Automata Formal Languages & Logic

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Department of Computer Science & Engineering

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Unit 2

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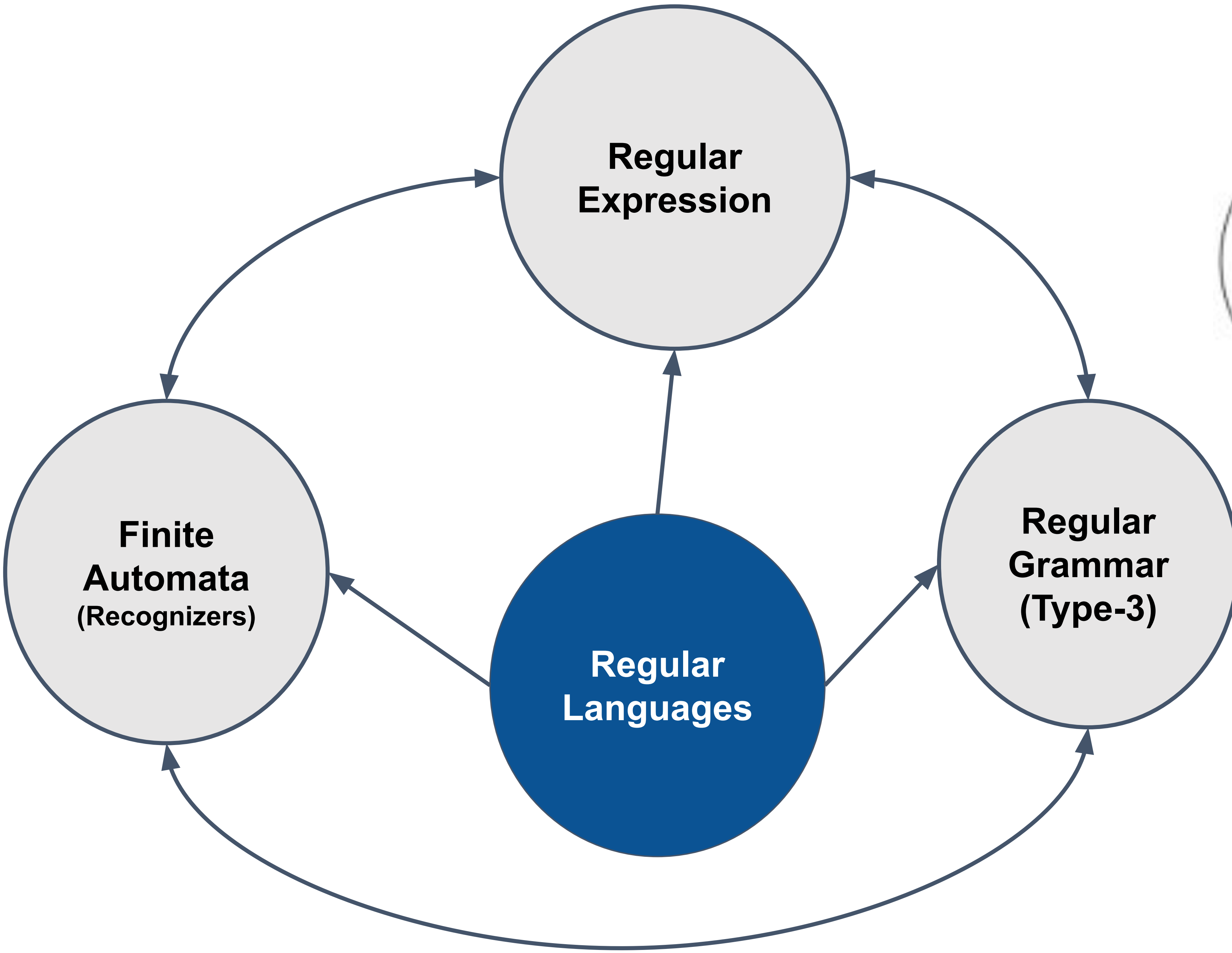
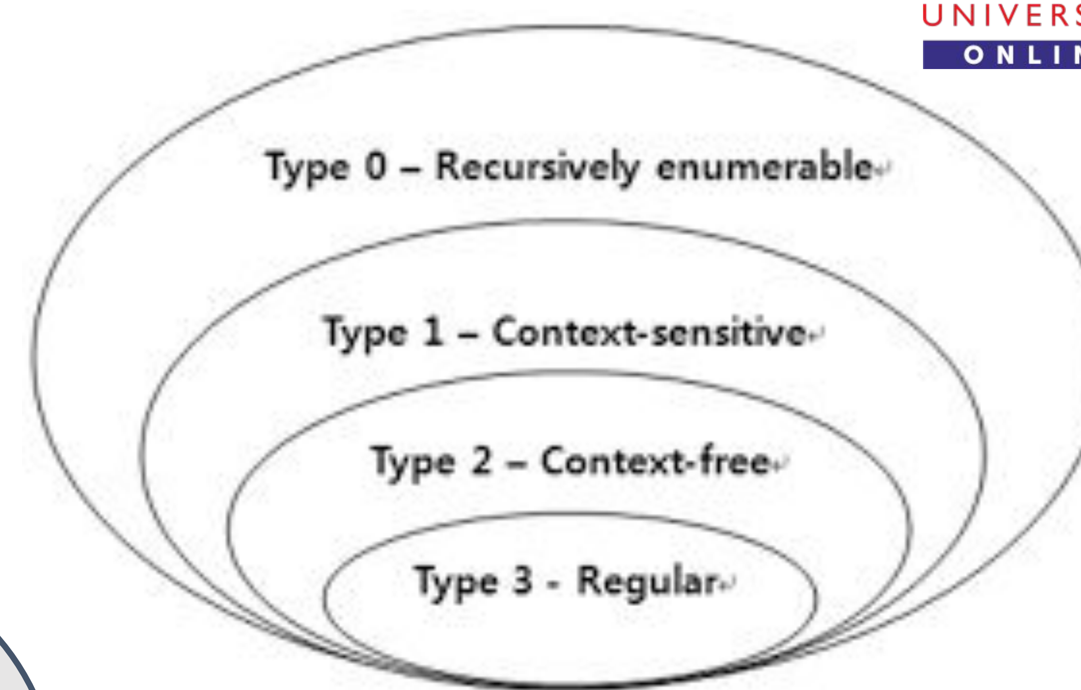
Unit 2 - Introduction



Chomsky Hierarchy



Unit 2 - Outline

- **Regular Expression :**
- **Regular Grammar :**
- **Properties of Regular Languages**
- **Pumping Lemma**

Regular Expression :

- Construction
- Regex in Practice
- Equivalence of Regex and Finite Automata :
    - Regex → FA
    - FA → Regex

Regular Grammar :

- Construction
- Equivalence of Regular Grammar & Finite Automata
  - RG -> FA
  - FA -> RG
- Parse Tree

Unit 2 - Outline

- Properties of Regular Languages
- Pumping Lemma
    - Limits of Finite Automata
    - A way to prove that the language is non-regular.

THANK YOU

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Regex is an algebraic way to describe regular languages.

Regular Expression

- Atoms
  - A Character/symbol
  - ϕ (L = { })
  - λ (L = {λ})
- Operators
  - (R)
  - R*
  - $R_1.R_2$ or R_1R_2
  - $R_1 + R_2$ or $R_1 \mid R_2$

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Example

$$a \quad b^* \quad c + d$$

Example

$$\underbrace{(a\ b^*\ c)}_{R_1} + \underbrace{d}_{R_2}$$

or

Example

$$(a \quad b^* \quad c) + d$$

Starting with an 'a'

Followed by 0 or more no. of b's

Ending with a 'c'

Example

$$(a \quad b^* \quad c) + d$$

String that contains only d

Starting with an ‘a’

Followed by 0 or more no. of b’s

Ending with a ‘c’

Example

$$(a\ b^*\ c) + d$$

L = { ac,
abc,
abbb….c,
d }

Union

Identity = ϕ

Union

Identity = ϕ

$R + \phi = \phi + R = R$

Union

Identity = ϕ

$R + \phi = \phi + R = R$

Commutative

$R_1 + R_2 = R_2 + R_1$

Union

Identity = ϕ

$R + \phi = \phi + R = R$

Commutative

$R_1 + R_2 = R_2 + R_1$

Associative

$(R_1 + R_2) + R_3 =$
$R_1 + (R_2 + R_3)$

Identity = ϵ or λ

Concatenation

Concatenation

Identity = ϵ or λ

$R \,.\, \epsilon = \epsilon \,.\, R = R$

$$R \, . \, \phi = \phi \, . \, R = \phi$$

Let L_1, L_2 be languages, then the concatenation $L_1 \circ L_2 = \{w \mid w = xy, x \in L_1, y \in L_2\}$. If $L_2 = \varnothing$, then there is no string $y \in L_2$ and so there is no possible w such that $w = xy$. Thus for any L_1, we'll have $L_1 \circ \varnothing = \varnothing$.

Concatenation

Identity = ϵ or λ

$R . \epsilon = \epsilon . R = R$

Non-Commutative

$R_1 . R_2 \neq R_2 . R_1$

Example :

$R_1 = a$

$R_2 = b$

then,

ab = ba

Concatenation

Identity = ϵ or λ

$R . \epsilon = \epsilon . R = R$

Non-Commutative

$R_1 . R_2 \neq R_2 . R_1$

Associative

$(R_1 . R_2) . R_3 = R_1 . (R_2 . R_3)$

Closure

$\epsilon^* = \epsilon$

$\phi^* = \epsilon$

$(R^*)^* = R^*$

$(R + \epsilon)^* = R^*$

$R^+ = RR^* = R^*R$

$(R^+ + \epsilon) = R^*$

$\epsilon + RR^* = \epsilon + R^* = R^*$

Closure

$$(a + b)^*$$
$$= (a^* + b^*)^*$$
$$= (a^* b^*)^*$$
$$= (a + b^*)^*$$
$$= (a^* + b)^*$$
$$= a^*(ba^*)^*$$
$$= b^*(ab^*)^*$$

Construct a Regular Expression for a given language L

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