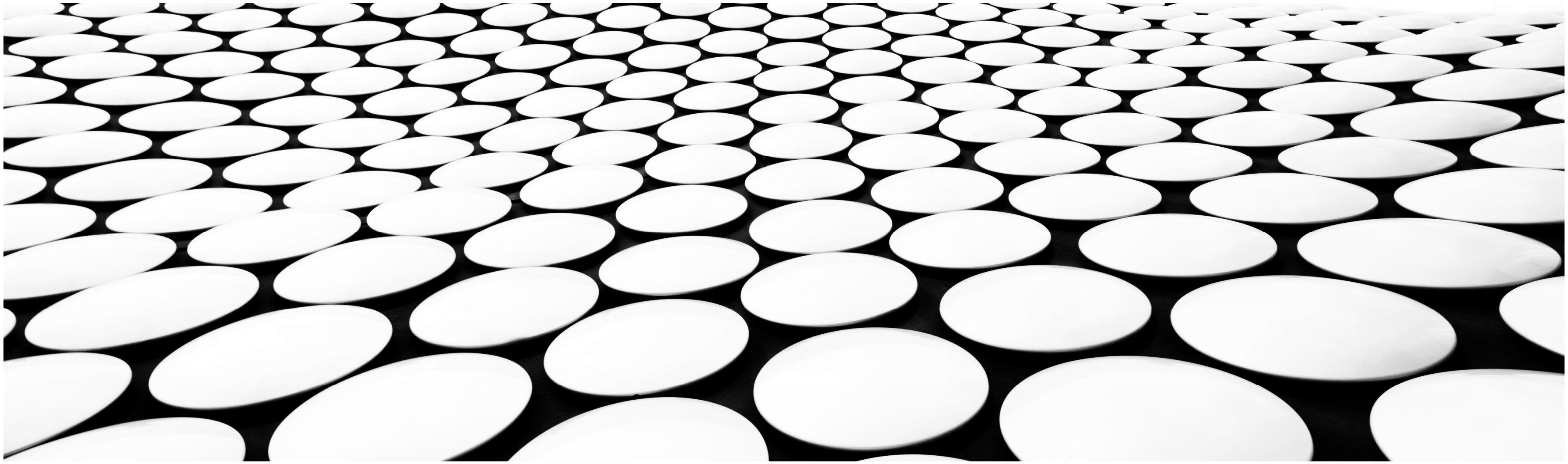
FINITE AUTOMATA

IF 2124 TEORI BAHASA FORMAL OTOMATA



Motivation

- Automata = abstract computing devices

- Turing studied Turing Machines (= computers) before there were any real computers

- We will also look at simpler devices than Turing machines (Finite State Automata, Pushdown Automata, . . .), and specification means, such as grammars and regular expressions.

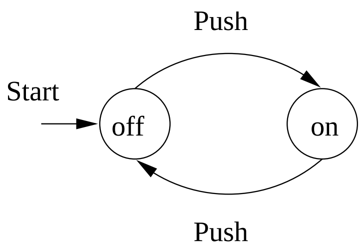
- NP-hardness = what cannot be efficiently computed

Finite Automata

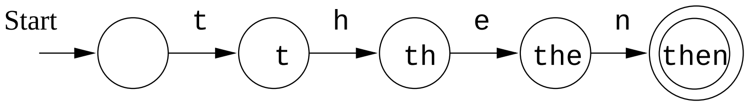
Finite Automata are used as a model for

- Software for designing digital cicuits
- Lexical analyzer of a compiler
- Searching for keywords in a file or on the web.
- Software for verifying finite state systems, such as communication protocols.

• Example: Finite Automaton modelling an on/off switch



• Example: Finite Automaton recognizing the string **`then`**



Central Concepts

Alphabet: Finite, nonempty set of symbols

Example: $\Sigma = \{0, 1\}$ binary alphabet

Example: $\Sigma = \{a, b, c, \ldots, z\}$ the set of all lower case letters

Example: The set of all ASCII characters

Strings: Finite sequence of symbols from an alphabet Σ, e.g. 0011001

Empty String: The string with zero occurrences of symbols from Σ

- The empty string is denoted ϵ

Length of String: Number of positions for symbols in the string.

$|w|$ denotes the length of string w

$|0110| = 4, |\epsilon| = 0$

Powers of an Alphabet: Σ^k = the set of strings of length k with symbols from Σ

Example: $\Sigma = \{0, 1\}$ $\quad\Sigma : \{0, 1\}$.

$\Sigma^1 = \{0, 1\}$ $\quad\Sigma^1 : \{0, 1\}$

$\Sigma^2 = \{00, 01, 10, 11\}$

$\Sigma^3 : \{000, 001, 010, 011, \ldots 111\}$.

$\Sigma^0 = \{\epsilon\}$

Question: How many strings are there in Σ^3

The set of all strings over Σ is denoted Σ^*

$\Sigma^* = \Sigma^0 \cup \Sigma^1 \cup \Sigma^2 \cup \cdots$

Also:

$\Sigma^+ = \Sigma^1 \cup \Sigma^2 \cup \Sigma^3 \cup \cdots$

$\Sigma^* = \Sigma^+ \cup \{\epsilon\}$

Concatenation: If x and y are strings, then xy is the string obtained by placing a copy of y immediately after a copy of x

$x = a_1 a_2 \ldots a_i, y = b_1 b_2 \ldots b_j$

$xy = a_1 a_2 \ldots a_i b_1 b_2 \ldots b_j$

Example: $x = 01101, y = 110, xy = 01101110$

Note: For any string x

$$x\epsilon = \epsilon x = x$$

Languages:

If Σ is an alphabet, and $L \subseteq \Sigma^*$ $= \{\varepsilon, 0, 1, 00, 01, 10, 11, 000, 001, \ldots \ldots\}$.
then L is a language

Examples of languages:

- The set of legal English words

- The set of legal C programs

- The set of strings consisting of n 0's followed by n 1's

$$\{\epsilon, 01, 0011, 000111, \ldots\}$$

• The set of strings with equal number of 0's and 1's

$$\{\epsilon, 01, 10, 0011, 0101, 1001, \ldots\}$$

• L_P = the set of binary numbers whose value is prime

$$\{10, 11, 101, 111, 1011, \ldots\}$$

• The empty language $\emptyset$

• The language $\boxed{\{\epsilon\}}$ consisting of the empty string

Note: $\boxed{\emptyset \neq \{\epsilon\}}$

Note2: The underlying alphabet Σ is always finite