# Evaluating Path Queries over Route Collections

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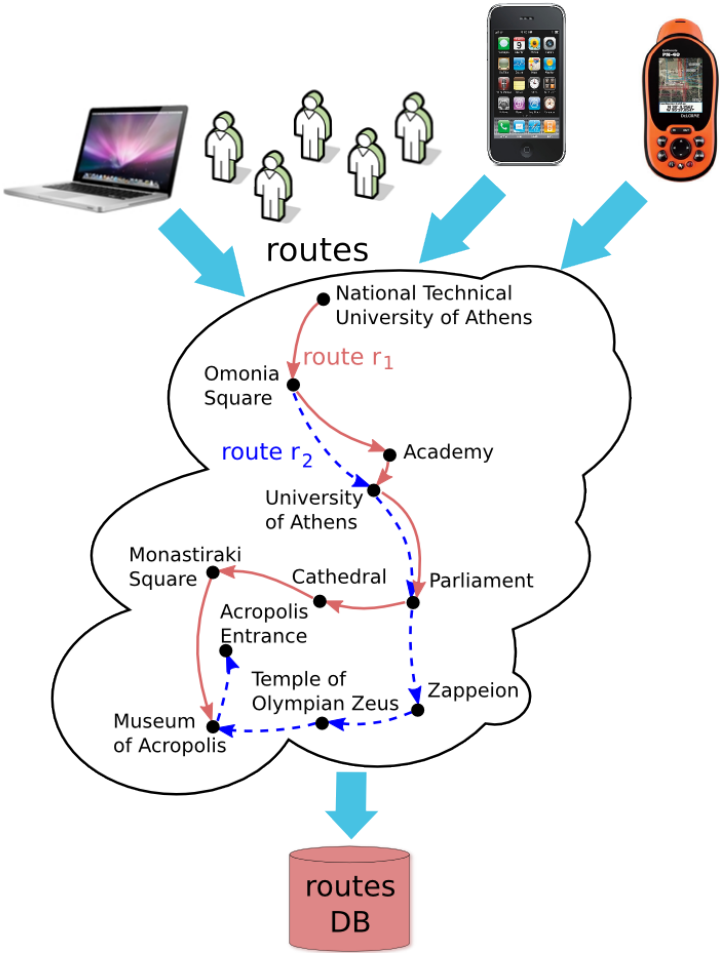
# Outline

- Introduction
  - Route collections, queries & frequent updates
- Existing work
  - Graph-based solutions
- Our framework
  - PATH & FLSP queries
  - Indices, algorithms & handling updates
- Future work

# Examples of route collections

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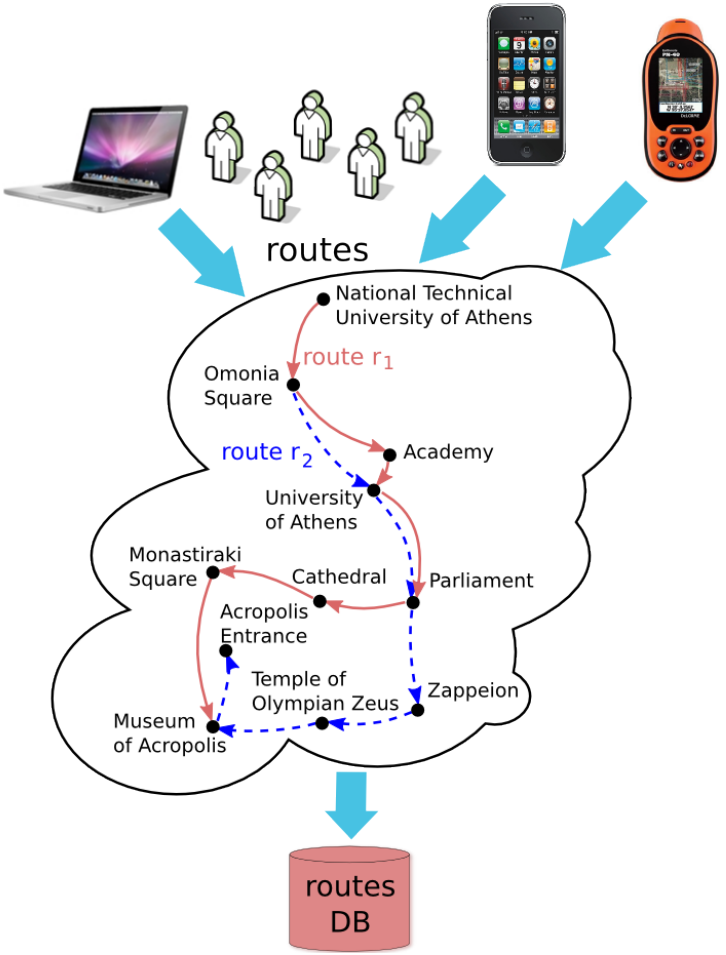


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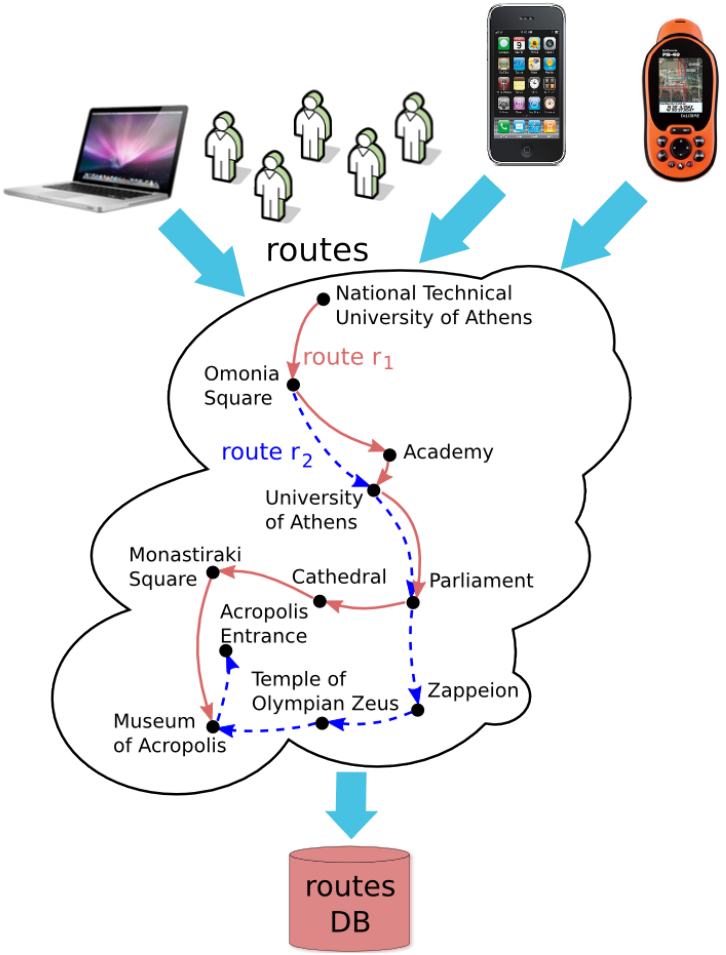


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- Answers may involve places from more than one routes

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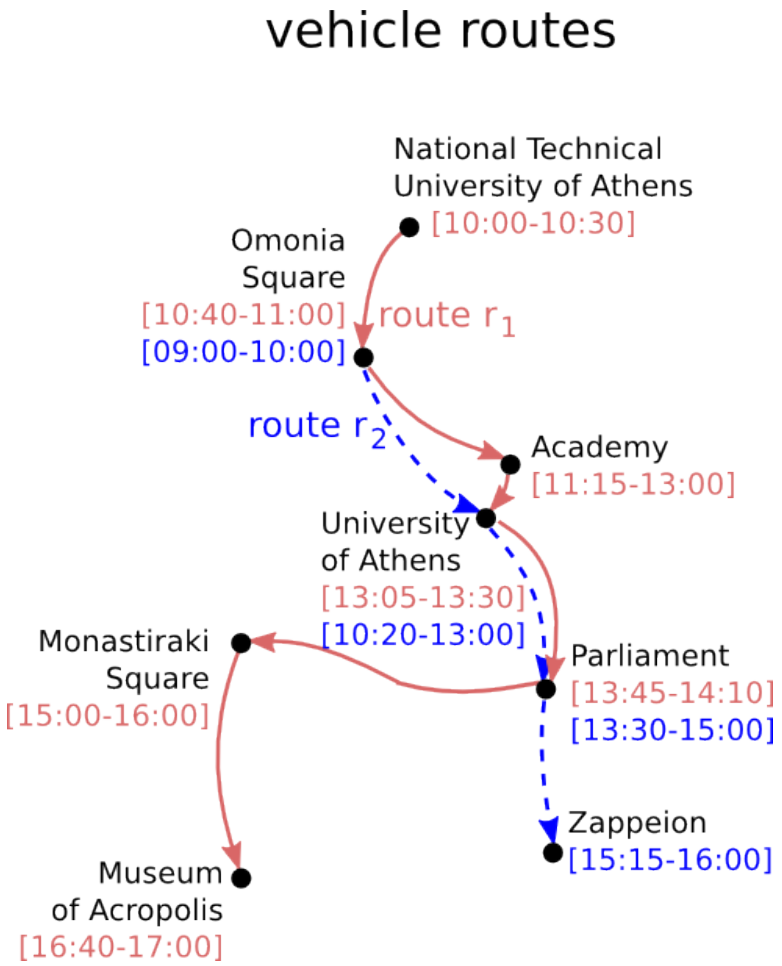


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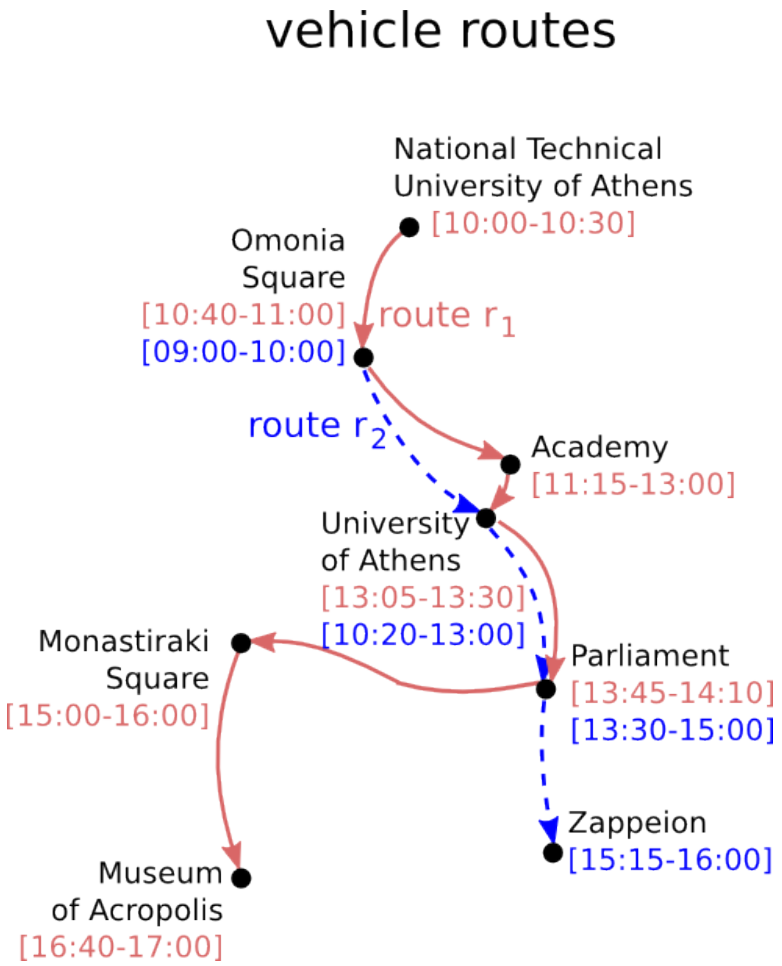


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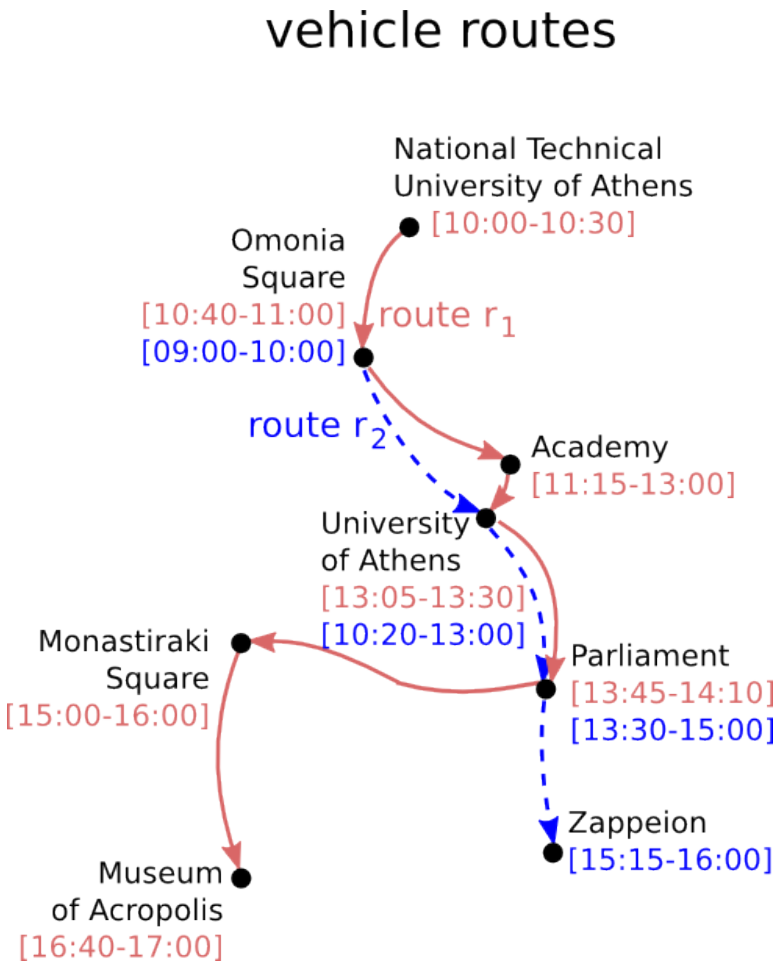


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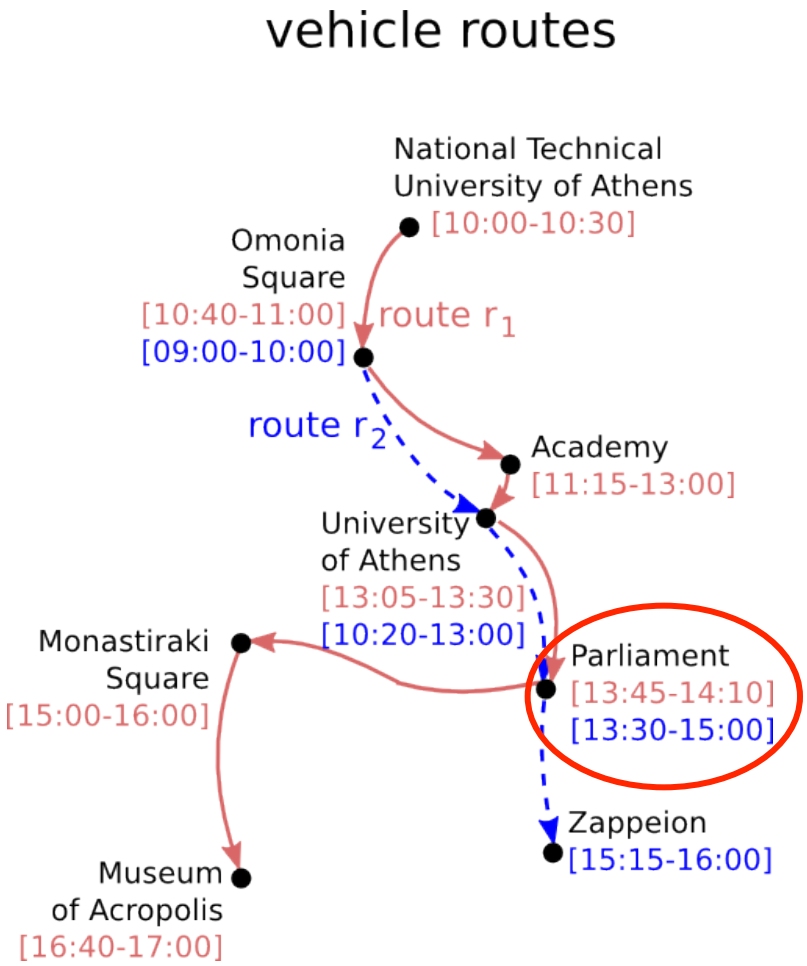


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Passing parcel possible

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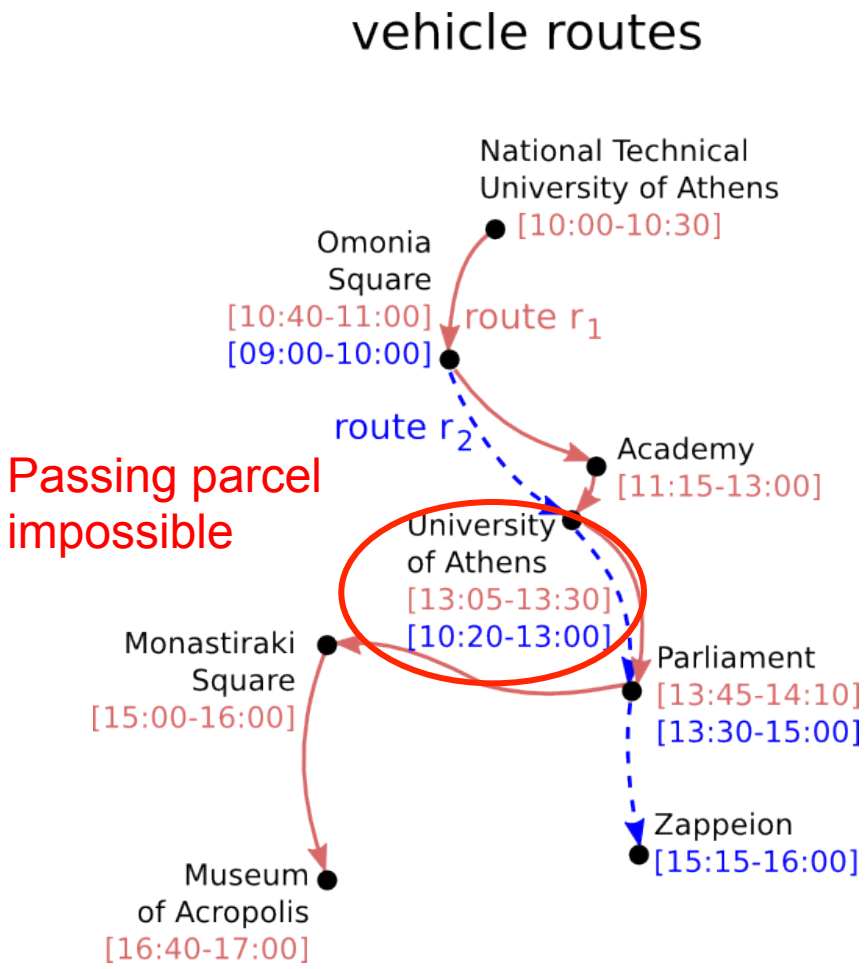


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- Related to dynamic pickup and delivery problem

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- Consider route collections
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  - In the latter we use links, i.e., shared nodes
  - PATH(S,T)
    - Find a sequence of interesting places from Omonia Square to Cathedral
  - FLSP($S,I_S,T,I_T$)
    - Moving cost m within routes
    - Changing cost c between routes via links
    - Find the sequence of points to pick-up parcel from Cathedral and deliver it to Zappeion that:
      - Abides with the temporal constraints imposed by time intervals
      - Minimizes primarily the changing cost and secondarily the moving cost

# Existing work

- Convert route collection to a graph
- Answer PATH and FLSP queries on the graph:
  - Direct evaluation
    - dfs for PATH
    - ucs, Dijkstra for FLSP
    - Low storage and maintenance cost
    - Slow query evaluation
  - Preprocessing
    - Precompute transitive closure, labeling & compression schems for PATH
    - Graph embedding + A* for FLSP
    - Fast query evaluation
    - High maintenance cost

# Our Framework

- Evaluate PATH and FLSP queries directly on route collections
- Our framework involves the following:
  - A search algorithm
    - Depth-first search for PATH queries
    - Uniform-Cost Search for FLSP queries
  - Indices on route collection for efficiently answering queries
    - Reduce iterations of the search algorithm
    - P-Index, H-Index, L-Index
  - Methods for handling frequent updates

# Indexing route collections

**Route collection**

$r_1$ (A,B,C)

$r_2$ (F,N,B,L)

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| node | *routes* list |
|---|---|
| A | <$r_1$:1> |
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**H-Index**

| route | *edges* list |
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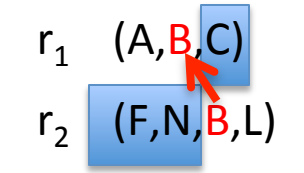


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| route | *links* list |
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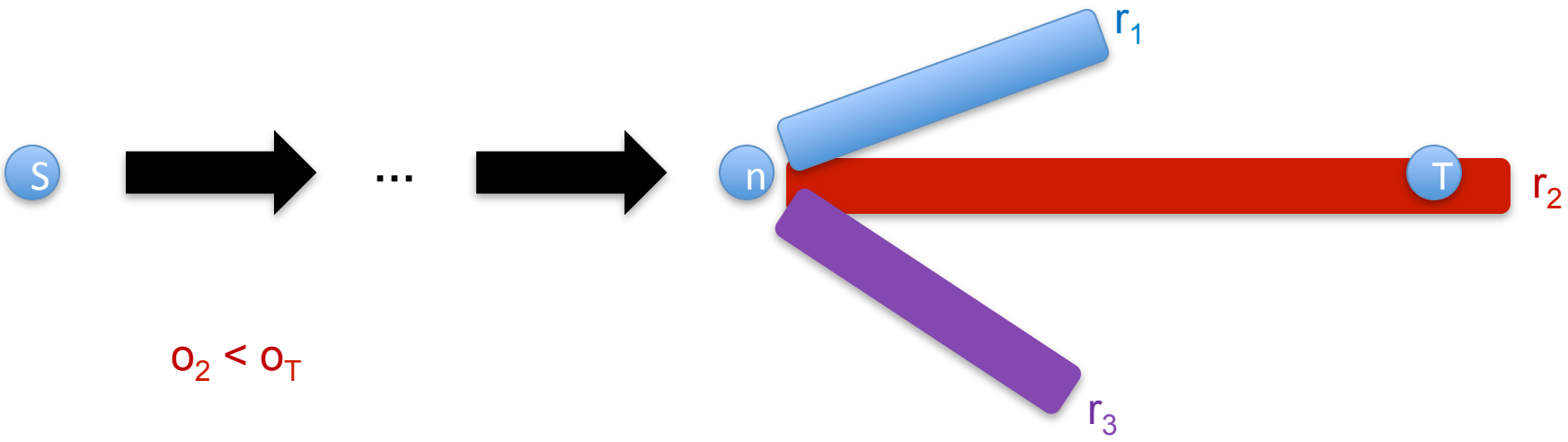
# Evaluating PATH queries

- Basic idea
  - Traverse nodes similar to depth-first search
  - Exploit indices on route collection to terminate search
    - P-Index => method pfsP
    - H-Index => method pfsH
    - L-Index => method pfsL
  - At each iteration:
    - Pop current node n
    - Check termination condition
    - Access routes containing n, *routes*[n] from P-Index
      - For each route, push nodes after n in search stack

# Evaluating PATH queries cont.

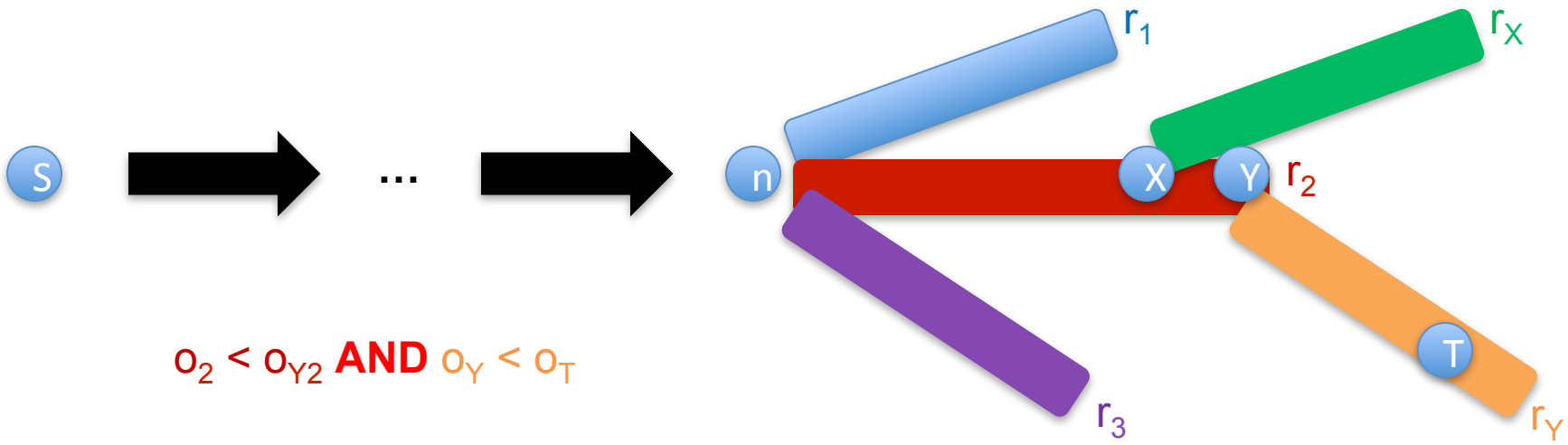
- pfsP terminates search
  - When: current node n is contained in a route before target t
  - How: joins *routes*[n] with *routes*[t] & stops after finding a common route entry




*routes*[n] = {<$r_1$:$o_1$>,<$r_2$:$o_2$>,<$r_3$:$o_3$>} **JOIN** *routes*[T] = {…,<$r_2$:$o_T$>,…}

# Evaluating PATH queries cont.

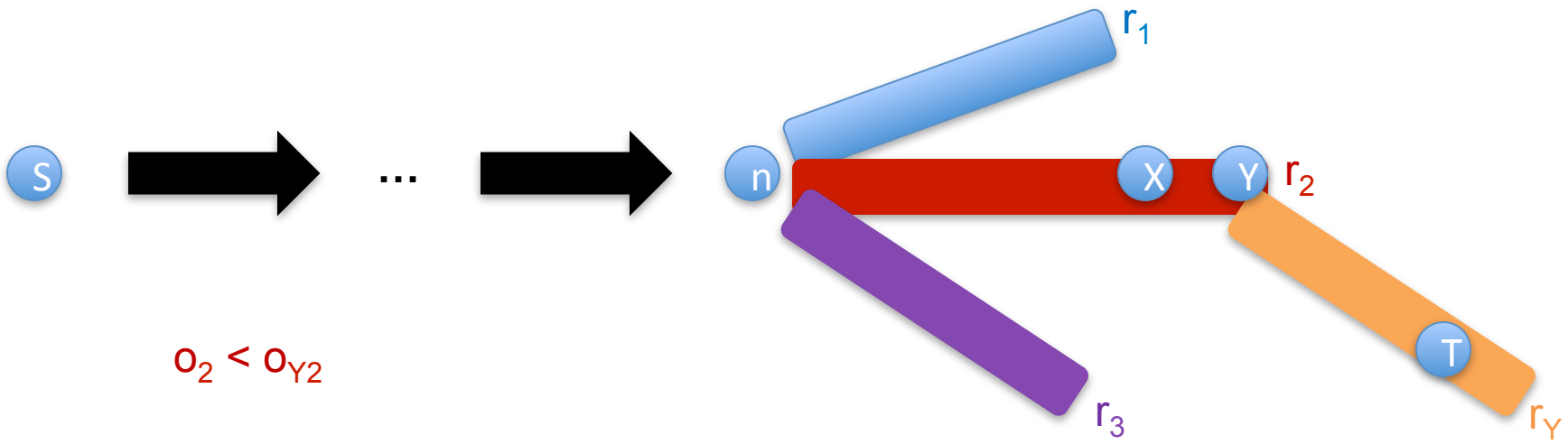
- pfsH terminates search
  - When: current node n is contained in a route that is connected with a route containing target t
  - How: for each route r containing n, joins *edges*[r] with *routes*[t] & stops after finding a common route entry




*edges*[$r_2$] = {<$r_X$,X:$o_{X2}$:$o_X$>,<$r_Y$,Y:$o_{Y2}$:$o_Y$>} **JOIN** *routes*[T] = {…,<$r_Y$:$o_T$>,…}

# Evaluating PATH queries cont.

- pfsL
  - Constructs list $\mathcal{T}$ of the links before target
  - Visits only the links in a route
  - Terminates search
    - When: current node n is contained in a route before a link of $\mathcal{T}$
    - How: for each route r containing n, joins *links*[r] with list $\mathcal{T}$ & stops after finding a common link entry




*links*[$r_2$] = {<X:$o_X$>,<Y:$o_{Y2}$>} **JOIN** $\mathcal{T}$ = {…,<Y,($r_Y$:$o_Y$:$o_T$)>,…}

# Evaluating FLSP queries

- Basic idea
  - Traverse nodes similar to uniform-cost search
  - Compute lower bound of the answer, a candidate answer
    - Using P-Index => method spP, L-Index => method spL
    - Triggers early termination condition
    - Prunes search space
  - At each iteration:
    - Pop current node n
    - Check termination condition against candidate answer
    - Update candidate answer through n
    - Access routes containing n, *routes*[n] from P-Index
      - For each route, push nodes after n in search stack iff expanding them would give answer better than candidate

# Handling frequent updates

- P-Index, H-Index, L-Index as inverted files on disk
  - Updates -> adding new routes
  - Not consider each new route separately
  - Batch updates, consider set of new routes
- Basic idea:
  - Build memory resident indices for new routes
  - Merge disk-based indices with memory resident ones

# Future work

- Three directions:
  - ① Address other kind of updates
    - Insert nodes in routes – as dynamic pickup and delivery problem is solved
    - Update time intervals of nodes
  - ② Evaluate other types of queries
    - Trip planning or optimal sequenced like queries
      - Each node is an instance of a class in set C, e.g. {Museum,Stadium,Restaurant}
      - Find a path passing through a Museum, then a Stadium and finally a Restaurant
  - ③ Combine query evaluation with keyword search
    - Starting and ending node given as set of keywords
    - Find a path passing through a Restaurant relevant to "sea food, lobster"


GONE
SURFING!