Range Search on Uncertain Trajectories

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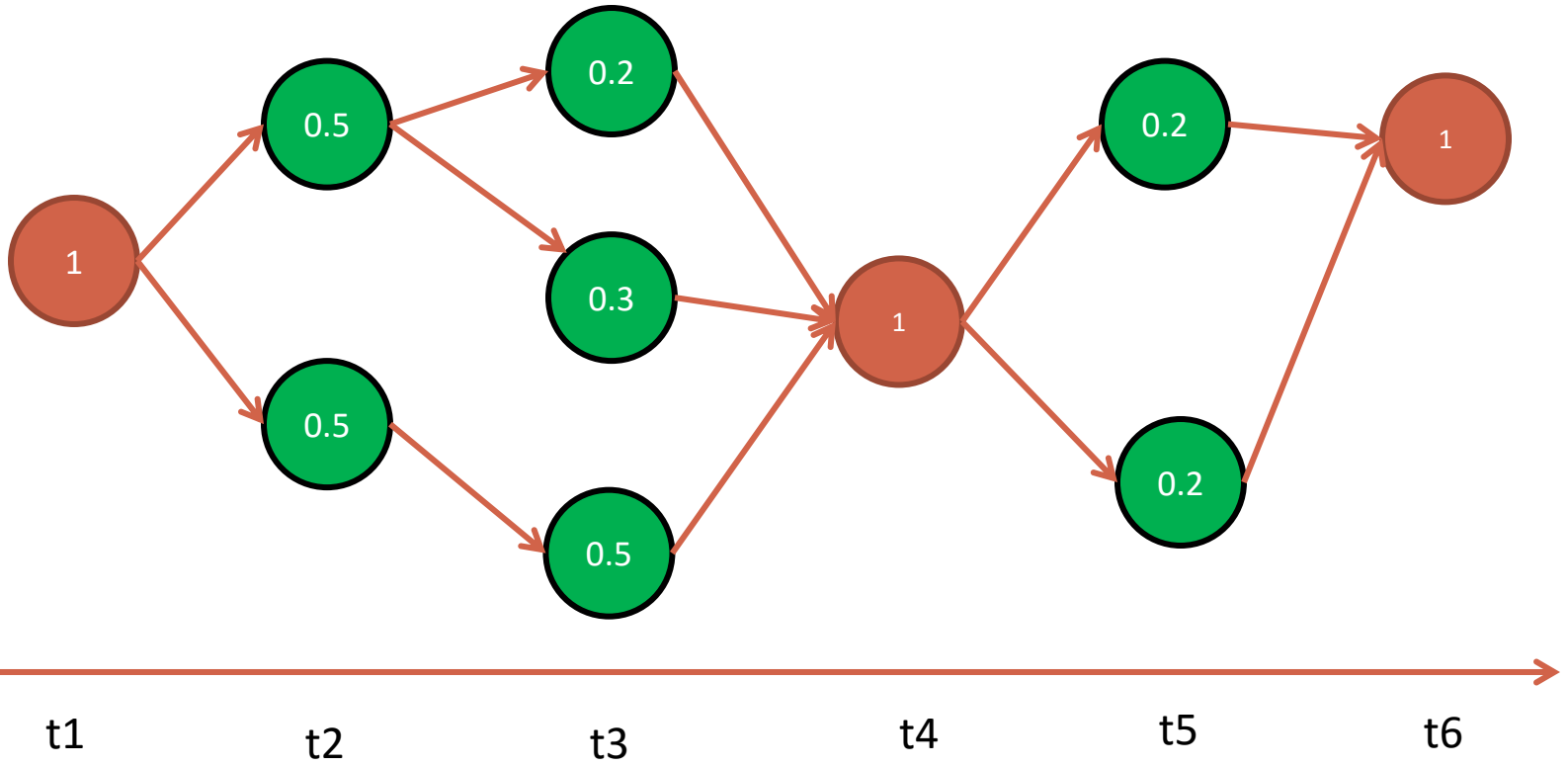
Outline

- Problem Definition
- Application
- General Framework
- Statistics Based Filtering
- Partition Based Filtering
- Experiments
- Conclusion

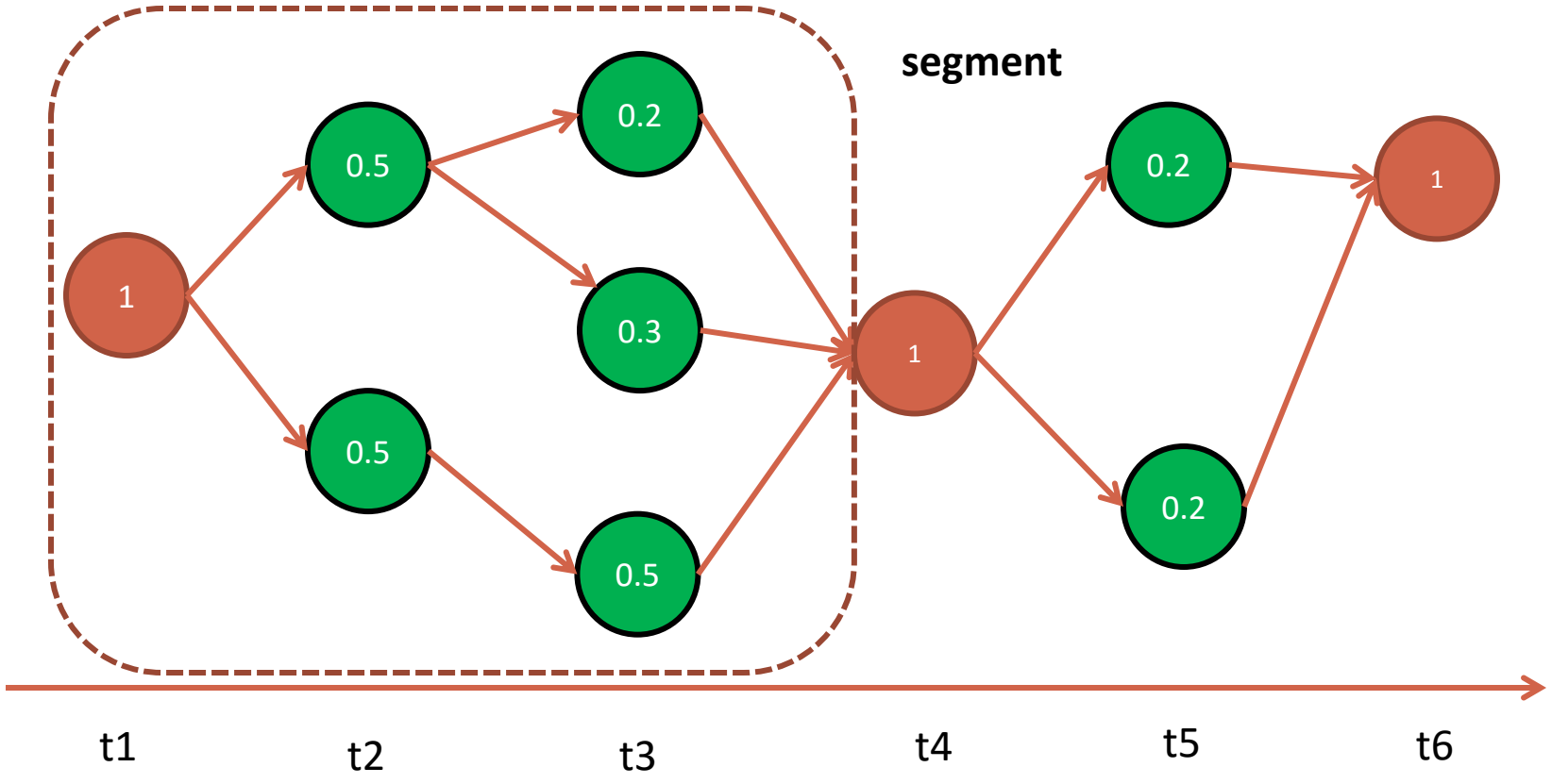
Uncertain Trajectory

- Uncertain trajectory for an object (Markov Chain model)



Uncertain Trajectory

- Uncertain trajectory for an object (Markov Chain model)



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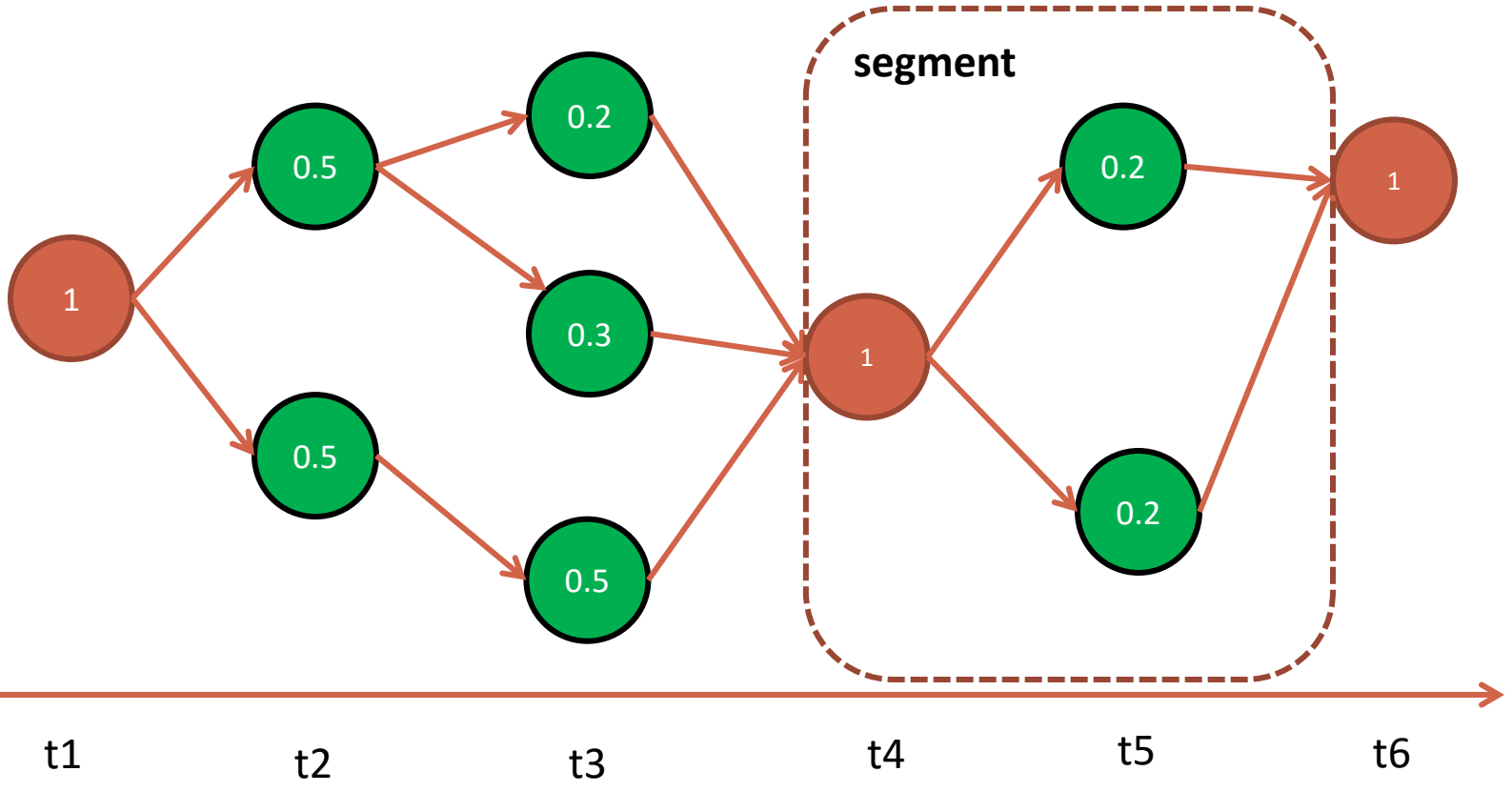

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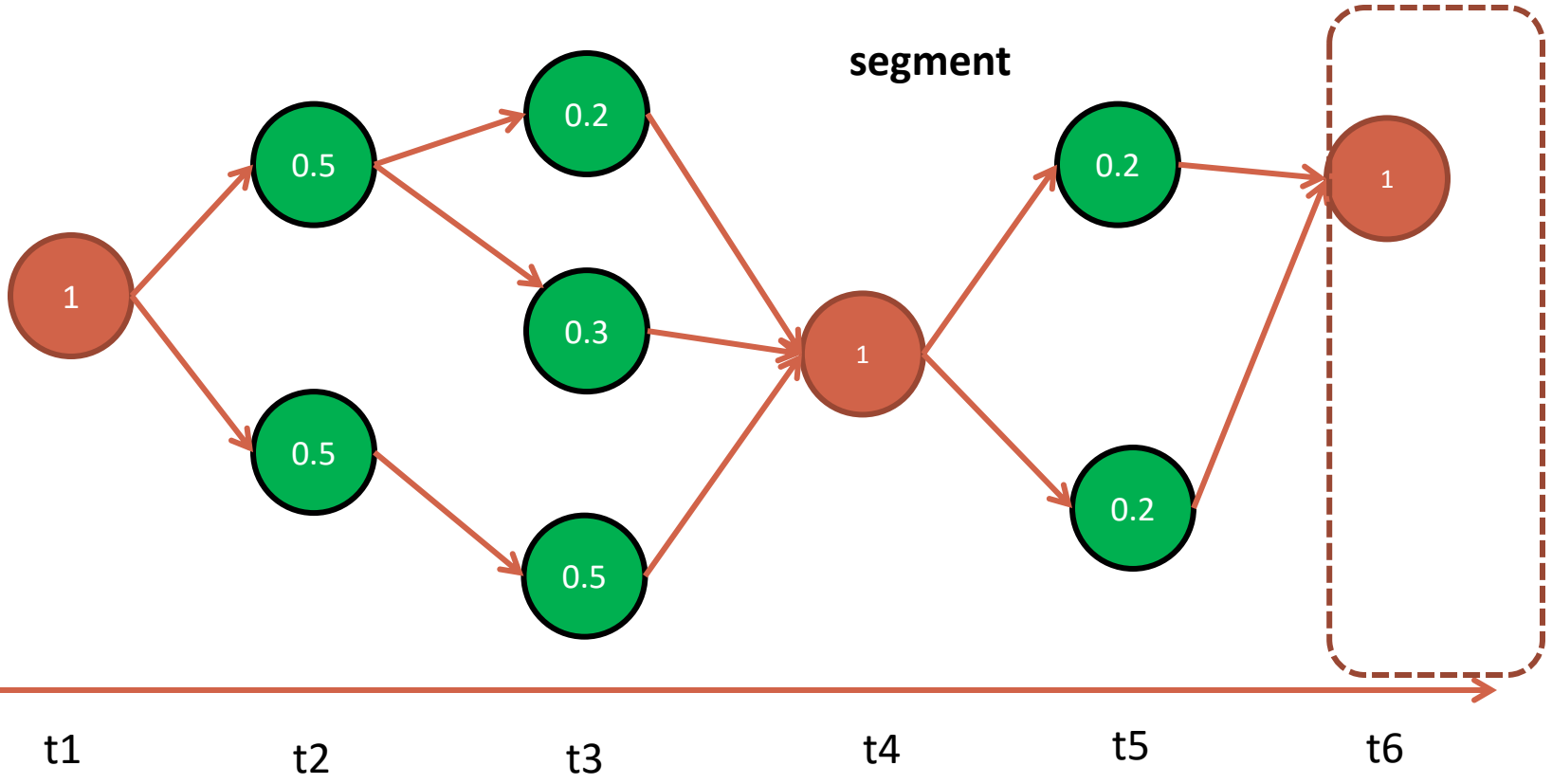

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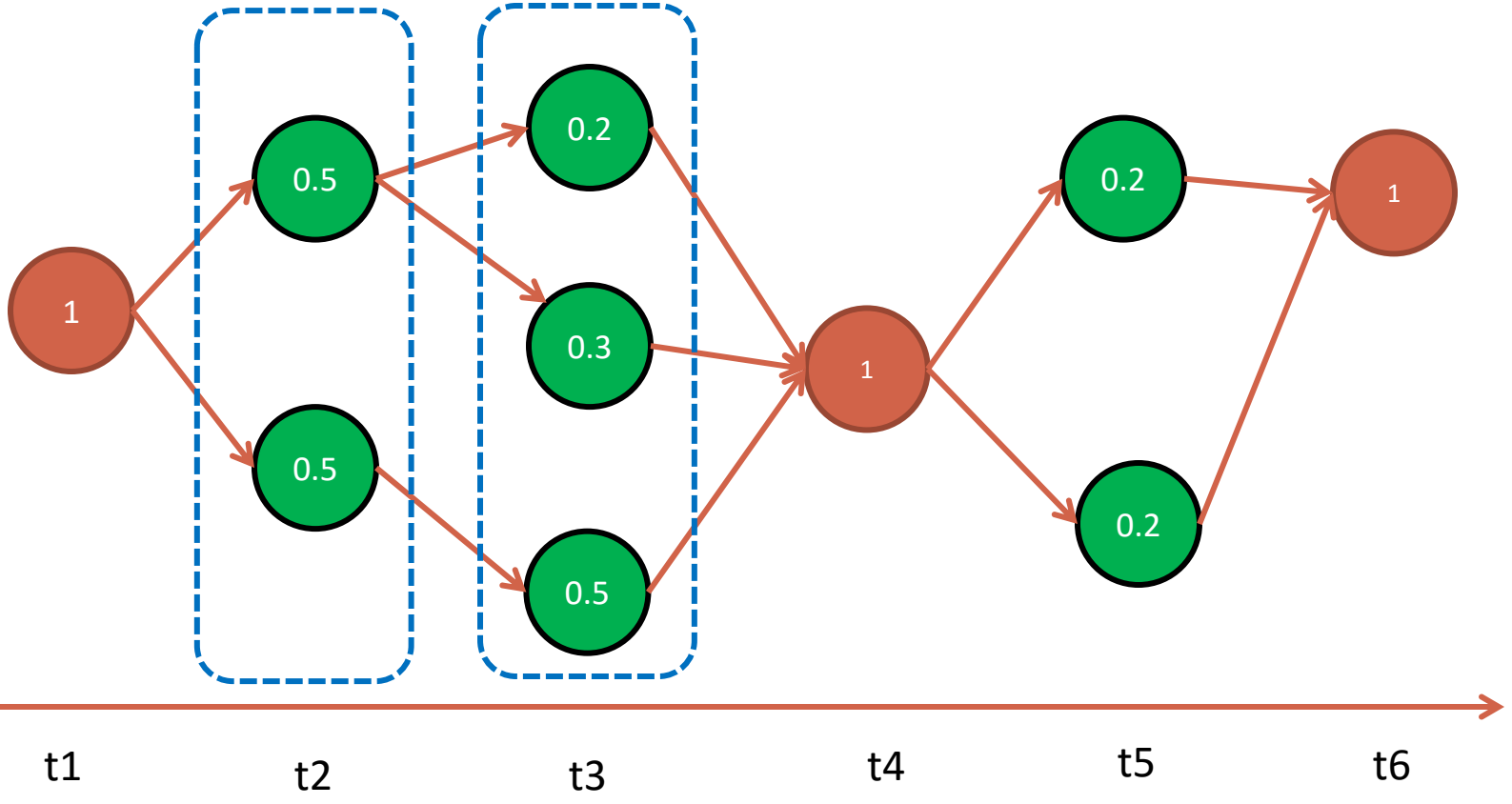
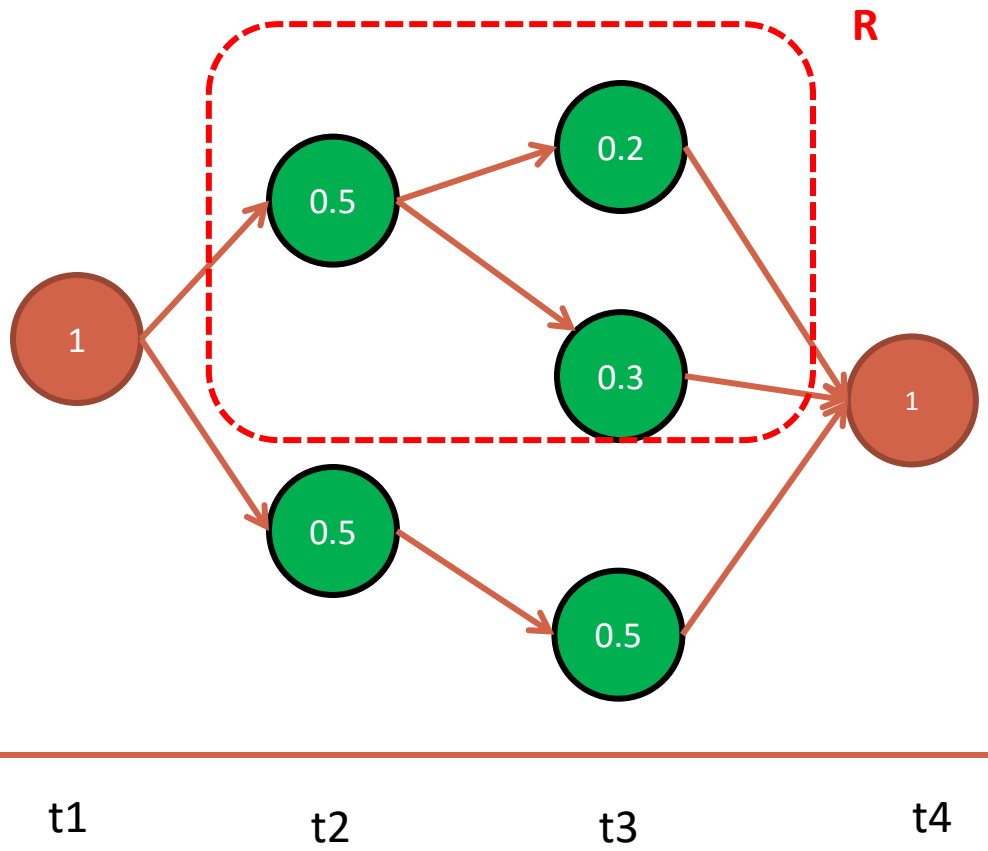


Range Search on Uncertain Trajectory

- Range Search

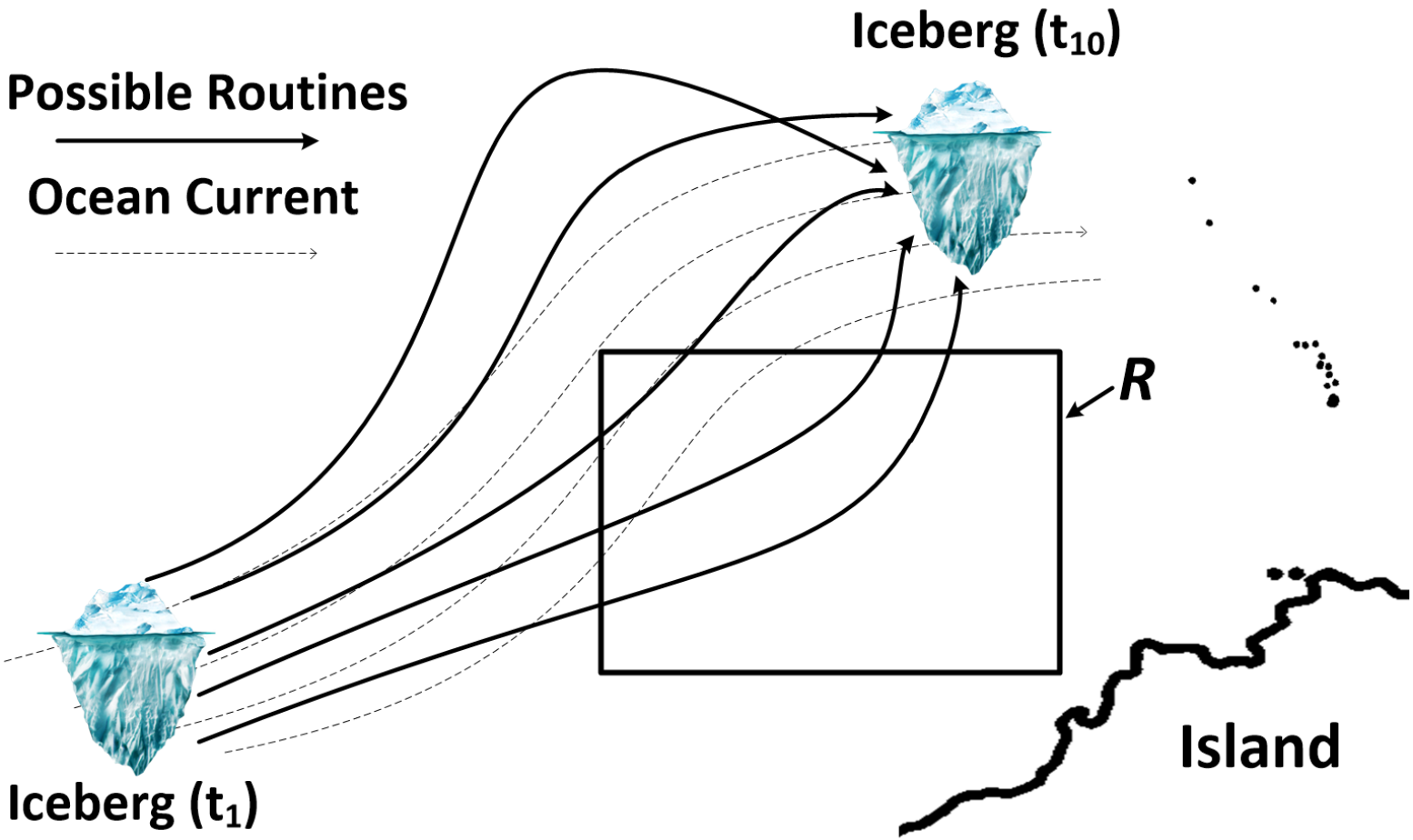


Range Search Query

- **Query region R**
- **Time interval (t1~t2)**
- **Probability threshold θ**
- **Duration threshold α**

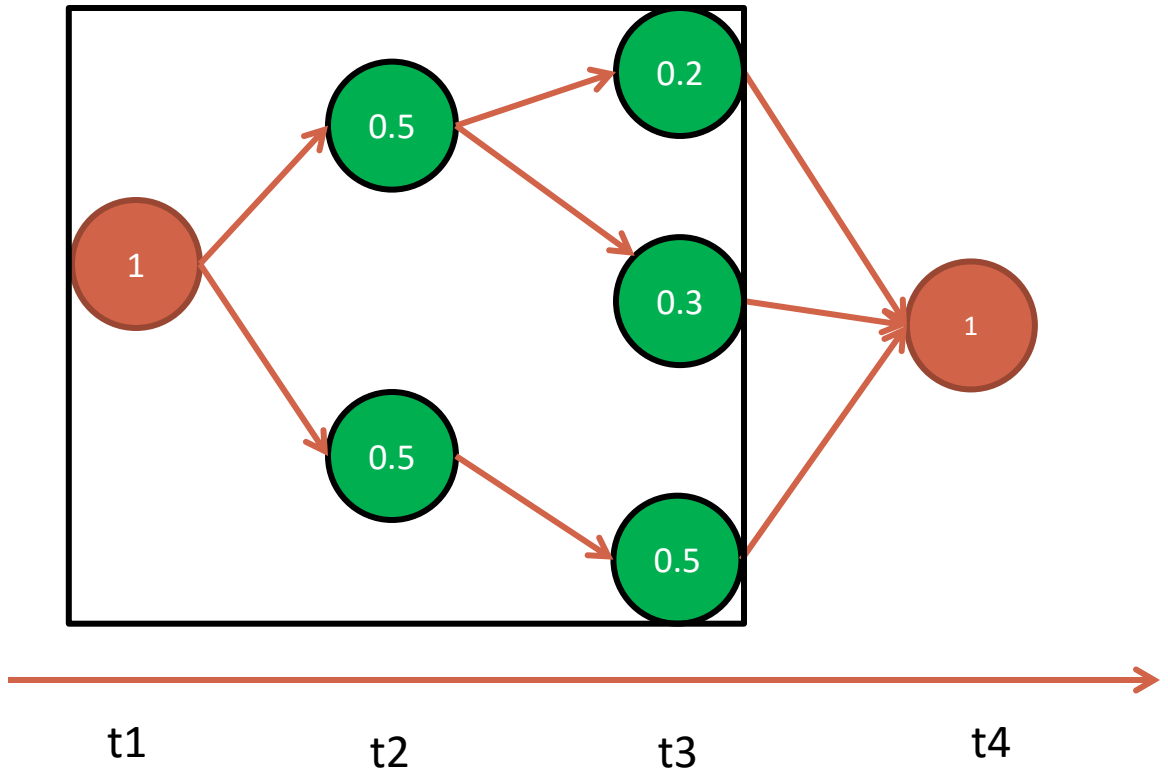
If θ = 0.4, α = 2, then the object should be returned

Applications



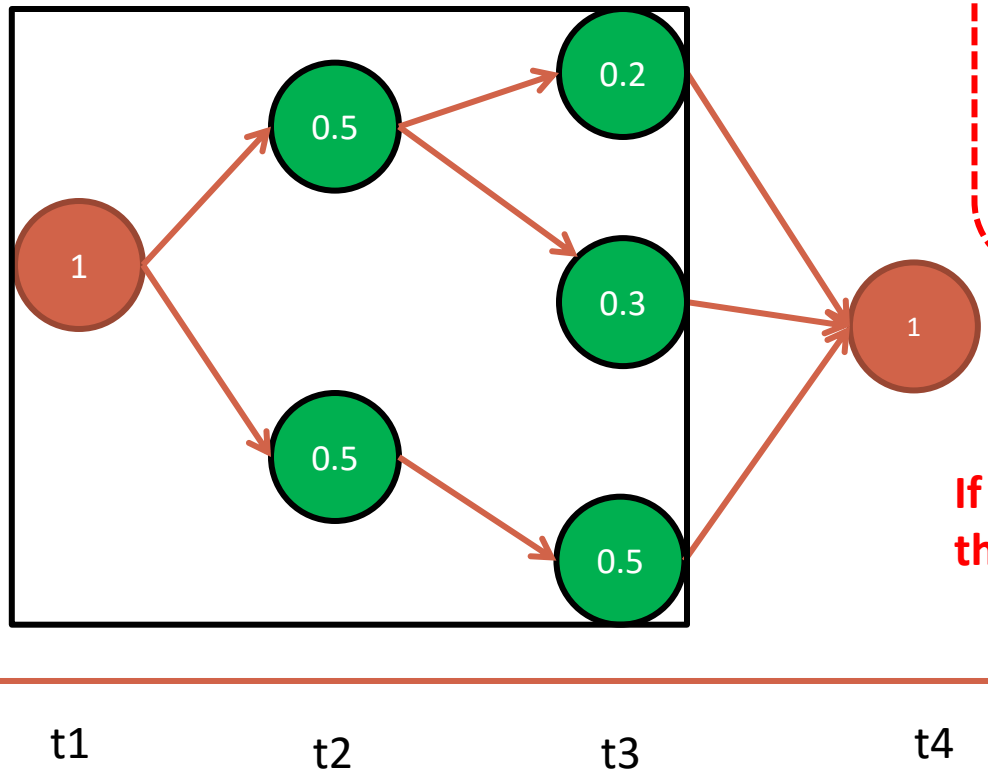
General Framework

- Minimum Bounding Box (MBB) of Segment



General Framework

- MBB based pruning and validation

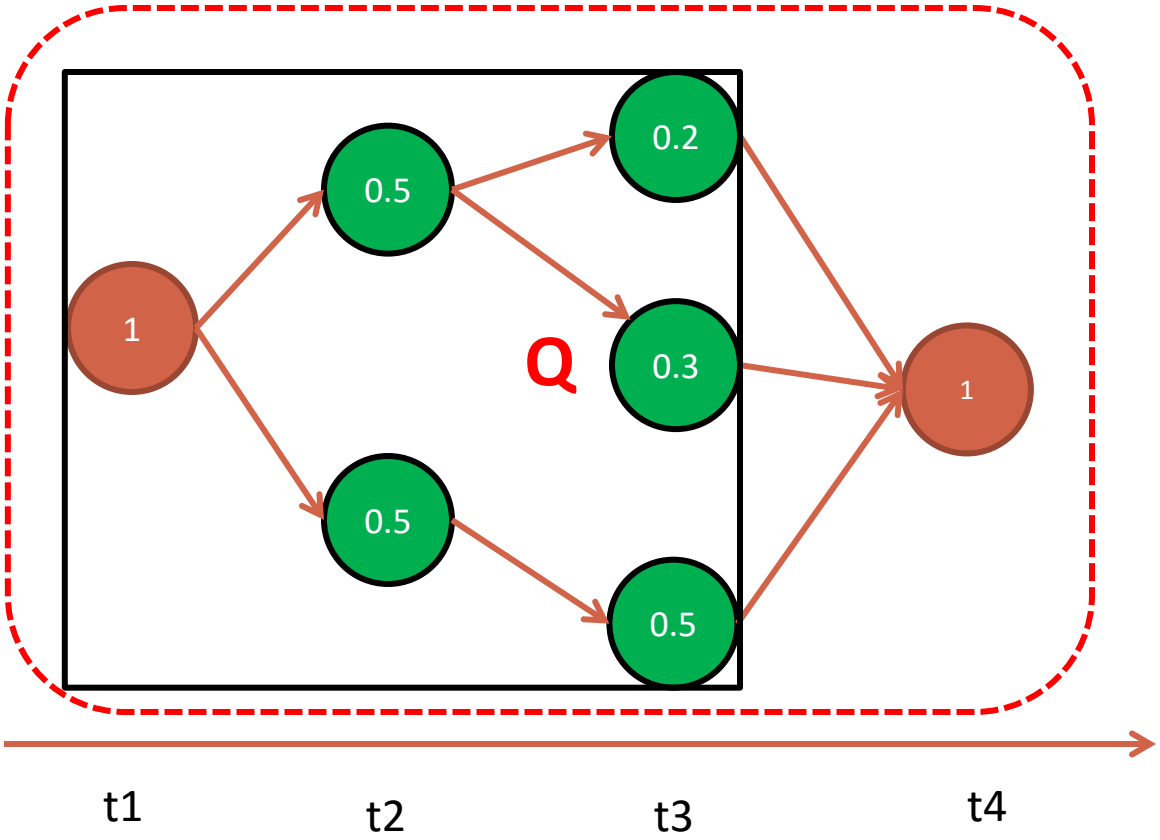


Q

If Q and MBB have no overlapping, then the segment can be pruned

General Framework

- MBB based pruning and validation

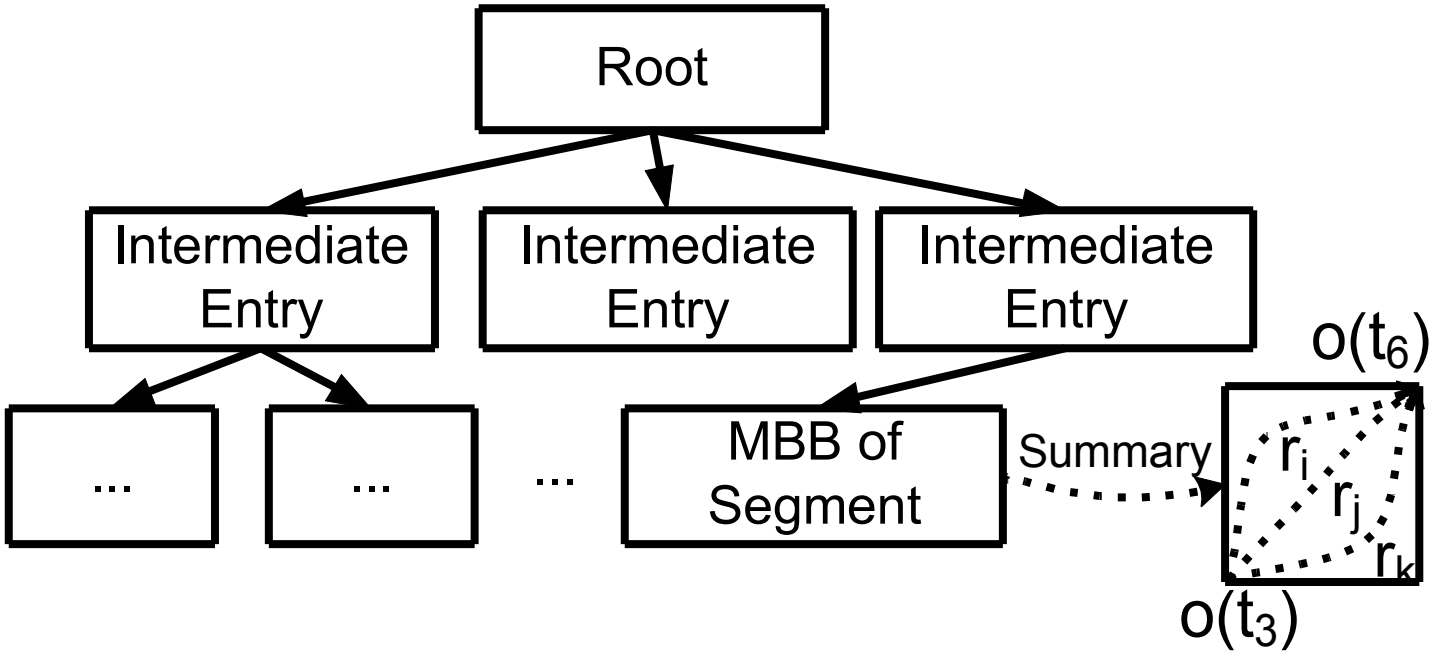


If Q contains the MBB, then the duration of object d = d + ds.

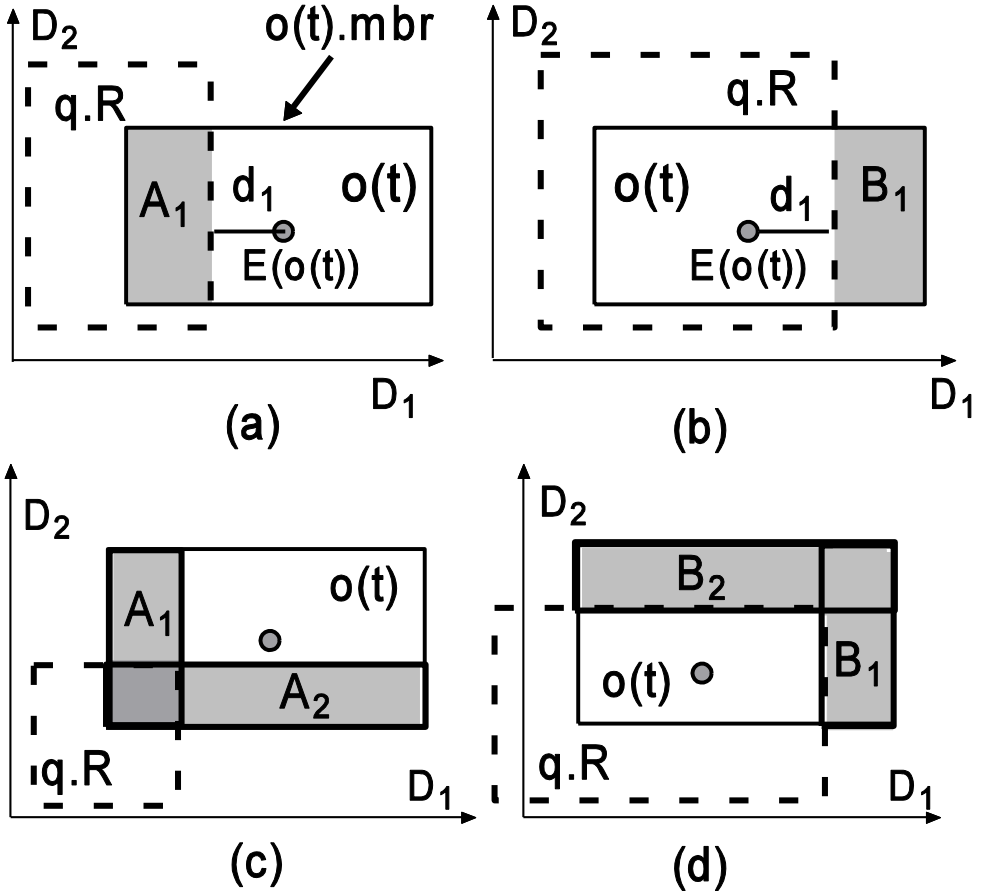
If Q overlaps with MBB, then the duration of object d $\leq$ d + ds.

General Framework

- Segments Summaries Tree based Search

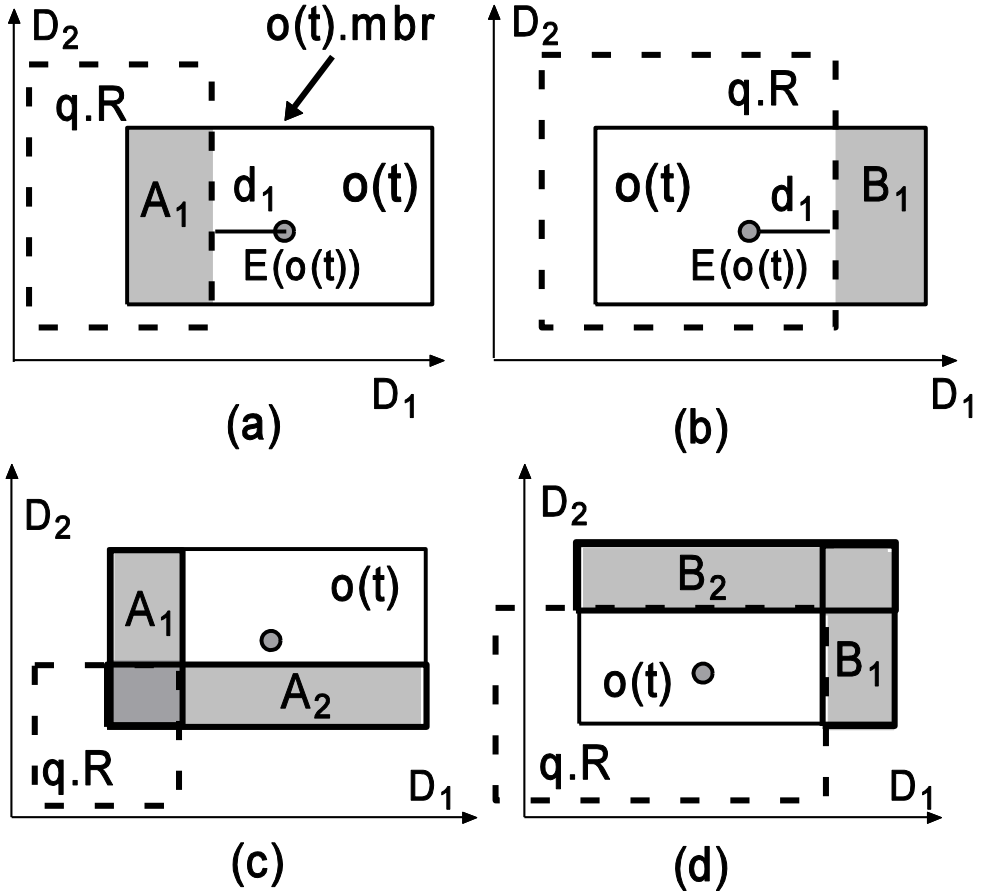


Statistics Based Filtering



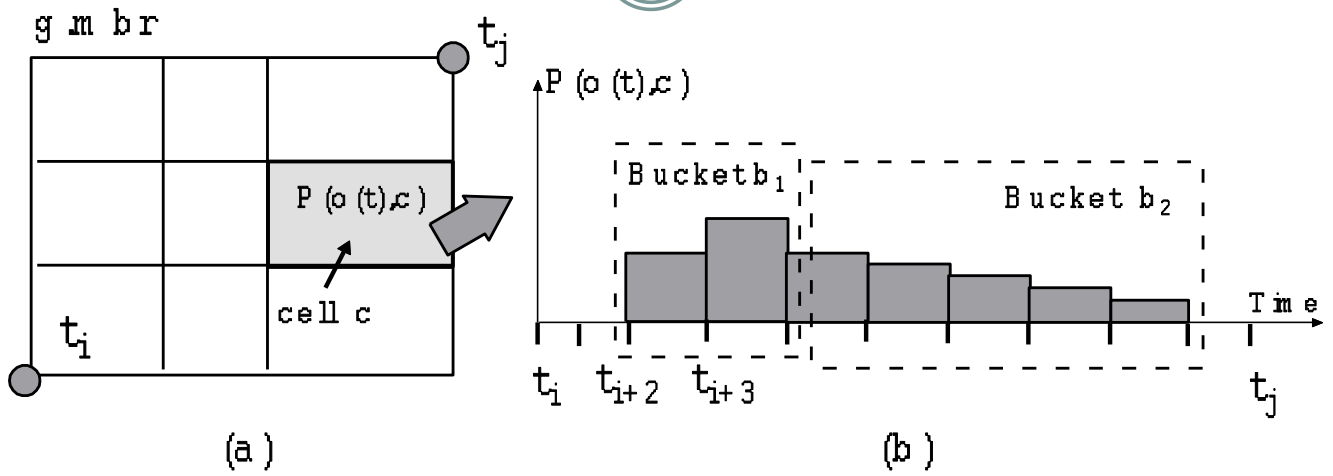
- **$P(A_i)$ denotes the probability of object that is contained by Q.R**
- **$P(B_i)$ records the probability of object that is not contained by Q.R**
- **If $\min\{P^+(A_1), P^+(A_2)\} < \theta$, time t can be pruned**
- **If $1- (P^-(B_1)+P^-(B_2)) \geq \theta$, time t can be validated**

Statistics Based Filtering



- **$P(A_i)$ denotes the probability of object that is contained by Q.R**
- **$P(B_i)$ records the probability of object that is not contained by Q.R**
- **$P^+(A_i)$, $P^-(B_i)$ can be approximated by maintaining the expectation and variance along dimension i using Cantelli's inequality**
- **To reduce the summary size, we can maintain the statistic information of a time interval**

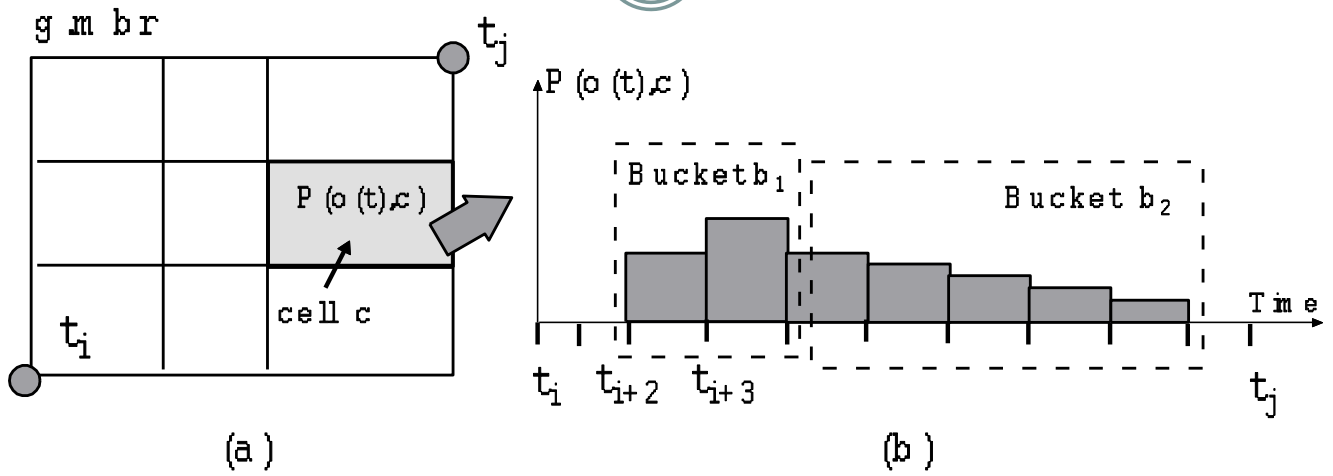
Partition Based Filtering



$$P^{-}(o(t), q.R) = \sum_{c \in \mathcal{S}(g) \ \wedge \ q.R \text{ contains } c} P(o(t), c)$$

$$P^{+}(o(t), q.R) = \sum_{c \in \mathcal{S}(g) \ \wedge \ q.R \text{ overlaps } c} P(o(t), c)$$

Partition Based Filtering



$$P^-(o(t), q) = \sum_{c \in \mathcal{S}(g) \ \wedge \ q.R \text{ contains } c} b(t, c).p^-$$

$$P^+(o(t), q) = \sum_{c \in \mathcal{S}(g) \ \wedge \ q.R \text{ overlaps } c} b(t, c).p^+$$

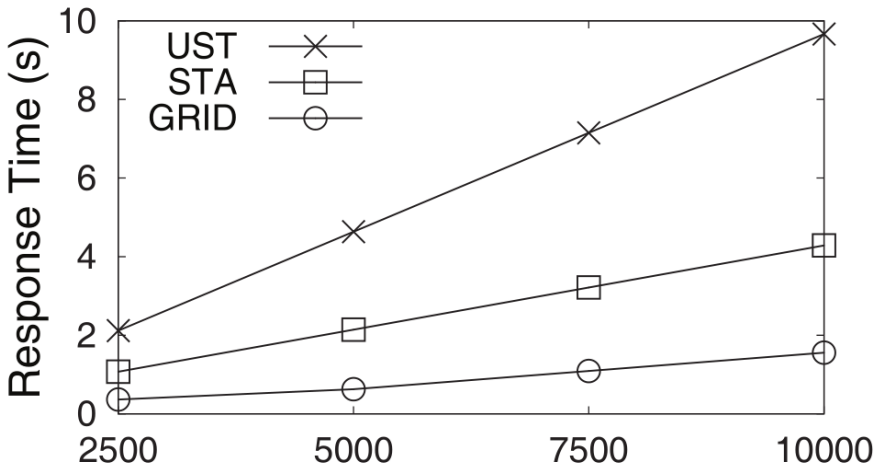
Experiments

- Algorithms
  - **UST**: The range search techniques proposed in [1] where sub-diamonds based filtering technique is employed.
  - **STA**: General framework by using statistics based filtering.
  - **GRID**: General framework by using partition based filtering.
- Parameter Settings

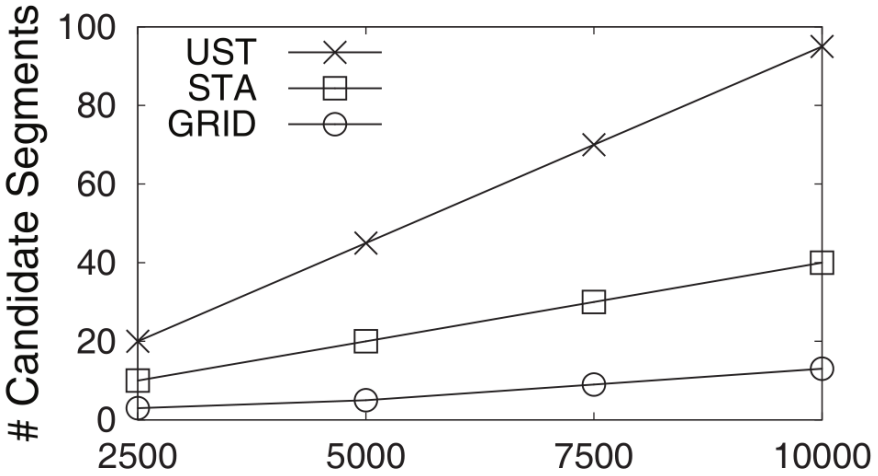
Notation	Definition
number of trajectories (N)	2500, **5000**, 7500, 10000
segment duration $\Delta_t(g)$	**[10, 15]**, [15, 20], [20, 25], [25, 30]
probabilistic threshold (θ)	0.1, 0.3, **0.5**, 0.7, 0.9, 1.0
duration threshold (η)	1, 4, **6**, 8, 10
query extent (area of $q.R$)	0.05, **0.1**, 0.15, 0.20, 0.25
query duration $\Delta_t(q)$	**10**, 15, 20, 25

[1] T. Emrich, H.-P. Kriegel, N. Mamoulis, M. Renz, and A. Züfle. Indexing uncertain spatio-temporal data. In CIKM, pages 395–404, 2012.

Experiments



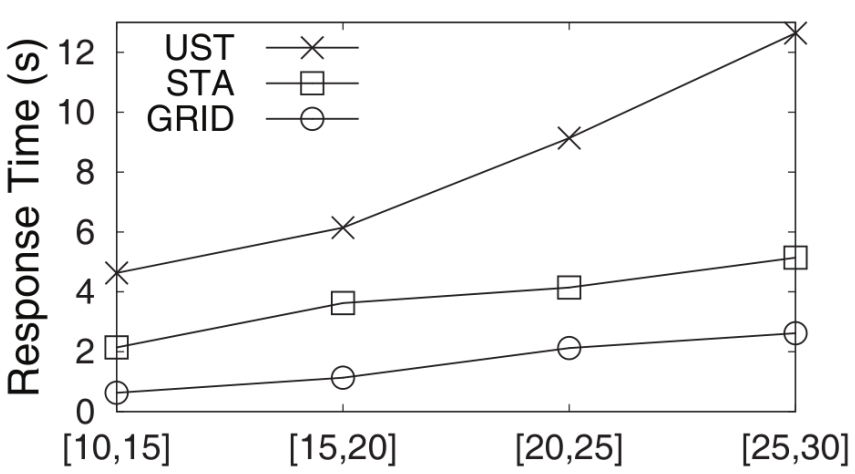
(a) *Response Time*



(b) *# Candidate Segments*

Impact of # Trajectories

Experiments



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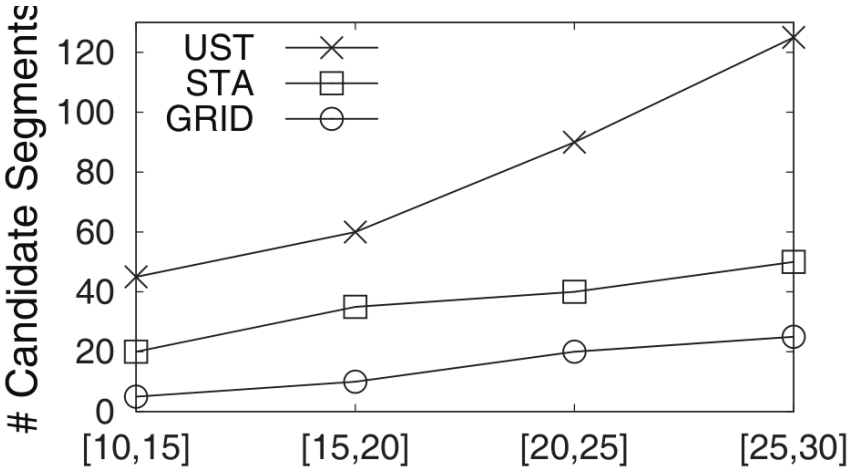

(b) *# Candidate Segments*

Impact of Segment Duration

Conclusion

- We formally define the problem of range search on uncertain trajectories.
- We introduce an indexing structure as well as a general framework to support range search on uncertain trajectories.
- We develop effective statistics based and partition based filtering techniques.

Thanks!
Q&A