

Run-based semantics for RPQs

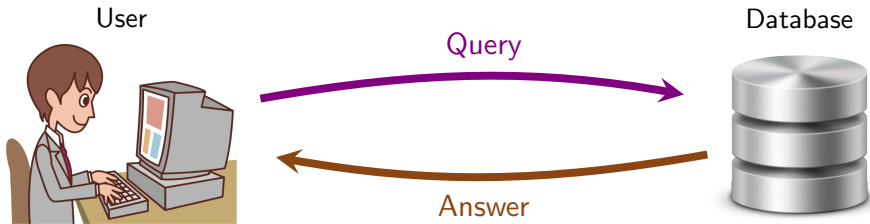
Victor MARSAULT*

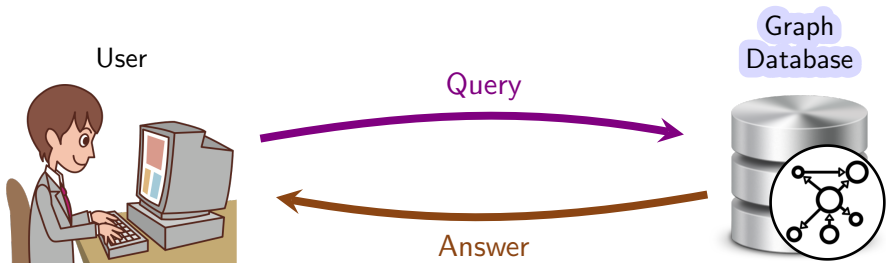
joint work with Claire DAVID* and Nadime FRANCIS*

* Université Gustave-Eiffel, CNRS, LIGM

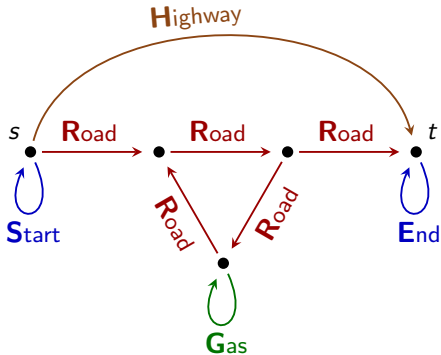
Highlights'22

2022-06-29

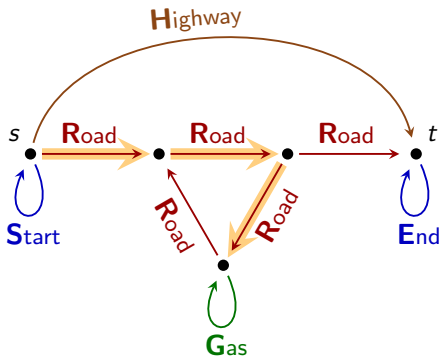




- Finite label alphabet:
 $\Sigma = \{\mathbf{S}, \mathbf{R}, \mathbf{H}, \mathbf{G}, \mathbf{E}\}$
- Vertices
- Edges labelled over Σ



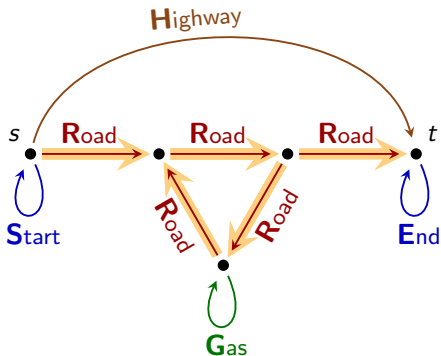
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Terminogy: Walk

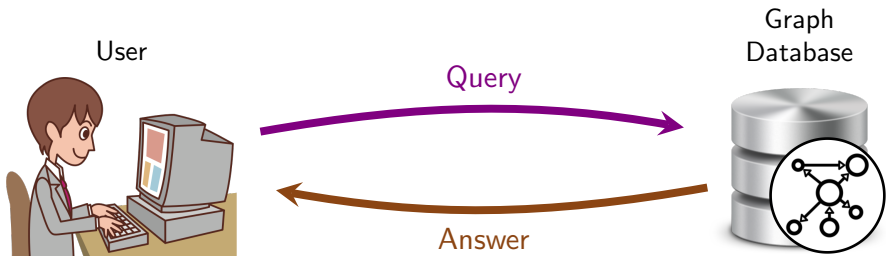
- a.k.a. Path
- Consistent sequence of edges

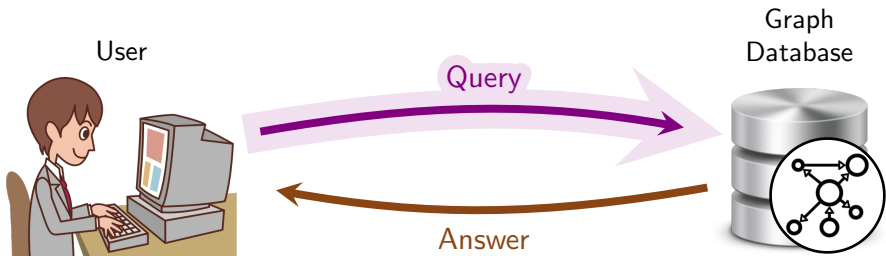
- Finite label alphabet:
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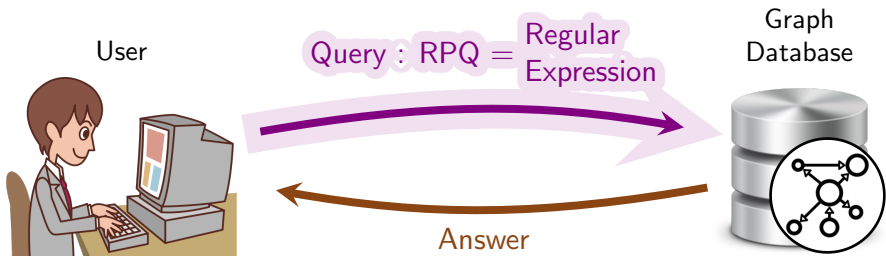


Terminology: Walk

- a.k.a. Path
- Consistent sequence of edges



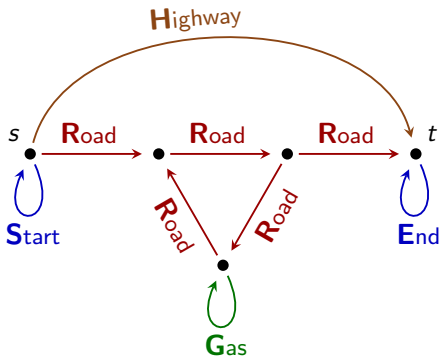




"Find a way from s to t"

$$Q_1 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

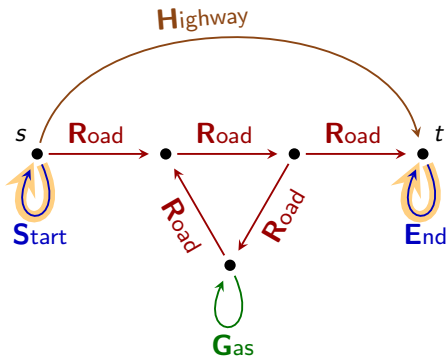
Which walks match Q_1 ?



"Find a way from s to t"

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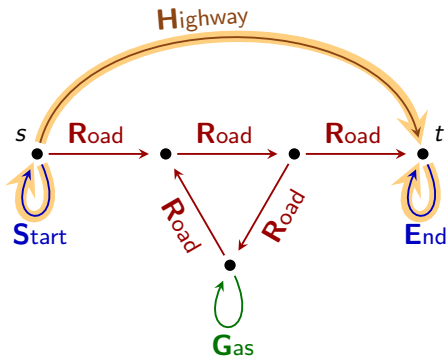


"Find a way from s to t"

$$Q_1 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

Which walks match Q_1 ?

- The highway

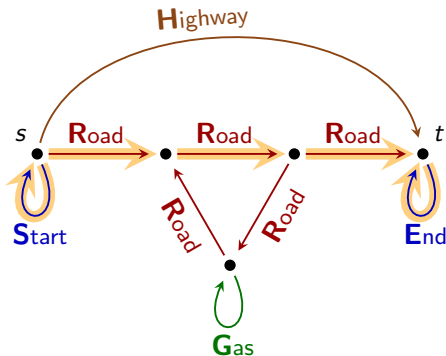


"Find a way from s to t"

$$Q_1 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

Which walks match Q_1 ?

- The highway
- The straight road

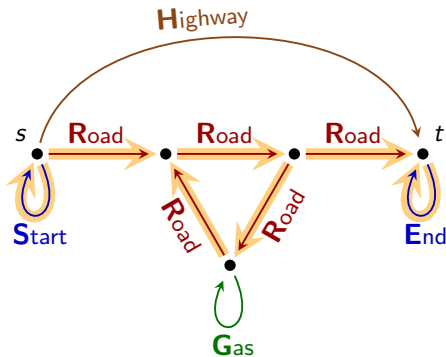


"Find a way from s to t"

$$Q_1 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

Which walks match Q_1 ?

- The highway
- The straight road
- Road with laps in the circuit



"Find a way from s to t"

$$Q_1 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

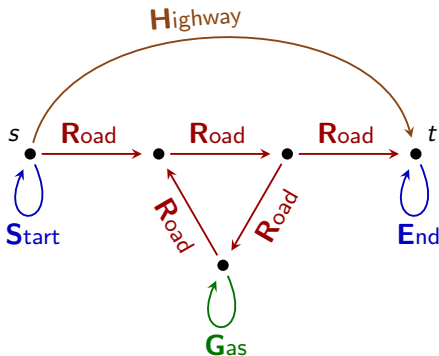
Which walks match Q_1 ?

- The highway
- The straight road
- Road with laps in the circuit

"...with mandatory gas stop"

$$Q_2 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{G} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

Which walks match Q_2 ?



"Find a way from s to t"

$$Q_1 = S (R+H)^* E$$

Which walks match Q_1 ?

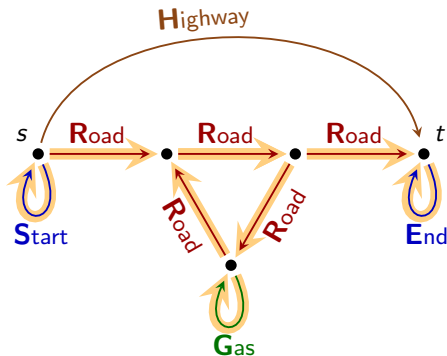
- The highway
- The straight road
- Road with laps in the circuit

"...with mandatory gas stop"

$$Q_2 = S (R+H)^* G (R+H)^* E$$

Which walks match Q_2 ?

- Road with laps in the circuit



"Find a way from s to t"

$$Q_1 = S (R+H)^* E$$

Which walks match Q_1 ?

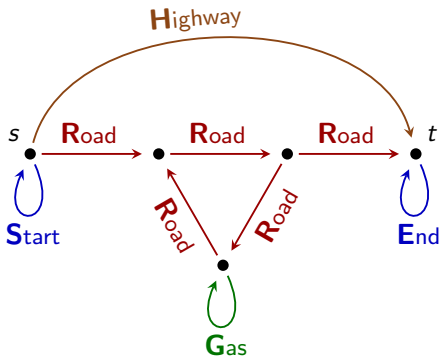
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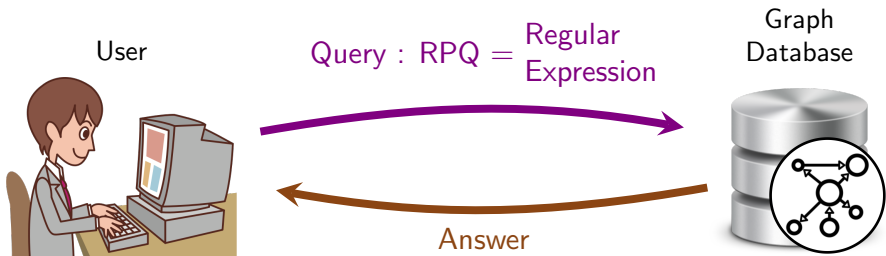
$$Q_2 = S (R+H)^* G (R+H)^* E$$

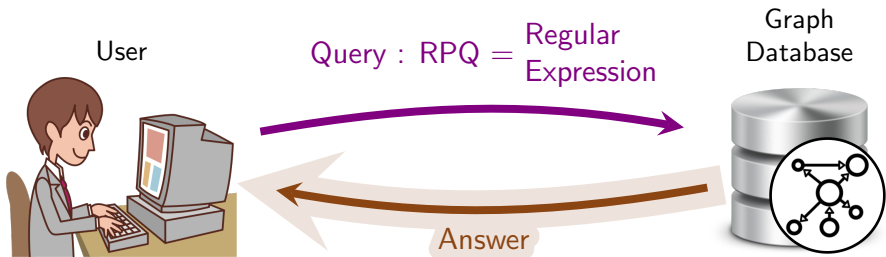
Which walks match Q_2 ?

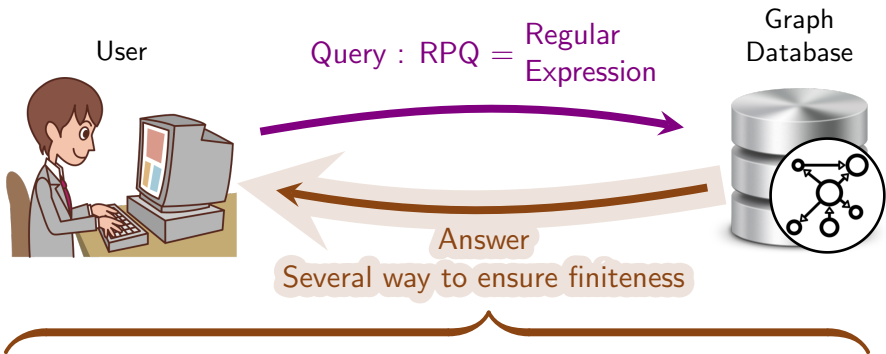
- Road with laps in the circuit

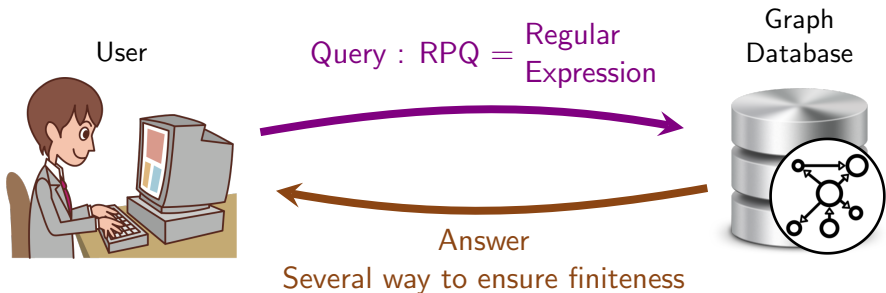


⇒ Infinitely many matches









In theory

Homomorphism semantics

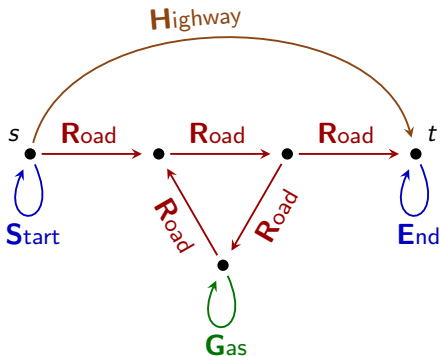
In practice

Trail semantics

... among others

Definition

- Returns the endpoints of matches



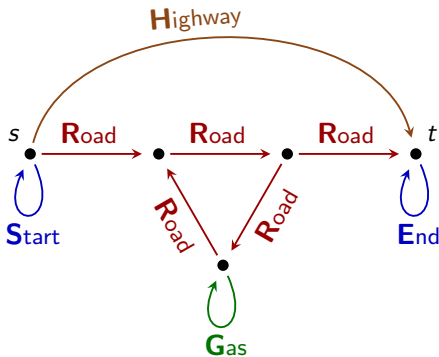
Definition

- Returns the endpoints of matches

$$Q_1 = S (R+H)^* E$$

$$Q_2 = S (R+H)^* G (R+H)^* E$$

- Q_1 and Q_2 return $\{(s, t)\}$



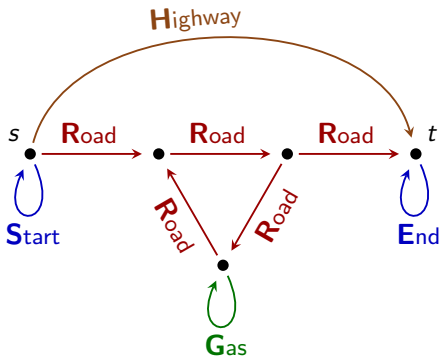
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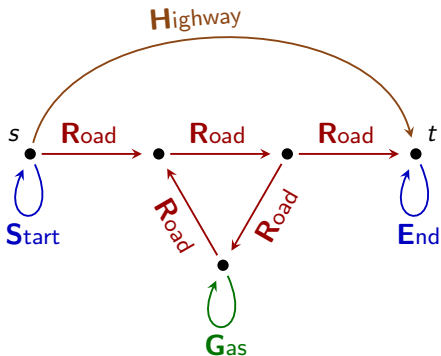
- Q_1 and Q_2 return $\{(s, t)\}$



- Return partial information (Boolean for Q_1 and Q_2)
- Cannot count

Definition

- Return walks
- Each edge may be used once

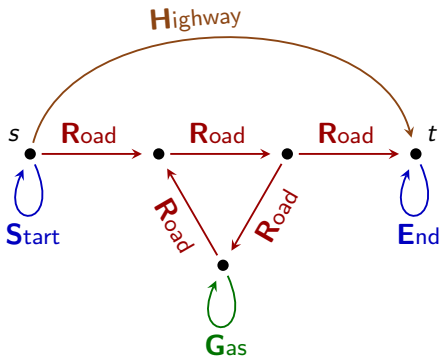


Definition

- Return walks
- Each edge may be used once

$$Q_1 = S (R+H)^* E$$

- Q_1 returns 2 walks
 - the highway
 - the straight road

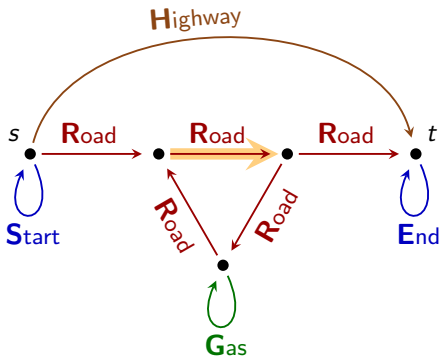


Definition

- Return walks
- Each edge may be used once

$$Q_1 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

- Q_1 returns 2 walks
 - the highway
 - the straight road
- Any road with circuit laps
⇒ repeated edges



Definition

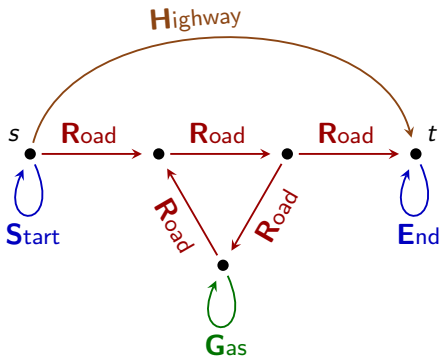
- Return walks
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$$Q_1 = S (R+H)^* E$$

- Q_1 returns 2 walks
 - the highway
 - the straight road
- Any road with circuit laps
 - \Rightarrow repeated edges

$$Q_2 = S (R+H)^* G (R+H)^* E$$

- Q_2 returns no results



Definition

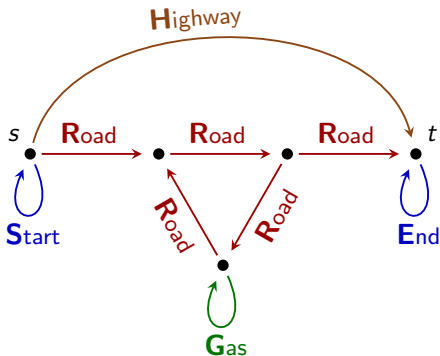
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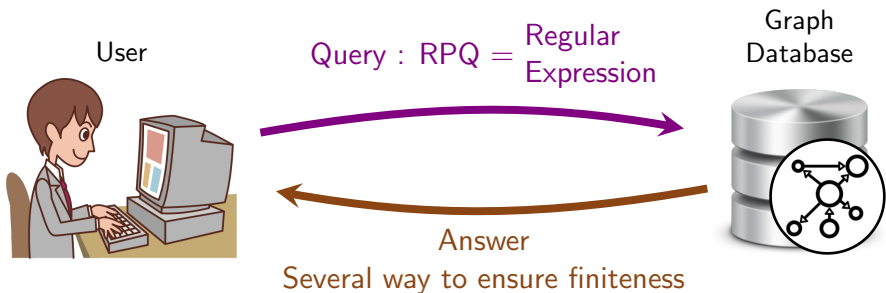
- Q_1 returns 2 walks
 - the highway
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 - \Rightarrow repeated edges

$$Q_2 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{G} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

- Q_2 returns no results



- Problems are **untractable**



In theory

Homomorphism semantics

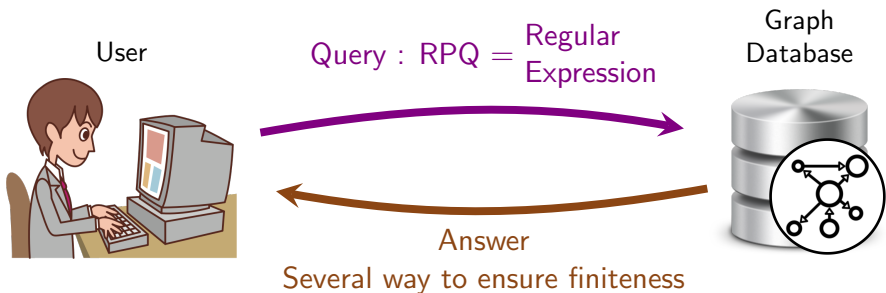
- Return endpoints
- Tractable
- No counting

In practice

Trail semantics

- Returns walks
- Untractable
- Counting

... among others



In theory

Homomorphism semantics

- Return endpoints
- Tractable
- No counting

Our proposal

Run-based semantics

In practice

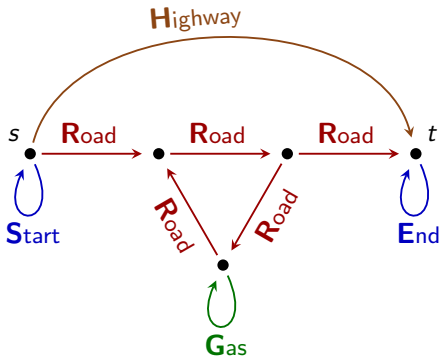
Trail semantics

- Returns walks
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... among others

Definition

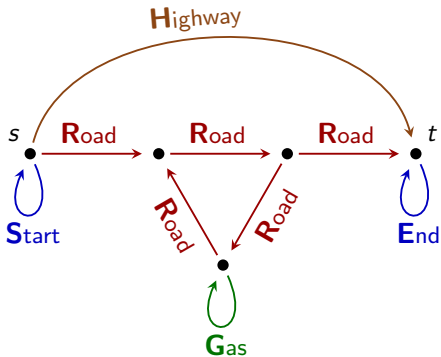
- Returns walks
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Definition

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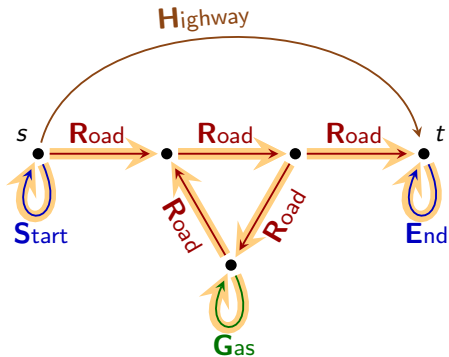


Definition

- Returns walks
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$$Q_2 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{G} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

- Returns the 1-lap road only

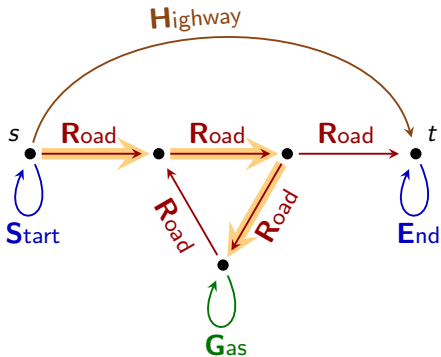


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- Returns the 1-lap road only
 - Before \mathbf{G} → use the left \mathbf{R}

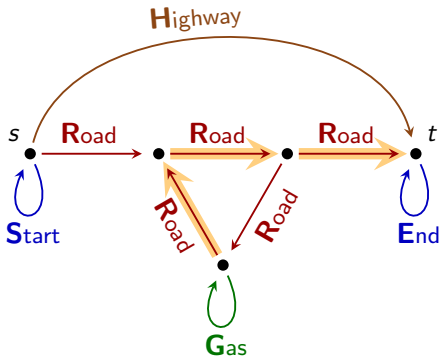


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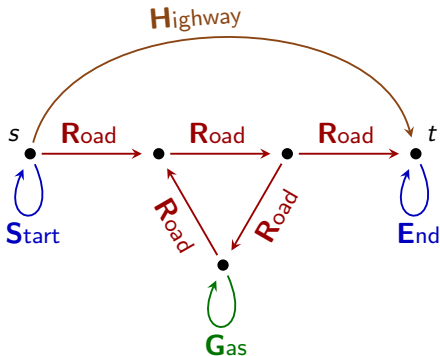


Definition

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$$Q_2 = \mathbf{S} (\mathbf{R} + \mathbf{H})^* \mathbf{G} (\mathbf{R} + \mathbf{H})^* \mathbf{E}$$

- Returns the 1-lap road only
 - Before \mathbf{G} → use the left \mathbf{R}
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- > 1 circuit lap \Rightarrow some edge use the same atom twice

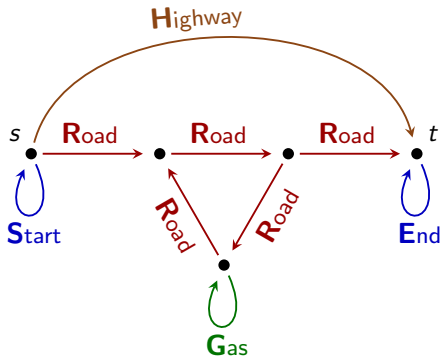


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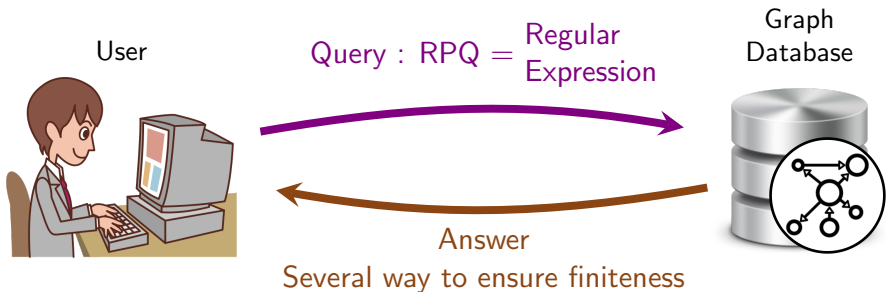


Property

W.r.t. emptiness:

Homomorphism semantics

\Leftrightarrow Binding-trail semantics



In theory

Homomorphism semantics

- Return endpoints
- Tractable
- No counting

Our proposal

Run-based semantics

- Returns walks
- Emptiness tractable
- Enumeration tractable
- Counting untractable

In practice

Trail semantics

- Returns walks
- Untractable
- Counting

... among others