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CSE211 – Formal Languages and Automata Theory

U1L6 – Types of Grammar and Chomsky Hierarchy

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Agenda

- Recap of previous session
- Types of Grammar
- Comparison of Grammars
- Chomsky Hierarchy of Grammars

Types of Grammar

- According to **Noam Chomsky**, an American linguist, philosopher, cognitive scientist and social activist, there are four types of grammars:
 - Type 3 - ***Regular grammars***
 - Type 2 - ***Context-free grammars***
 - Type 1 - ***Context-sensitive grammars***
 - Type 0 - ***Recursively enumerable grammar***

Type 3 Grammar:

- Type 3 Grammar is known as **Regular Grammar**
- Regular languages are those languages which can be described using **regular expressions**
- These languages can be modeled by **NFA or DFA**
- Type 3 should be **in the form of**

$$V \rightarrow T^*V / T^*$$

- The rule $S \rightarrow \epsilon$ is also allowed here if S does not appear on the right side of any rule.
- Used to define **search patterns** and the **lexical structure** of programming languages.

Type 2 Grammar

- Type 2 Grammar is known as **Context Free Grammar**
- **Context Free Languages** are represented by the context free grammar (CFG)
- The production rule **is of the form**

$$A \rightarrow \alpha$$

where $A \in V$ and $\alpha \in (V \cup T)^*$

- Recognized by a **Non-Deterministic Pushdown Automaton (PDA)**
- Context-free languages are the theoretical basis for the **syntax of** most programming languages.

Type 1 Grammar

- **Type-1 grammar** is known as **Context Sensitive Grammar**
- **Used to represent** context sensitive language
- The productions must be **in the form**

$$A \rightarrow B \quad \text{Where } A, B \in (V \cup T)^+ \text{ and the}$$

count of symbol in A is less than or equal to B

- **May have more than one symbol** on the left hand side of their production rules.
- The **number of symbols on the left-hand side must not exceed** the number of symbols on the right-hand side.
- The rule of the form **$A \rightarrow \epsilon$ is not allowed** unless A is a

Dr.PS start symbol

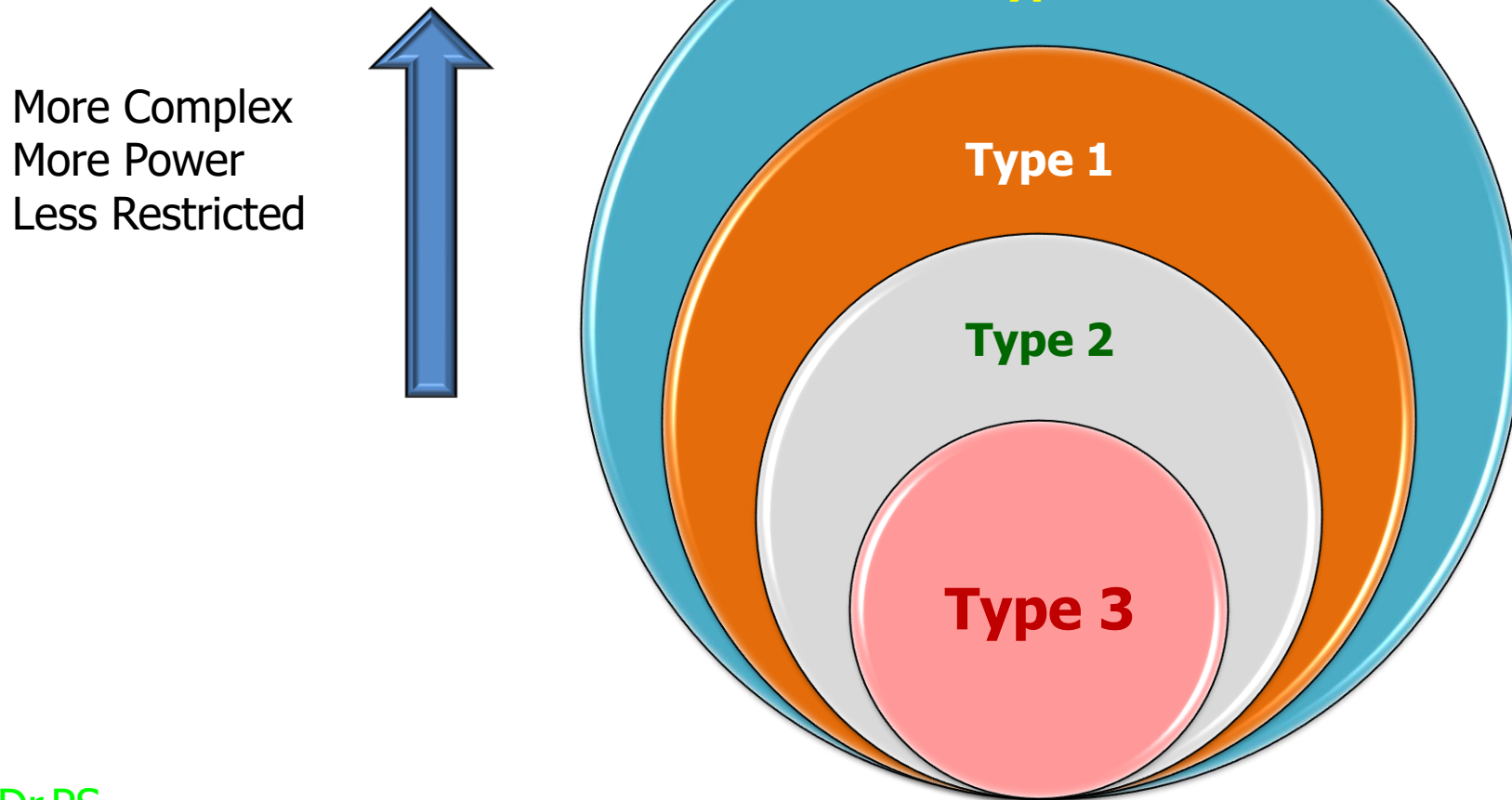
Type 0 Grammar

- Type 0 grammar is known as **Unrestricted grammar**
- The languages are known as the **recursively enumerable languages**
- There is **no restriction on the grammar rules** of these types of languages
- These languages can be efficiently modeled **by Turing machines**
- They are too general **to describe the syntax of** programming languages and natural languages.

Comparison of Grammars

Grammar Type	Grammar Accepted	Language Accepted	Automaton
Type 0	Unrestricted grammar	Recursively enumerable language	Turing Machine
Type 1	Context-sensitive grammar	Context-sensitive language	Linear-bounded automaton
Type 2	Context-free grammar	Context-free language	Pushdown automaton
Type 3	Regular grammar	Regular language	Finite state automaton

Chomsky Hierarchy



Summary

- Types of Grammar
- Comparison of Grammars
- Chomsky Hierarchy of Grammars

References

- John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, *Introduction to Automata Theory, Languages, and Computation*, Pearson, 3rd Edition, 2011.
- Peter Linz, *An Introduction to Formal Languages and Automata*, Jones and Bartle Learning International, United Kingdom, 6th Edition, 2016.
- https://www.tutorialspoint.com/automata_theory/chomsky_classification_of_grammars.htm

Next Class:

Deterministic Finite Automata

THANK YOU.