## Mini Project (Phase 1)

- Due at the beginning of Module B Evaluation Workshop.
- Choose an object/phenomenon unique to you.
- Informally describe the logic-structure connection involving the object/phenomenon.
- No length requirement. Must be wordprocessed (except diagrams).
- Self-evaluation: 1 pt if requirements satisfied.

Read project page

CMSC210 B4

1

### **Review Questions**

- Type of a relation? [E.g., B2 Ex1-C]
- How to justify properties of a relation?
  - Reflexive: For every  $a \in A$ ,  $(a, a) \in R$  holds.
  - Symmetric: For *every*  $(a, b) \in R$ ,  $(b, a) \in R$  holds.
  - Antisymmetric: If  $both(a, b) \in R$  and  $(b, a) \in R$  hold, a = b. [i.e., cannot have both unless a = b]
  - Transitive: For every  $(a, b) \in R$  and  $(b, c) \in R$ ,  $(a, c) \in R$  holds.

2

CMSC210 B4

### **B4: Structures**

### Today

- Formally represent structures and use them to analyze phenomena
  - Formally represent a structure
  - Overview of structure classification
  - Structures for language acquisition
- Take-home exercises
  - Human body, El Capitan

CMSC210 B4

### Section 1

### Defining a Structure

- How to organize structure components to define a structure?
  - Multiple structure components
  - Helpful for comparing multiple structures

CMSC210 B4

### Structure

- An *n*-tuple involving sets, relations, and functions.
- Convention (in this course)
  - Structure name in Roman bold, e.g., Structure
- Example
  - $-\mathbf{Max} = (\mathbf{R}, max)$

 $\mathbf{R} = \text{the set of real numbers}$  set

 $max: \mathbf{R} \times \mathbf{R} \to \mathbf{R}$  function type

 $max = \{((x, y), z) \mid \text{if } x > y, z = x; \text{ otherwise } z = y\}$ 

CMSC210 B4

function definition

### Levels of Structure Definition

- Complete definition
  - All structure components are completely define.
  - E.g., Max in the previous slide
- Definition of a collection of structures
  - Some structure components show *only types* but no actual definitions.

- E.g., RealBinaryOp = (R, op)

R = the set of real numbers

 $op: \mathbf{R} \times \mathbf{R} \to \mathbf{R}$  type, but **no** function definition

· Max is an instance of RealBinaryOp.

CMSC210 B4

6

## **Section Summary**

- · Structure definition
  - Name = n-tuple
  - Structure component definition and types
- Degree of structure definition
  - Complete
  - Definition of a class

cf. Java abstract class/interface

CMSC210 B4

### **Group Exercise**

- Completely define a structure (NorthPole) to represent North Pole (as we discussed in class/exercises)
  - Set of Santa Claus, S
  - Set of reindeer, R
  - Set of objects, O (define this concisely!)
  - Relation "carries", carries

Include the "type" of relation

CMSC210 B4

### Section 2

### Structure Classification

- Operational structures
  - Involves sets and functions, but no relations
  - E.g., Max, PrimitiveCount, Strings
- · Relational structures
  - Involves sets and relations, but no functions
  - E.g., Graph,  $(R, \leq)$ , Professionals
- Hybrid structures
  - Involves sets, relations, and functions

CMSC210 B4

### Fine-Tuned Classification

- Operational structures
  - Properties of function/operation: surjective, injective, bijective
  - Properties of binary function/operation: associative, identity element, commutativity
- · Relational structures
  - Properties of relation: reflexivity, symmetry, transitivity

CMSC210 B4 10

# **Section Summary**

- · Broad classification
  - Operational, relational, hybrid
- Fine-tuned classification
  - Based on properties of relation/function

CMSC210 B4 11

# **Group Exercise**

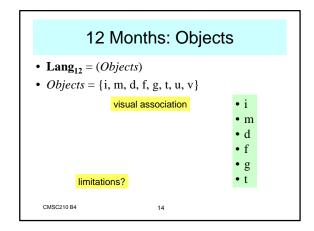
A. Define a structure (**Org**) to represent a corporate organization

Define completely with made-up information

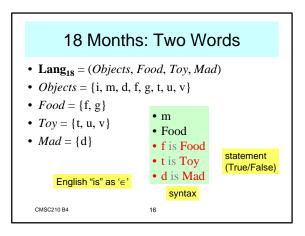
- B. Is **Org** an operational, relational, or hybrid structure?
- C. What kind of properties does the relation/function possess?

CMSC210 B4

# Modeling Language Acquisition • Very rough language acquisition process - 12 months: objects (mommy, daddy, etc.) - 15 months: common nouns (toy, food, etc.) - 18 months: two-word sentences - 24 months: three-word sentences - After that Representing these stages using structures?



# 15 Months: Common Nouns • Lang<sub>15</sub> = (Objects, Food, Toy, Mad) lexicon (dictionar) • Objects = $\{i, m, d, f, g, t, u, v\}$ • Food = $\{f, g\}$ • Toy = $\{t, u, v\}$ semantics • Mad = $\{d\}$ • Common nouns as set • CMSC210 B4 • Common Nouns • In the serious of the serious



### 24 Months: Three Words • Lang<sub>24</sub> = (Objects, Food, Toy, Mad, PlayWith) • $Objects = \{i, m, d, f, g, t, u, v\}$ • m • $Food = \{f, g\}$ • Food • $Toy = \{t, u, v\}$ • f (is) Food • $Mad = \{d\}$ • i PlayWith t • $PlayWith = \{(i, t), (d, f)\}$ • d PlayWith f PlayWith: Objects \* Objects • i PlayWith f Verbs as binary relation syntax even more crucial CMSC210 B4

# After That • Use of function? • Adjectives? • Relative clauses? • Logical words: and, or, if, ...? • Ambiguity? • Understanding and generation?

### B2 Ex3: Pair as a Set

19

### Conditions

- $(a, b) \neq (b, a)$
- $(a, b) = (c, d) \Leftrightarrow (a = c \text{ and } b = d)$
- $(a, a) \neq (a) \neq a$

*n*-tuples in general ...

Textbook Ex. 19, p. 54

CMSC210 B4

# **Summary Exercise**

- Are you ready to do today's take-home exercises?
  - If yes, very briefly explain how you got all the necessary information, techniques, etc.?
  - If no, what do you need to do?
- Questions/Comments/Suggestions

CMSC210 B4

20