Ontologies and Knowledge-based Systems

- Is there a flexible way to represent relations?
- How can knowledge bases be made to inter-operate semantically?

Choosing Objects and Relations

How to represent: "Pen #7 is red."

Choosing Objects and Relations

How to represent: "Pen #7 is red."

- $red(pen_7)$. It's easy to ask "What's red?" Can't ask "what is the color of pen_7?"

Choosing Objects and Relations

How to represent: "Pen #7 is red."

- $red(pen_7)$. It's easy to ask "What's red?"
  Can't ask "what is the color of pen_7?"
- $color(pen_7, red)$. It's easy to ask "What's red?"
  It's easy to ask "What is the color of pen_7?"
  Can't ask "What property of pen_7 has value red?"

Choosing Objects and Relations

How to represent: "Pen #7 is red."

- $red(pen_7)$. It's easy to ask "What's red?"
  Can't ask "what is the color of pen_7?"
- $color(pen_7, red)$. It's easy to ask "What's red?"
  It's easy to ask "What is the color of pen_7?"
  Can't ask "What property of pen_7 has value red?"
- $prop(pen_7, color, red)$. It's easy to ask all these questions.

Choosing Objects and Relations

How to represent: "Pen #7 is red."

- $red(pen_7)$. It's easy to ask "What's red?"
  Can't ask "what is the color of pen_7?"
- $color(pen_7, red)$. It's easy to ask "What's red?"
  It's easy to ask "What is the color of pen_7?"
  Can't ask "What property of pen_7 has value red?"
- $prop(pen_7, color, red)$. It's easy to ask all these questions.

$prop(Object, Property, Value)$ is the only relation needed:
object-property-value representation

Universality of *prop*

To represent "a is a parcel"

Universality of *prop*

To represent "a is a parcel"

- $prop(a, type, parcel)$, where $type$ is a special property
- $prop(a, parcel, true)$, where $parcel$ is a Boolean property

Reification

- To represent $scheduled(cs422, 2, 1030, cc208)$. "section 2 of course $cs422$ is scheduled at 10:30 in room $cc208$."

Reification

- To represent $scheduled(cs422, 2, 1030, cc208)$. "section 2 of course $cs422$ is scheduled at 10:30 in room $cc208$."
- Let $b123$ name the booking:

  $prop(b123, course, cs422).$

  $prop(b123, section, 2).$

  $prop(b123, time, 1030).$

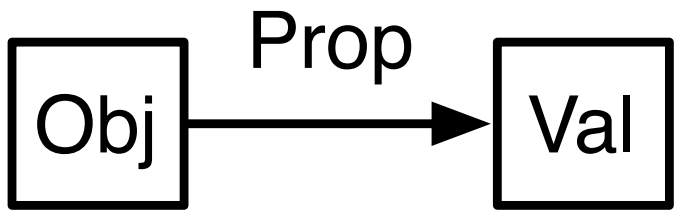
  $prop(b123, room, cc208).$
- We have reified the booking.
- Reify means: to make into an object.
- What if we want to add the year?

Semantics Networks

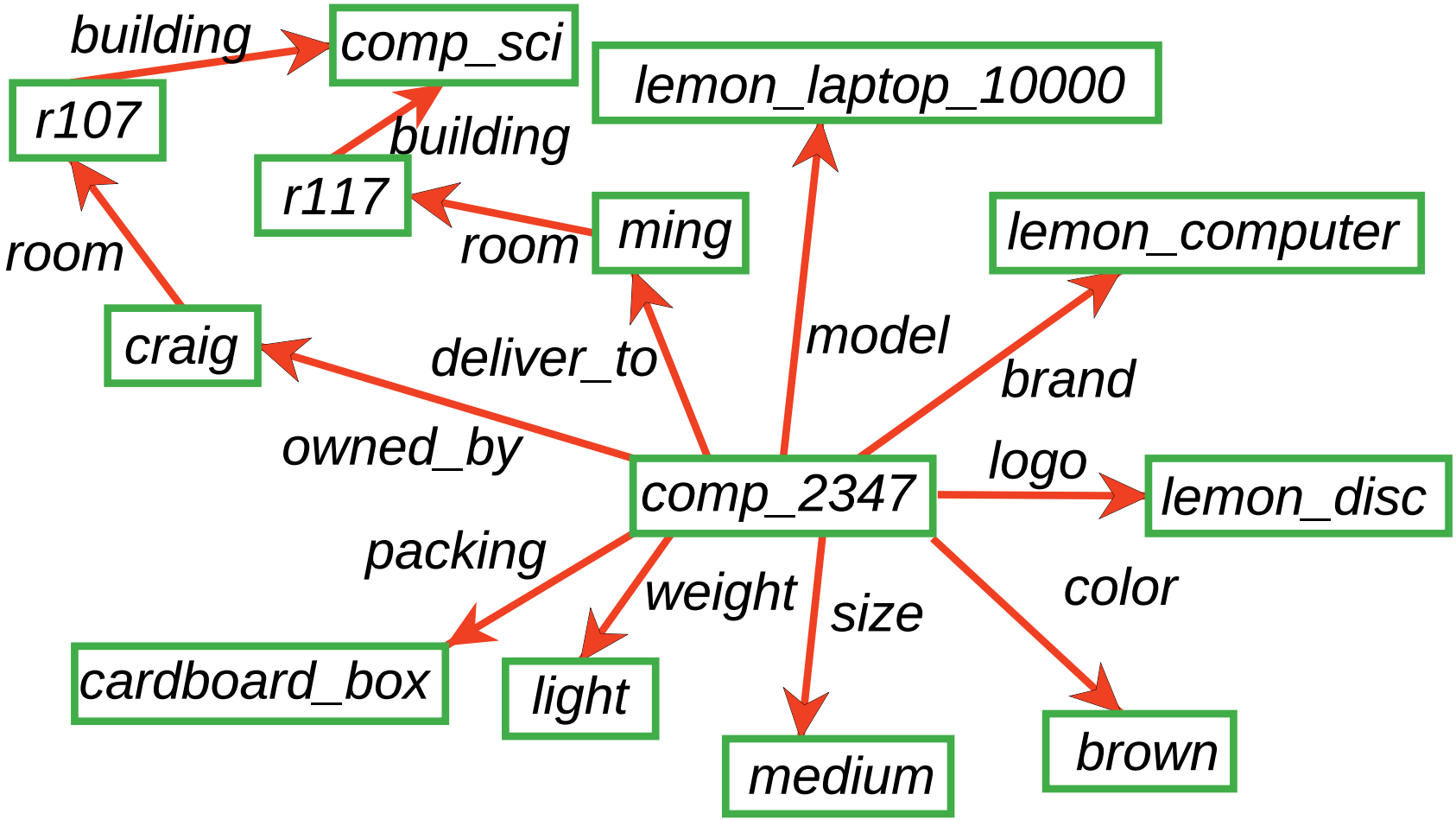
When you only have one relation, *prop*, it can be omitted without loss of information.
Write

$$prop(Object, Property, Value)$$

as



An Example Semantic Network



Equivalent Logic Program

$prop(comp\_2347, owned\_by, craig).$

$prop(comp\_2347, deliver\_to, ming).$

$prop(comp\_2347, model, lemon\_laptop\_10000).$

$prop(comp\_2347, brand, lemon\_computer).$

$prop(comp\_2347, logo, lemon\_disc).$

$prop(comp\_2347, color, brown).$

$prop(craig, room, r107).$

$prop(r107, building, comp\_sci).$

$\vdots$

Turtle: a simple language of triples

A triple is written as

Subject Verb Object.

A comma can group objects with the same subject and verb.

$S\ V\ O_1, O_2.$ is an abbreviation for $\begin{array}{l} S\ V\ O_1. \\ S\ V\ O_2. \end{array}$

A semi-colon can group verb-object pairs for the same subject.

$S\ V_1\ O_1; V_2\ O_2.$ is an abbreviation for $\begin{array}{l} S\ V_1\ O_1. \\ S\ V_2\ O_2. \end{array}$

Square brackets can be used to define an individual that is not given an identifier. It can then be used as the object of a triple.

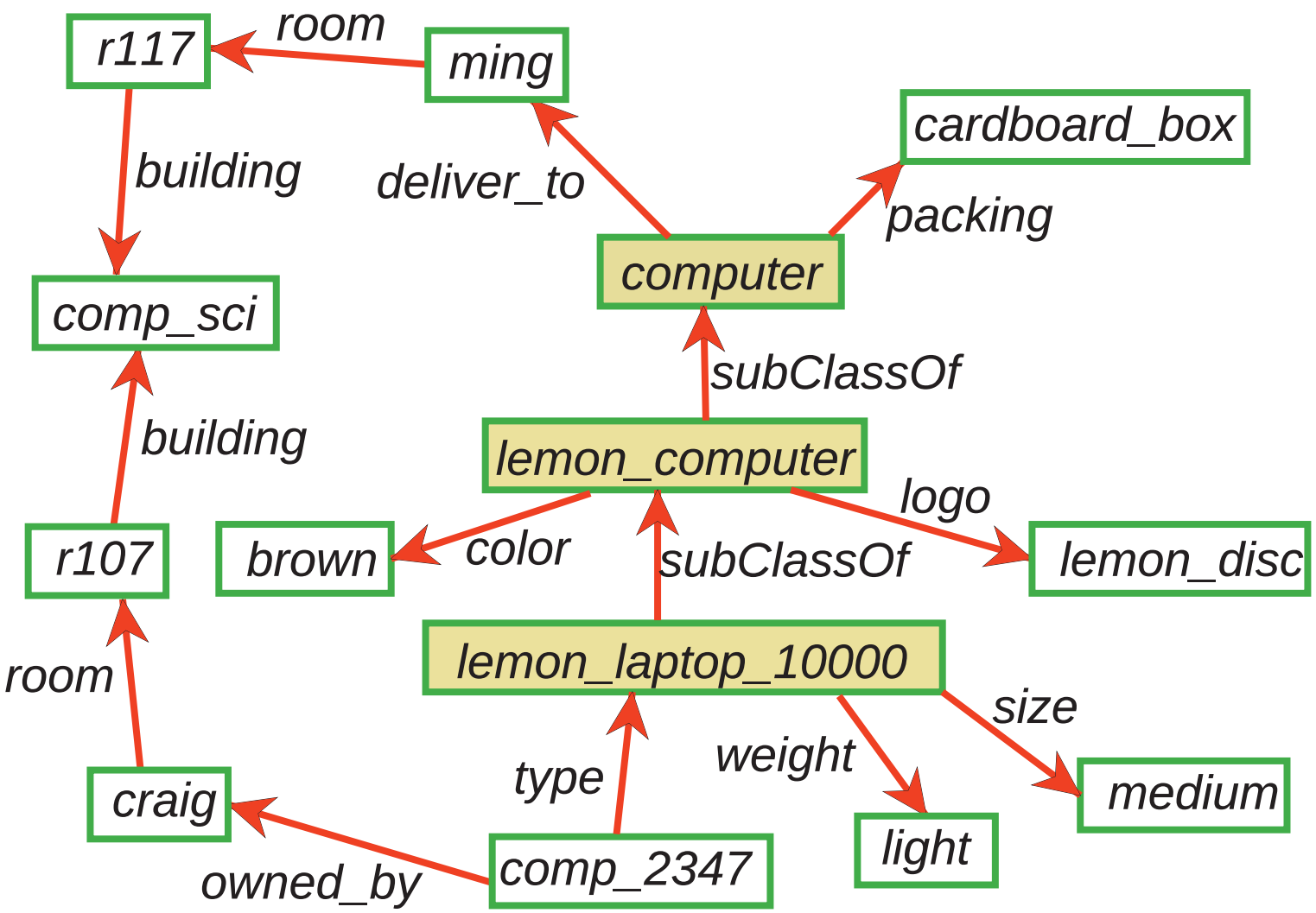
Turtle Example

⟨comp_3645⟩ ⟨#owned_by⟩ ⟨#fran⟩ ;
⟨#color⟩ ⟨#green⟩ , ⟨#yellow⟩ ;
⟨#managed_by⟩ [⟨#occupation⟩ ⟨#sys_admin⟩ ;
⟨#serves_building⟩ ⟨#comp_sci⟩].

Primitive versus Derived Properties

- Primitive knowledge is that which is defined explicitly by facts.
- Derived knowledge is knowledge defined by rules.
- a class is a set of individuals that are grouped together as they have similar properties.
- Example: All lemon computers may have *color* = *brown*. Associate this property with the class, not the individual.
- Allow a special property *type* between an individual and a class.
- Use a special property *subClassOf* between two classes that allows for property inheritance.

A Structured Semantic Network



Logic of Property

An arc $\xrightarrow{p} n$ from a class c with a property p to value n means every individual in the class has value n of property p:

$$prop(Obj, p, n) \leftarrow$$
$$\quad prop(Obj, type, c).$$

Example:

$$prop(X, weight, light) \leftarrow$$
$$\quad prop(X, type, lemon\_laptop\_10000).$$
$$prop(X, packing, cardboard\_box) \leftarrow$$
$$\quad prop(X, type, computer).$$

Logic of Property Inheritance

You can do inheritance through the subclass relationship:

$$prop(X, type, T) \leftarrow$$
$$prop(S, subClassOf, T) \wedge$$
$$prop(X, type, S).$$

Multiple Inheritance

- An individual is usually a member of more than one class. For example, the same person may be a mother, a teacher, a football coach,. . . .
- The individual can inherit the properties of all of the classes it is a member of: multiple inheritance.
- If there are default values, we can have a problem when an individual inherits conflicting defaults from the different classes: multiple inheritance problem.

Choosing Primitive and Derived Properties

- Associate an property value with the most general class with that property value.
- Don't associate contingent properties of a class with the class. For example, if all of current computers just happen to be brown.