Bar-Ilan University

# Proposition Knowledge Graphs

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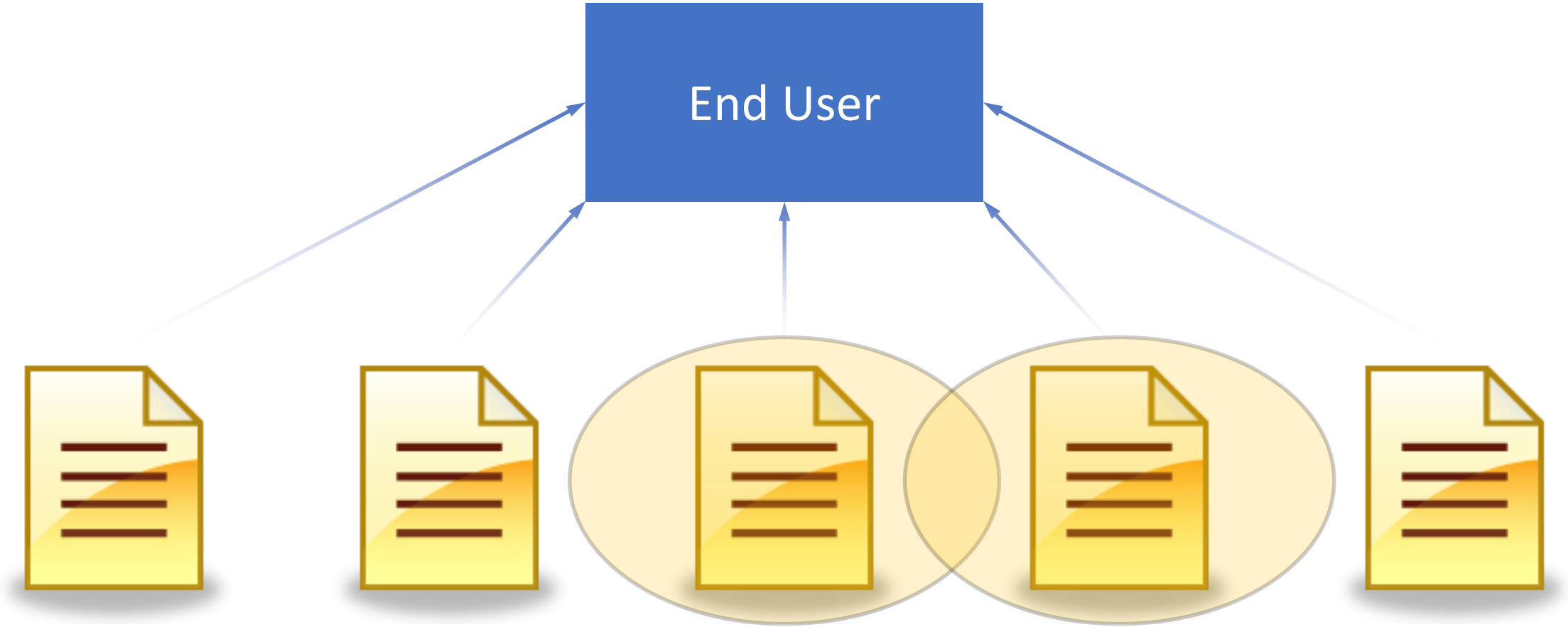
# Problem

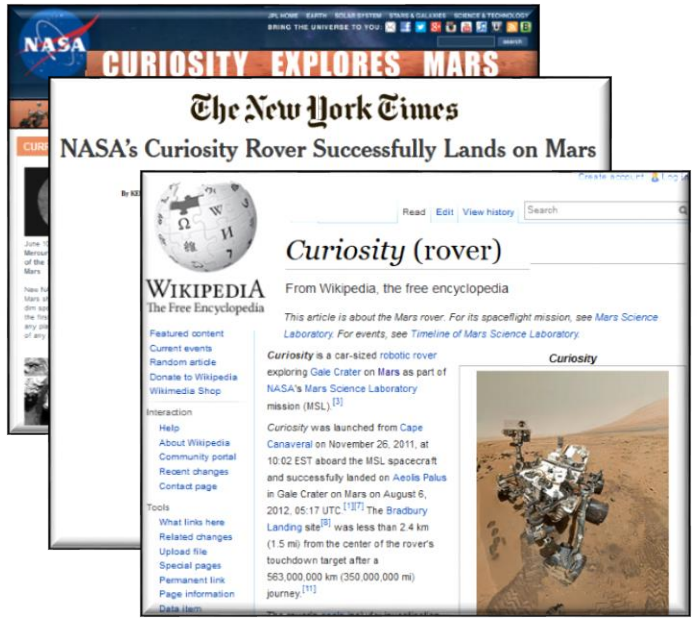


# Case Study: Curiosity (Mars Rover)

Curiosity is a fully equipped lab.

Curiosity is a rover.

Mars rover Curiosity will look for environments where life could have taken hold.




The Mars rover Curiosity is a mobile science lab.

Curiosity will look for evidence that Mars might have had conditions for supporting life.

Curiosity, the Mars rover, functions as a mobile science laboratory.

Curiosity successfully landed on Mars.

Mars rover Curiosity successfully landed on the red planet.

# Goal: Representation for Information Discovery

- Representing a **Single Sentence**:
  Captures maximum of the meaning conveyed

- Consolidation Across **Multiple Sentences**:
  Groups semantically-equivalent propositions

- **Traversable** Representation:
  Allows its end user to semantically navigate its structure

# Talk Outline

- Single Sentence Representation
  - SRL
  - AMR
  - Open-IE
  - **Proposition Structure**
- Proposition Knowledge Graphs
  - From Single to **Multiple Sentence** Representation

# Representing a Single Sentence

## Existing Frameworks

**SRL**

AMR

Open-IE

# Semantic Role Labeling (SRL)

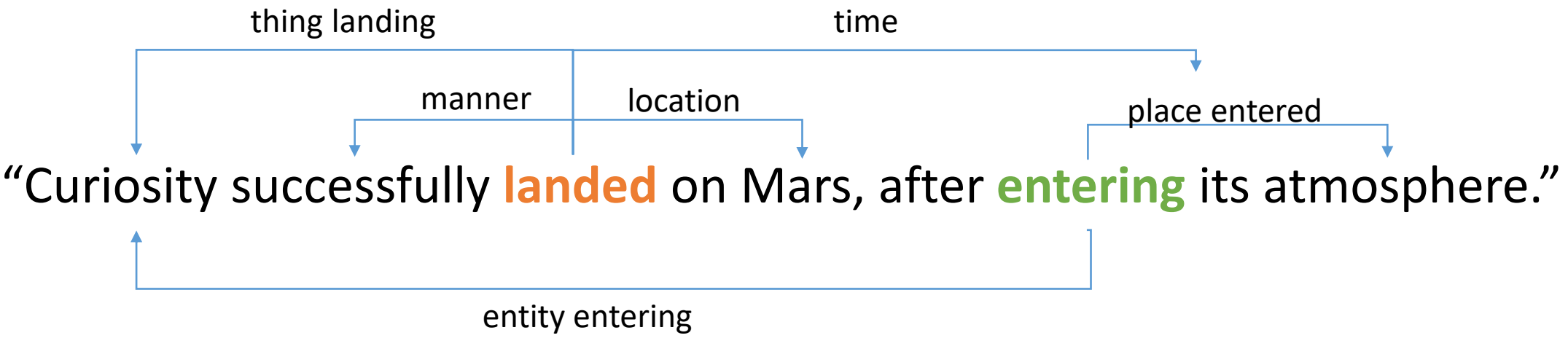
- Maps predicates and arguments in a sentence to a predefined ontology

- Existing ontologies:
  - PropBank
  - FrameNet
  - NomBank

# Semantic Role Labeling (SRL)

“Curiosity successfully **landed** on Mars, after **entering** its atmosphere.”

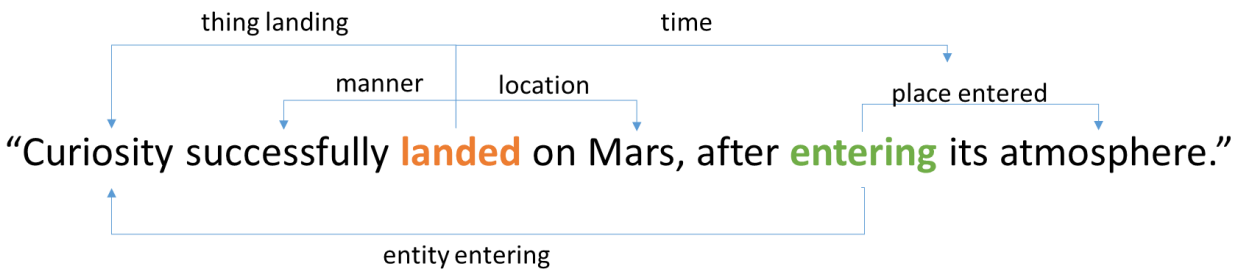
# Semantic Role Labeling (SRL)



# Semantic Role Labeling (SRL)

**Pros**

**Cons**



# Representing a Single Sentence

## Existing Frameworks

SRL

**AMR**

Open-IE

# Abstract Meaning Representation (AMR)

- Maps a sentence onto a hierarchical structure of propositions
- Uses PropBank for predicates, where possible

# Abstract Meaning Representation (AMR)

"Curiosity successfully landed on Mars, after entering its atmosphere."

```
(l / land-01
        :arg1 (c / Curiosity)
        :location (m / Mars)
        :manner (s / successful)
        :time (b / after
                :op1 (e / enter-01
                        :arg0 c
                        :arg1 (a / atmosphere
                                :poss m))))
```

# Abstract Meaning Representation (AMR)

**Pros**

**Cons**

```
(l / land-01
        :arg1 (c / Curiosity)
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```

# Representing a Single Sentence

## Existing Frameworks

SRL

AMR

**Open-IE**

# Open Information Extraction (Open IE)

- Extracts propositions from text based on surface/syntactic patterns
- Represents propositions as predicate-argument tuples
- Each element is a natural language string

# Open Information Extraction (Open IE)

“Curiosity successfully landed on Mars, after entering its atmosphere.”

((“Curiosity”, “successfully landed on”, “Mars”);
**ClausalModifier:** “after entering its atmosphere”)

# Open Information Extraction (Open IE)

**Pros**

**Cons**

((“Curiosity”, “successfully landed on”, “Mars”);
**ClausalModifier:** “after entering its atmosphere”)

# Proposition Knowledge Graphs

**Representing a Single Sentence**

Consolidation Across Multiple Sentences

Traversing the Representation

# Representing a Single Sentence

"Curiosity will **look for** evidence that
Mars might **have** had conditions for **supporting** life."

# Representing a Single Sentence

"Curiosity will **look for** evidence that
Mars might **have** had conditions for **supporting** life."

| | |
|---|---|
| Predicate: | **look for** |
| Tense: | *future* |
| Subject: | **Curiosity** |
| Object: | **evidence** |

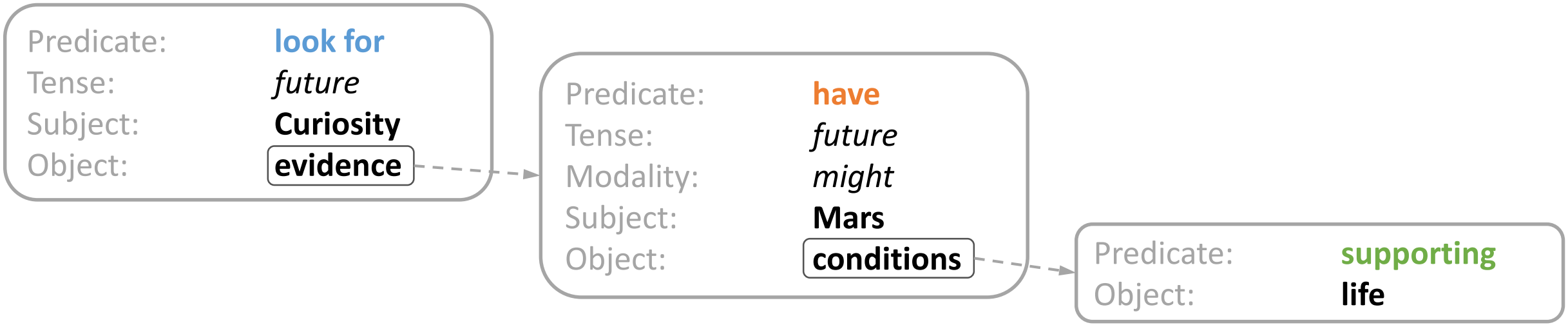
| | |
|---|---|
| Predicate: | **have** |
| Tense: | *future* |
| Modality: | *might* |
| Subject: | **Mars** |
| Object: | **conditions** |

| | |
|---|---|
| Predicate: | **supporting** |
| Object: | **life** |

**Nodes** are **propositions**

# Representing a Single Sentence

"Curiosity will **look for** evidence that
Mars might **have** had conditions for **supporting** life."




**Edges** are **syntactic relations**

# Representing a Single Sentence

"Curiosity will **look for** evidence that
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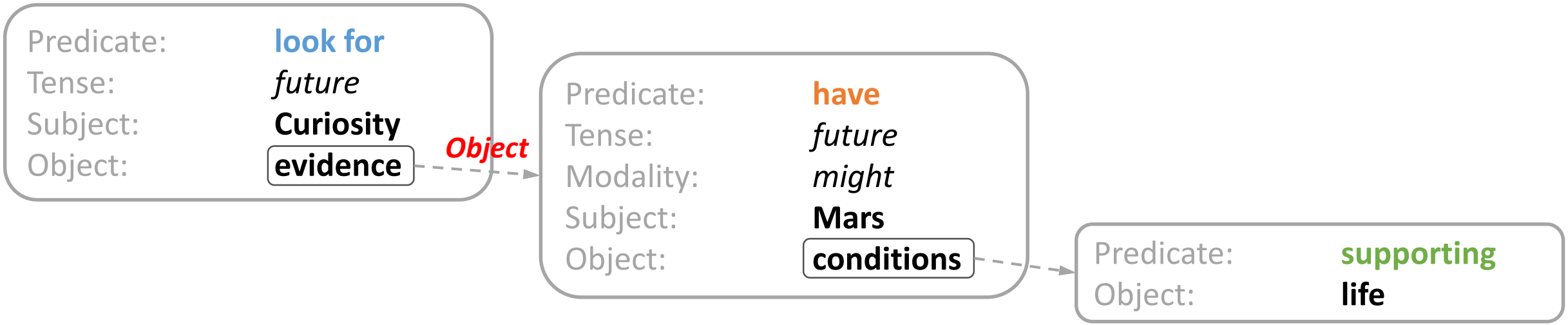



**Edges** are **syntactic relations**

# Representing a Single Sentence

- Propositions can be **implied from syntax**

possessives

Curiosity's robotic arm is used to collect samples ----→ *Curiosity **has a** robotic arm*

Apposition

Curiosity, the Mars rover, landed on Mars ----→ *Curiosity **is** the Mars rover*

- Implied propositions can also be introduced by *adjectives, nominalizations, conjunctions*, and more

# Proposition Knowledge Graphs (PKG)

**Pros**

**Cons**

# Proposition Knowledge Graphs (PKG)

- We have seen:
  - PKG adopts Open-IE robustness
  - PKG improves over its expressiveness

- Semantic relations are left for higher level representation
  - Which we will see next

# Proposition Knowledge Graphs

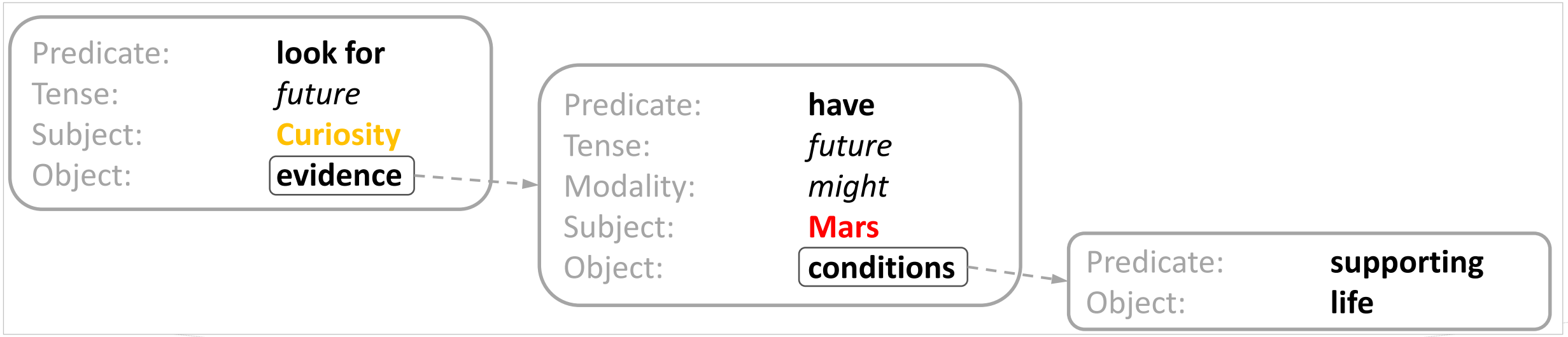
Representing a Single Sentence

**Consolidation Across Multiple Sentences**

Traversing the Representation

# Consolidation

Proposition structures serve as backbone for higher level representation

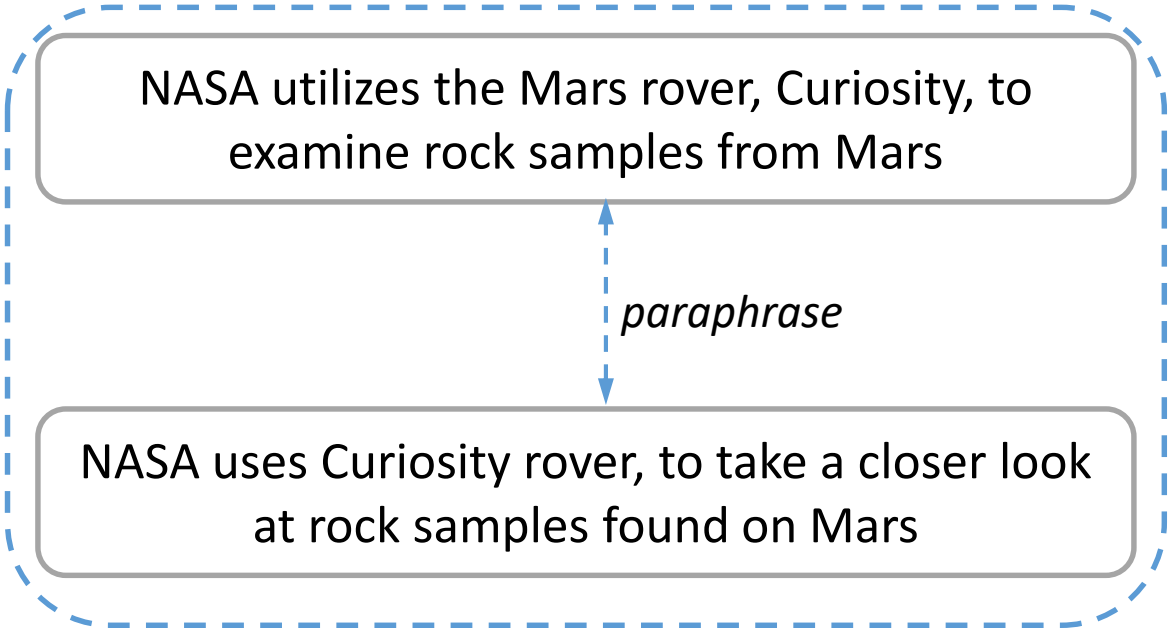



Curiosity will look for evidence that Mars might have had conditions for supporting life.

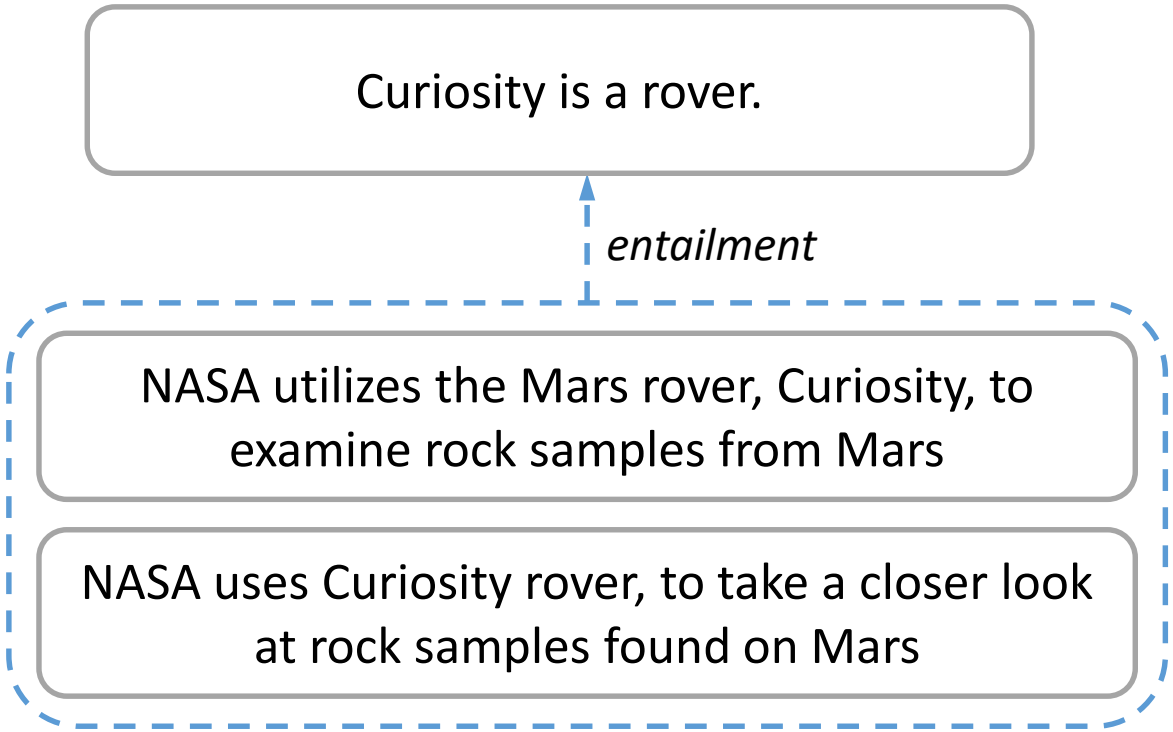
# Consolidation

- **Semantic edges** are drawn between sentences
  - Entailment
  - Temporal
  - Conditional
  - Causality

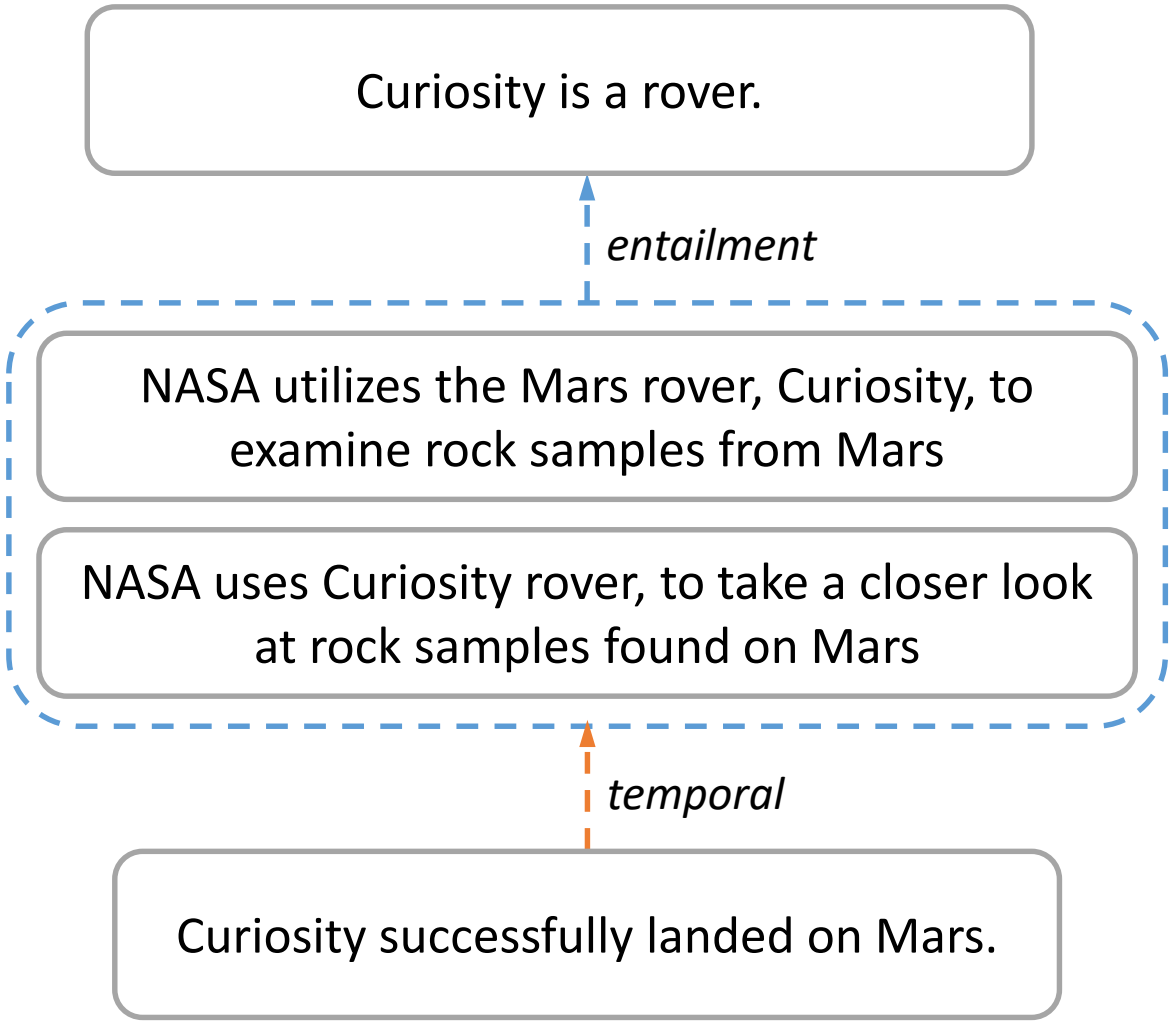
# Paraphrases



# Entailment


Curiosity is a rover.
entailment
NASA utilizes the Mars rover, Curiosity, to examine rock samples from Mars
NASA uses Curiosity rover, to take a closer look at rock samples found on Mars

# Temporal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NASA utilizes the Mars rover, Curiosity, to examine rock samples from Mars
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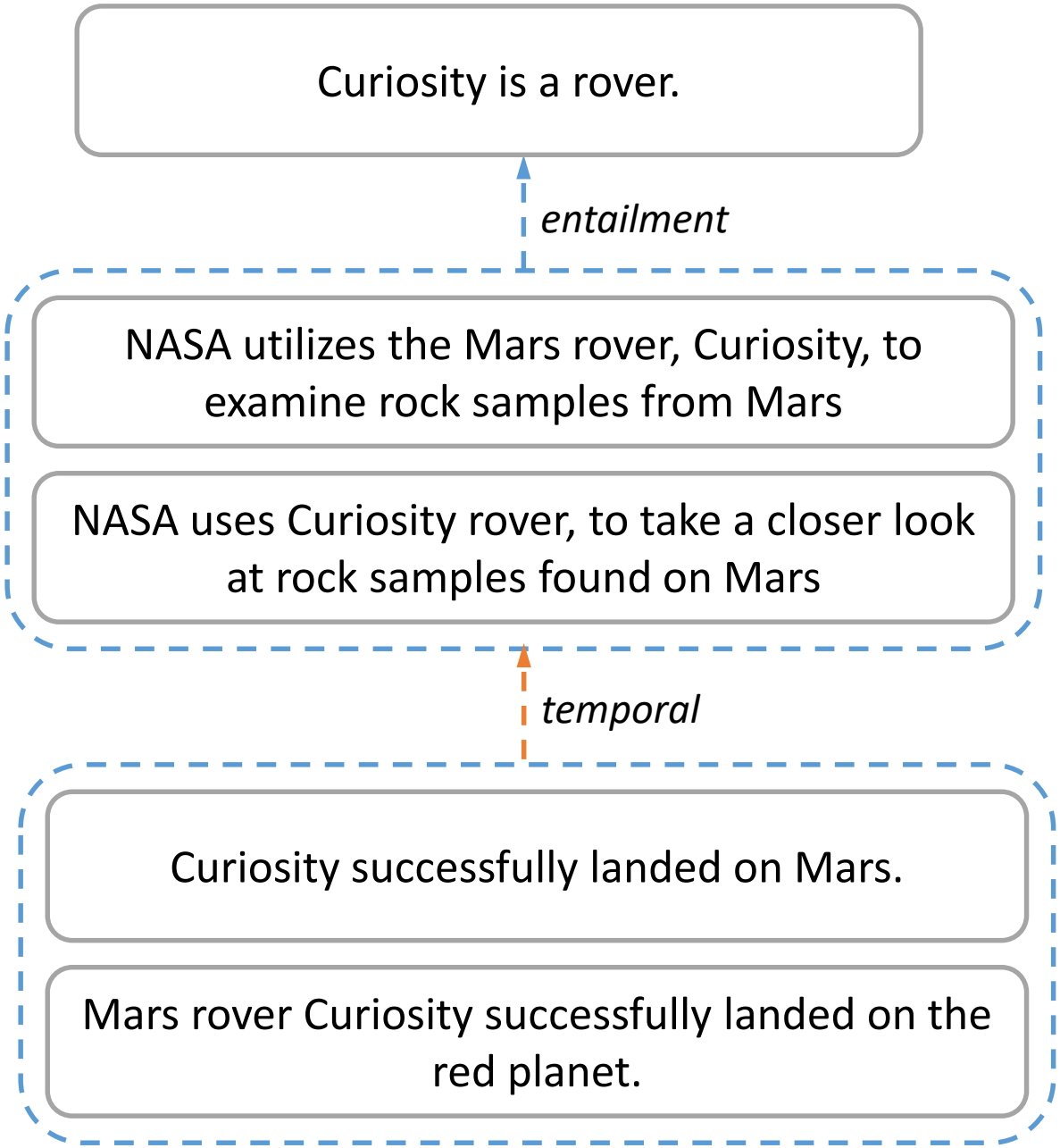
temporal
Curiosity successfully landed on Mars.

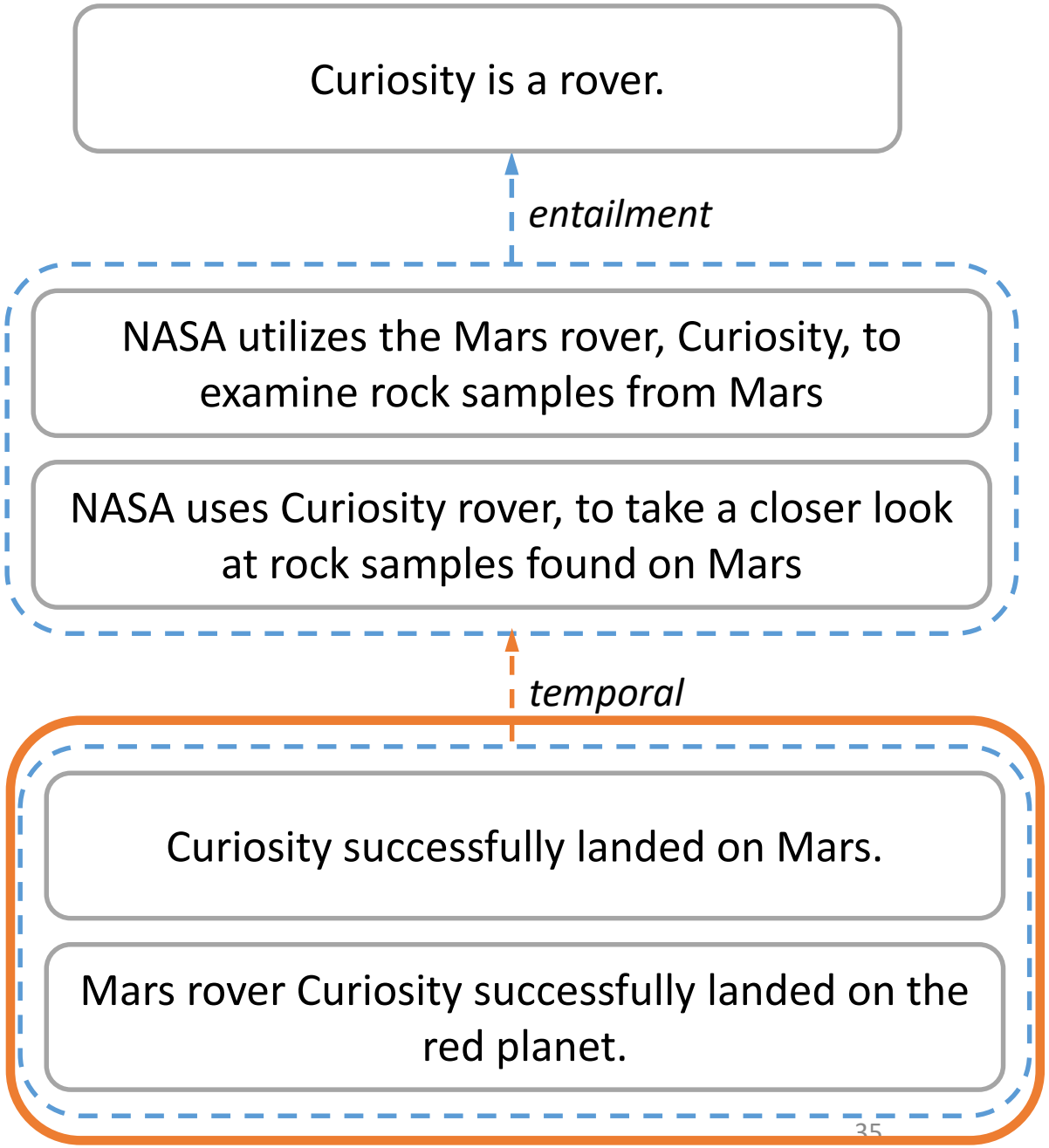
# Proposition Knowledge Graphs

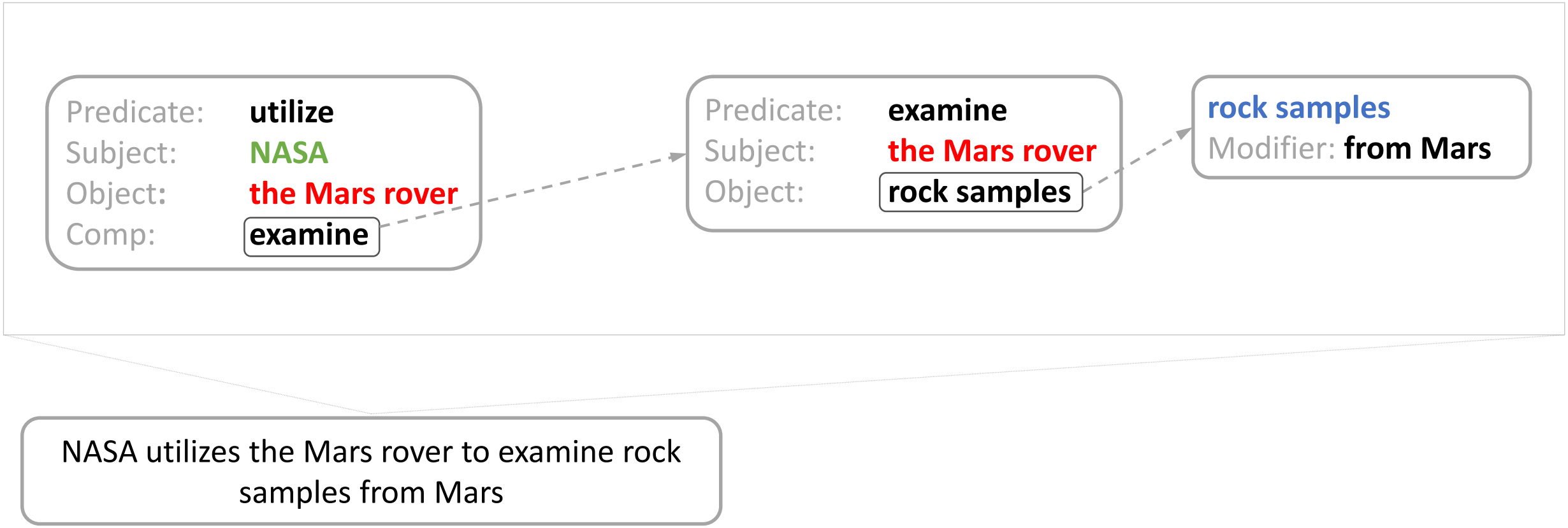
Representing a Single Sentence
Consolidation Across Multiple Sentences
**Traversing the Representation**

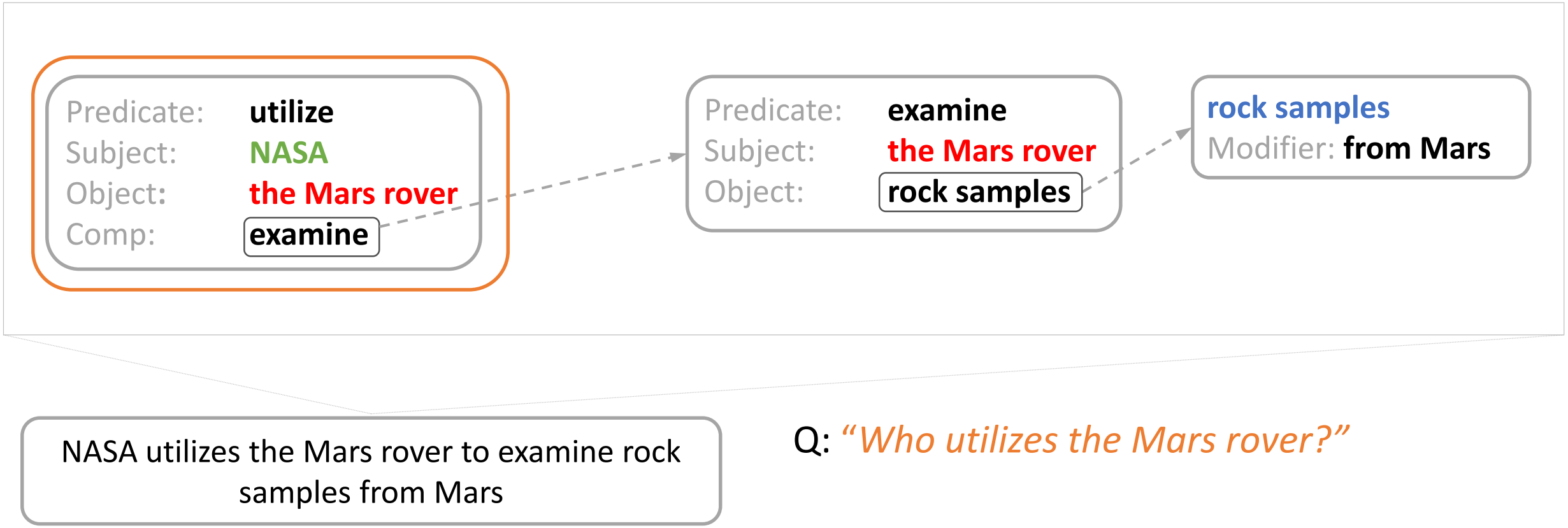
Q: *“What did Curiosity do after landing?”*



Q: *“What did Curiosity do after landing?”*

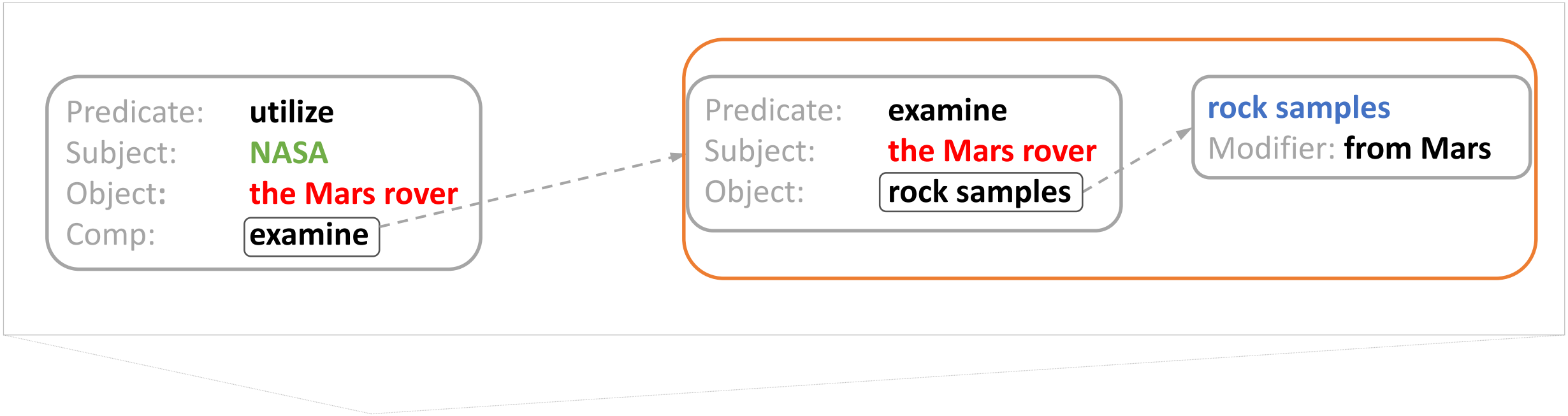



Predicate: utilize
Subject: NASA
Object: the Mars rover
Comp: examine
Predicate: examine
Subject: the Mars rover
Object: rock samples
rock samples
Modifier: from Mars
NASA utilizes the Mars rover to examine rock samples from Mars




NASA utilizes the Mars rover to examine rock samples from Mars

Q: *"Who utilizes the Mars rover?"*




NASA utilizes the Mars rover to examine rock samples from Mars

Q: *"Who utilizes the Mars rover?"*

Q: *"What did the Mars rover examine?"*

# Challenges (Ongoing Work)

- Extract rich propositions from text
- Extract inter-proposition relations implied by text
- Discover semantic relations between sentences not implied by text

Thank you for listening!