Design Patterns

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Outline

- Design Patterns

- Design Pattern Workflow

- Design Pattern Principles

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Design Patterns

Logically well-defined visual representations informed by and evaluated against competency questions, designed to support human-human and human-machine interoperability

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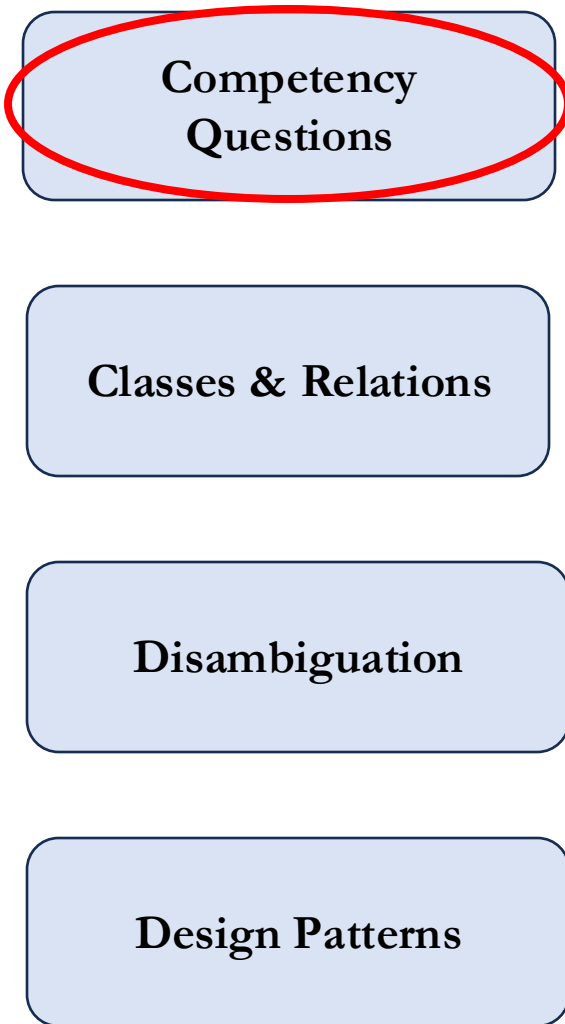
Guidance

Competency Questions

Classes & Relations

Disambiguation

Design Patterns

Guidance

- Competency questions are **used to guide ontology development** and **generate unit tests** to ensure ontologies are sufficiently well-developed

- Identify a preliminary list of competency questions **first**

- They will help you scope your project

Competency Questions

Classes & Relations

Disambiguation

Design Patterns

Type of OCQ	Purpose	Examples
Scoping CQ (SCQ)	Define the domain and scope of the ontology	Which predators eat rabbits? What information is clinically relevant for social interaction assessment?
Validation CQ (VCQ)	Verify the accuracy of the content	Is ruby a type of chocolate? What is the Base of ThinAndCrispyPizza?
Foundational CQ (FCQ)	Align entities with a foundational ontology	Is water bottle classified as a Material Entity in the BFO foundational ontology? Is coffee something that cannot be counted, or only in specific quantities?
Relationship CQ (RCQ)	Investigate the characteristics of relationships	What is the domain and range of the eating relationship? If a body contains a heart and a heart contains a cell, does the body contain the cell?
Metaproperty CQ (MpCQ)	Classify entities based on metaproperties	Is each instance of a coffee bean necessarily (at all times of its existence) an instance of a coffee bean? Does a thesis defense have a definite endpoint?

Keet, M, Kahn, Z. 2023 *On the Roles of Competency Questions in Ontology Engineering*
http://www.meteck.org/files/EKAW24positionPaperCQs.pdf

At what speed does a patrol boat move in knots over an hour?
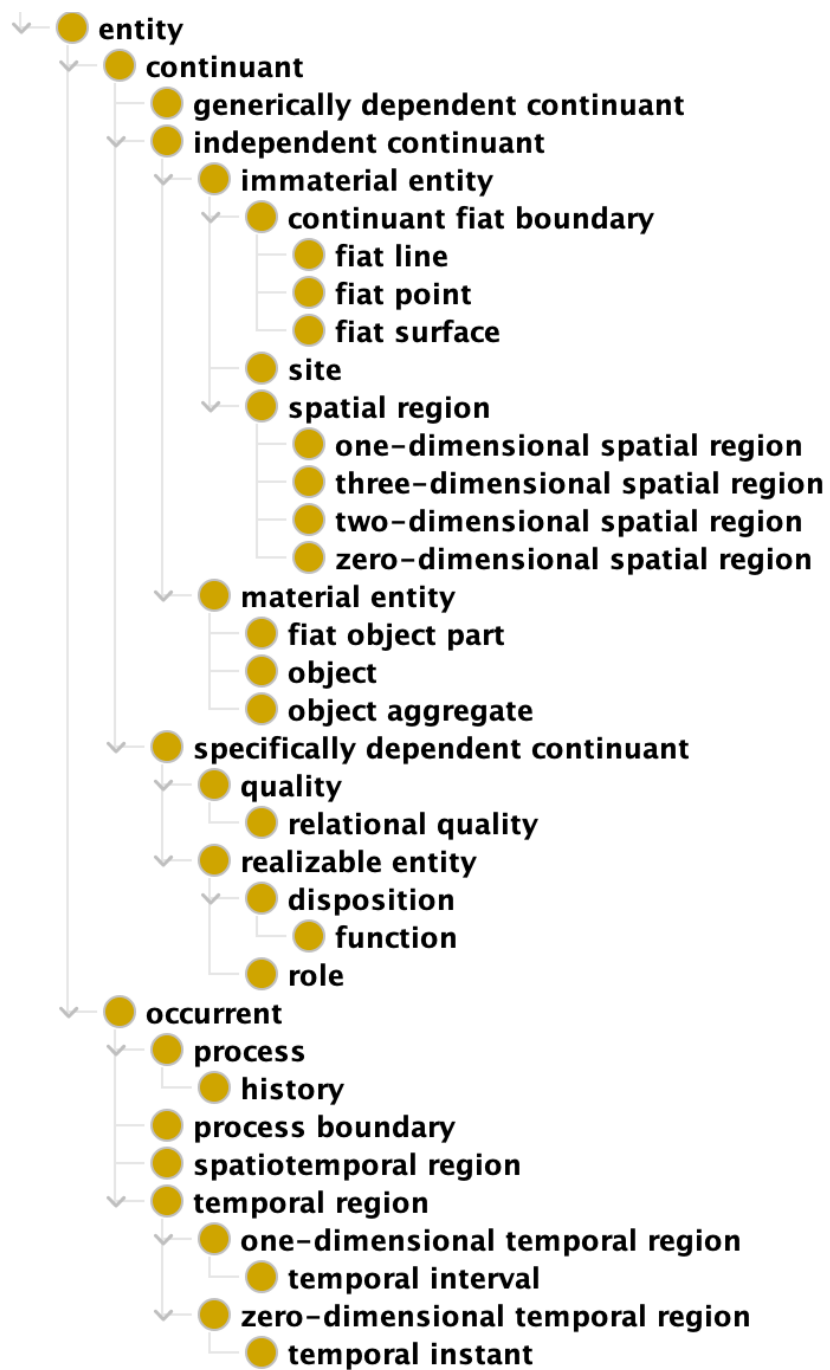
Classes & Relations

- Using competency questions as guidance, list the classes and relations you will need to represent to answer the questions

- Create this list through the lens of, say, Basic Formal Ontology (BFO) and/or Common Core Ontologies classes and relations

- I illustrate using BFO

Competency Questions

Classes & Relations

Disambiguation

Design Patterns

- entity
  - continuant
    - generically dependent continuant
    - independent continuant
      - immaterial entity
        - continuant fiat boundary
          - fiat line
          - fiat point
          - fiat surface
        - site
        - spatial region
          - one-dimensional spatial region
          - three-dimensional spatial region
          - two-dimensional spatial region
          - zero-dimensional spatial region
      - material entity
        - fiat object part
        - object
        - object aggregate
    - specifically dependent continuant
      - quality
        - relational quality
      - realizable entity
        - disposition
          - function
        - role
  - occurrent
    - process
      - history
    - process boundary
    - spatiotemporal region
    - temporal region
      - one-dimensional temporal region
        - temporal interval
      - zero-dimensional temporal region
        - temporal instant

- concretizes
- continuant part of
  - member part of
- environs
- exists at
- first instant of
- generically depends on
- has continuant part
  - has member part
- has first instant
- has history
- has last instant
- has material basis
- has occurrent part
  - has temporal part
- has participant
- has realization
- history of
- is carrier of
- is concretized by
- last instant of
- located in
- location of
- material basis of
- occupies spatial region
- occupies spatiotemporal region
- occupies temporal region
- occurrent part of
  - temporal part of
- occurs in
- participates in
- preceded by
- precedes
- realizes
- spatially projects onto
- specifically depended on by
  - bearer of
- specifically depends on
  - inheres in
- temporally projects onto

Rules of Thumb

- When identifying classes, describe:

    1. Material entities within scope, i.e. **Material Entity**
    2. Qualities these material entities have, i.e. **Quality**
    3. What these material entities could do, i.e. **Realizable Entity**
    4. What these material entities actually do, i.e. **Process**
    5. Where these material entities and boundaries are located, i.e. **Immaterial Entity**
    6. When these entities exist, i.e. **Temporal Region**
    7. Information we use to talk about 1-6, i.e. **Generically Depedent Continuant**

https://github.com/BFO-ontology/BFO-
2020

Classes

- Material Entities –

- Qualities –

- Processes –

- Realizables –

- Sites & Boundaries –

- Temporal Region –

- Information –

At what speed does a patrol boat move in knots over an hour?

Classes

- Material Entities – **Patrol boat**

- Qualities –

- Processes –

- Realizables –

- Sites & Boundaries –

- Temporal Region –

- Information –

At what speed does a patrol boat move in knots over an hour?

Classes

- Material Entities – Patrol boat

- Qualities –

- Processes – **Act of motion**

- Realizables –

- Sites & Boundaries –

- Temporal Region –

- Information –

At what speed does a patrol boat move in knots over an hour?

Classes

- Material Entities – Patrol boat

- Qualities –

- Processes – Act of motion, **speed?**

- Realizables –

- Sites & Boundaries –

- Temporal Region –

- Information – **speed?**

At what speed does a patrol boat move in knots over an hour?

Classes

- Material Entities – Patrol boat
- Qualities –
- Processes – Act of motion, speed*
- Realizables –
- Sites & Boundaries –
- Temporal Region –
- Information – speed*

use * to note ambiguity then move on; we will revisit

At what speed does a patrol boat move in knots over an hour?

Classes

- Material Entities – Patrol boat

- Qualities –

- Processes – Act of motion, speed*

- Realizables –

- Sites & Boundaries –

- Temporal Region –

- Information – speed*, **knots measurement**

At what speed does a patrol boat move in knots over an hour?

Classes

- Material Entities – Patrol boat

- Qualities –
- Processes – Act of motion, speed*
- Realizables –
- Sites & Boundaries –
- Temporal Region – **hours***
- Information – speed*, knots measurement, **hours***

use * to note ambiguity then move on; we will revisit

At what speed does a patrol boat move in knots over an hour?

Disambiguate

- Logic is **demanding**, in part because it is **complete**

- We make explicit the implicit semantics within data, which requires disambiguating

- It is easier to stitch meaning together having cut it from whole cloth, than it is from disparate meanings

Competency Questions

Classes & Relations

Disambiguation

Design Patterns

Disambiguation

- **Information** vs what that information **is about**, e.g. occupation code vs a holder of an occupation

- **Material** vs **immaterial** things, e.g. a given river vs the site where the river used to flow

- **Bearing properties** vs **bearers of properties**, e.g. apple's redness vs the apple

- **Processes** vs **product**, e.g. ontology engineering vs ontology produced

Disambiguation

- **Information** vs what that information **is about**, e.g. occupation code vs a holder of an occupation

- **Material** vs **immaterial** things, e.g. a given river vs the site where the river used to flow

- **Bearing properties** vs **bearers of properties**, e.g. apple's redness vs the apple

- **Processes** vs **product**, e.g. ontology engineering vs ontology produced

Revisiting Ambiguity

- "speed" as a process vs information about a process

Revisiting Ambiguity

- "speed" as a process vs information about a process

- Speed is the magnitude of a change in position over time

INFORMATION

Revisiting Ambiguity

- "speed" as a process vs information about a process

- Speed is the changing of position over time

PROCESS

Revisiting Ambiguity

- "speed" as a process vs information about a process

At what speed does a patrol boat move in knots over an hour?

WHICH DO WE CARE ABOUT FOR THIS COMPETENCY QUESTION?

Simplify

- Material Entities – Patrol boat

- Qualities –

- Processes – Act of motion, speed*

- Realizables –

- Sites & Boundaries –

- Temporal Region – hours*

- Information – speed*, knots measurement, hours*

At what speed does a patrol boat move in knots over an hour?

Simplify

- Material Entities – Patrol boat

- ~~Qualities –~~

- Processes – Act of motion, speed*

- ~~Realizables –~~

- ~~Sites & Boundaries –~~

- Temporal Region – hours*

- Information – ~~speed*,~~ knots measurement, ~~hours*~~

simplify the list

At what speed does a patrol boat move in knots over an hour?

Relations

- Material Entities – Patrol boat
- Processes – Act of motion, speed
- Temporal Region – hours
- Information – knots measurement

and reflect on relationships among the listed entities

At what speed does a patrol boat move in knots over an hour?

Rules of Thumb

- When identifying relations, describe:

1. Qualities to material entities, i.e. **inheres in**
2. Realizables to material entities, i.e. **inheres in**, **has material basis**
3. Processes to material entities, i.e **participates in**
4. Realizables to processes, i.e. **has realization**
5. Immaterial location of material entity, i.e. **located in**
6. When any such entities exist, i.e. **exists at**, **datatype property**
7. When any such entities carry information, e.g. **generically depends on**

https://github.com/BFO-ontology/BFO-2020

Relations

- Material Entities – **Patrol boat**

- Processes – **Act of motion**, speed

- Temporal Region – hours

- Information – knots measurement

patrol boats participate in processes

https://github.com/BFO-ontology/BFO-

```
concretizes
continuant part of
    member part of
environs
exists at
first instant of
generically depends on
has continuant part
    has member part
has first instant
has history
has last instant
has material basis
has occurrent part
    has temporal part
has participant
has realization
history of
is carrier of
is concretized by
last instant of
located in
location of
material basis of
occupies spatial region
occupies spatiotemporal region
occupies temporal region
occurrent part of
    temporal part of
occurs in
participates in
preceded by
precedes
realizes
spatially projects onto
specifically depended on by
    bearer of
specifically depends on
    inheres in
temporally projects onto
```

Design Patterns

- Classes and relations identified, turn next to constructing visual representations reflecting the competency questions

- If you have completed the preceding steps, this should be relatively straightforward

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Pretty Principles

- **Always** include a legend or key

- Distinguish **classes** as ovals from **instances** as diamonds from strings as rectangles (or each by color)

- Distingish **direct relations** from **shortcuts** by solid and hyphenated arrows

- **All-Some Rule**: Read arrows as reflecting "any instance of class X arrow some instance of class Y"
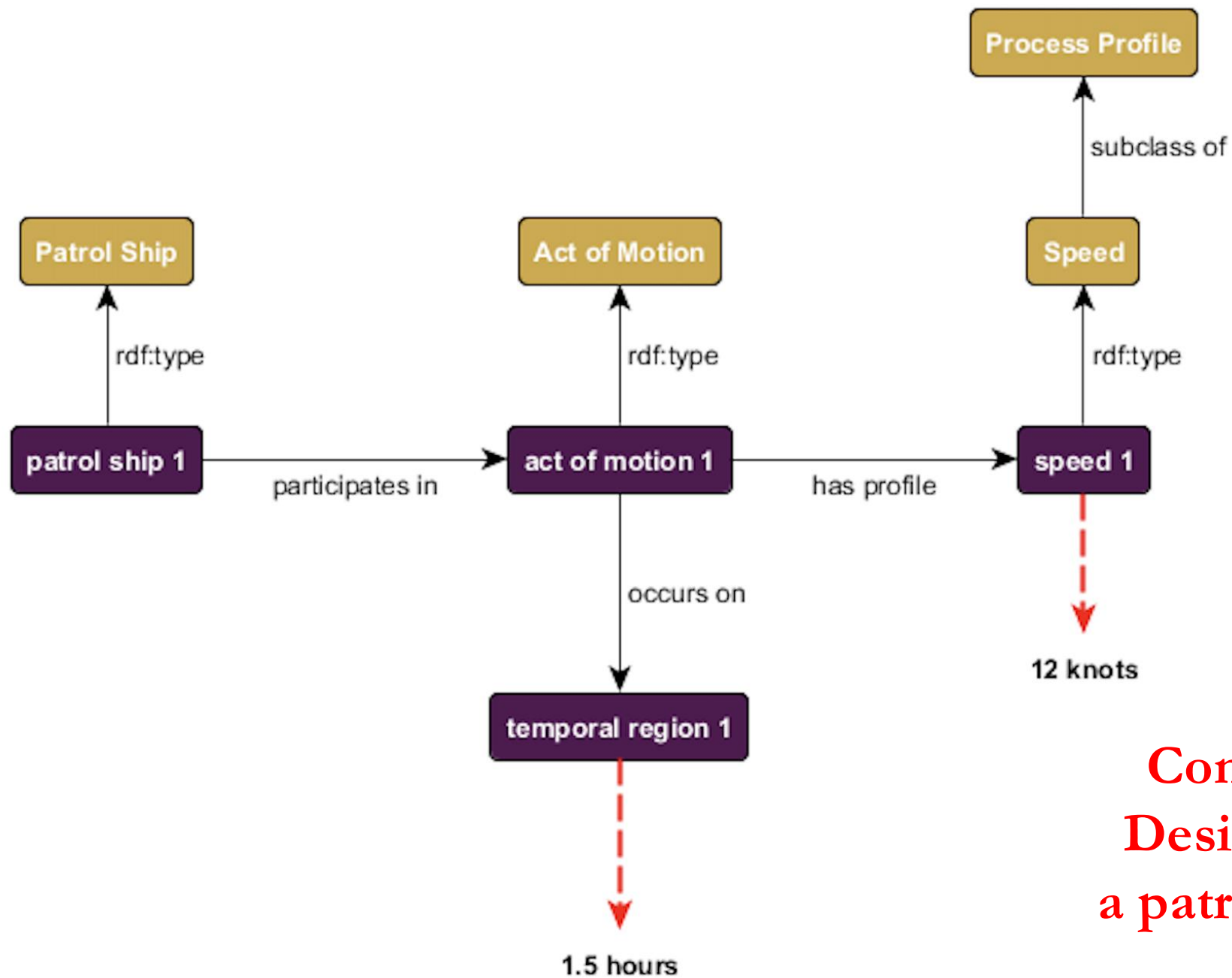
Common Core Ontologies Design Pattern representing a patrol ship traveling 12 knots over 1.5 hours

Human-Machine Interoperability

- Ontology engineers must often work with developers who need to deploy our artifacts

- Developers do not always need the full ontology design patterns or ontologies that we create

- We create full patterns to future-proof our projects

- We must be able to give developers what they need

Cut from the Whole Cloth Principle

- Call the full pattern ontology engineers are trained to generate a **Complex Design Pattern (CDPs)**

- Call sub-graphs of Complex Design Patterns that aim to addressing specific user needs **Simplified Design Patterns (SDPs)**

- Our task is to show how to construct SDPs from CDPs, so we maintain a connection from what developer's need now to what they might need in the future
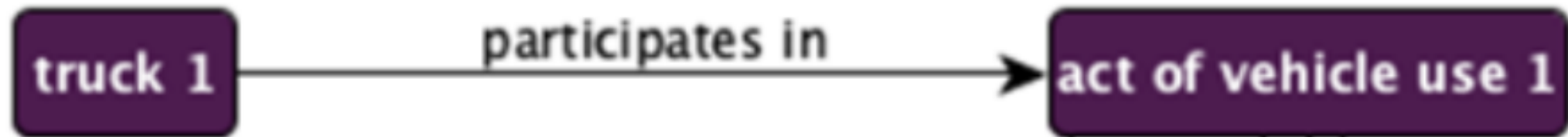
Represent the path taken by a ground vehicle over some geospatial region.
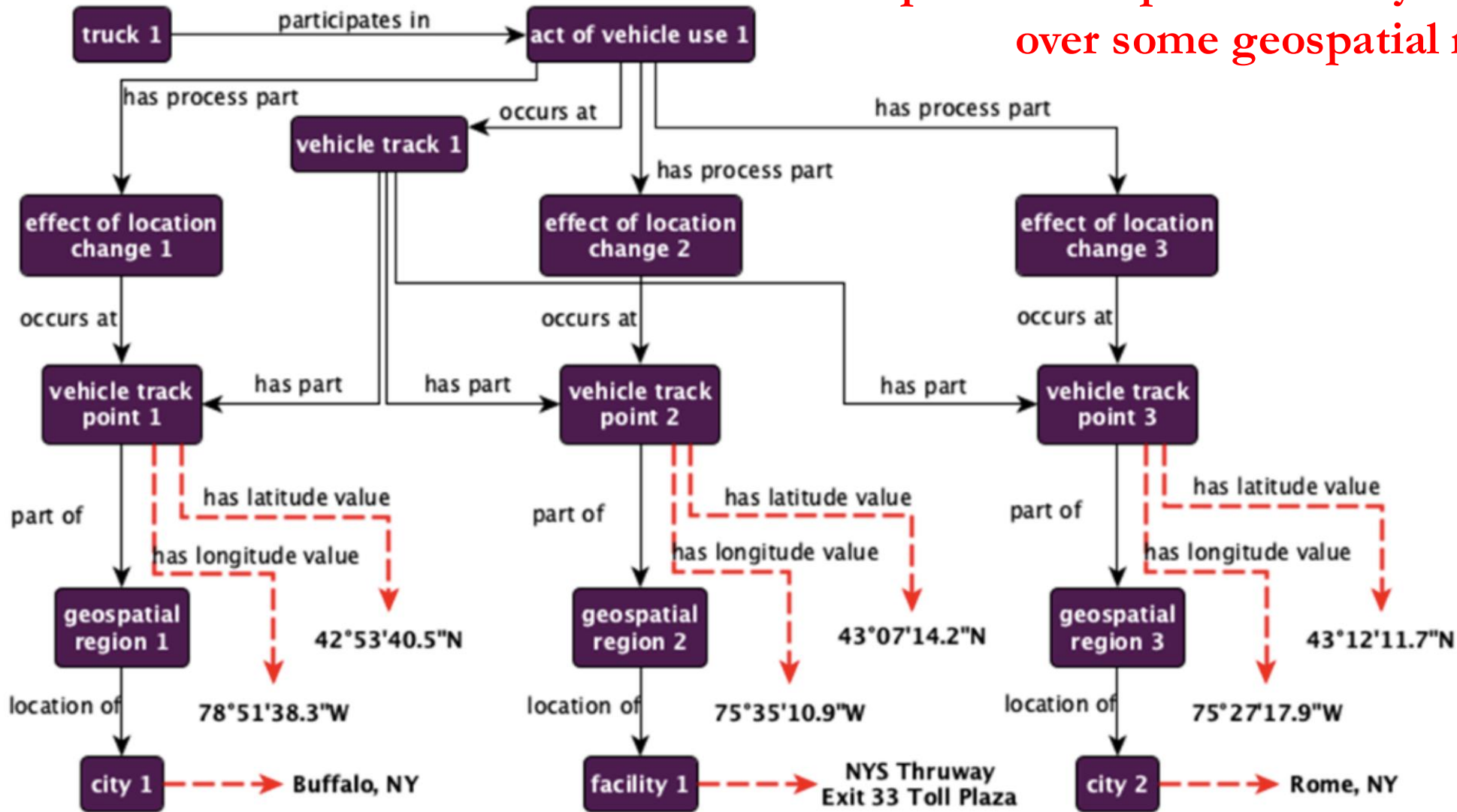
Developers may only need, for example, that a truck participates in an act of vehicle use
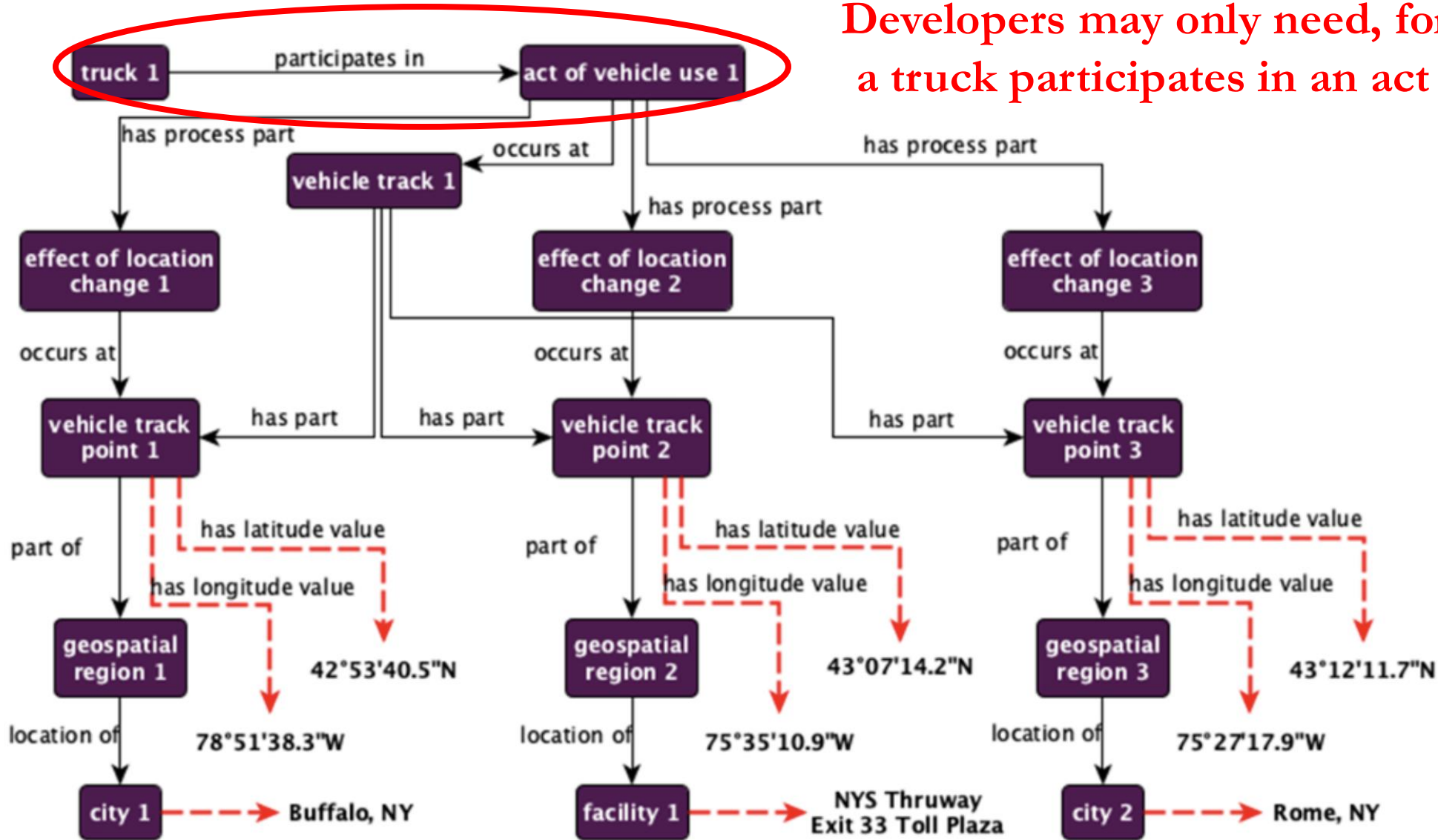
If so, then that is what you give them...

truck 1 — participates in → act of vehicle use 1

This is acceptable because – in the actual ontology artifact on a given computing system – we can cut this part of the graph from the larger graph represented in the preceding design pattern

Balancing Principle

- It's easier to cut simplified design patterns out of complex design patterns

- Even so, there is still a balancing act to maintain

- You do not want your design pattern to be so narrow that it only addresses one competency question

- Nor do you want it so broad that it could potentially answer every

Balancing Principle

- Competency questions provide guidance here once again

- You should ask, as a rough guide:

How many competency questions can I answer with this design pattern?