School of Engineering and Applied Science (SEAS), Ahmedabad University

CSE 400: Fundamentals of Probability in Computing

Project Scribe Milestone-1

Group: s1_g8_its

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Scribe Question 1: Project System and Objective

We first of all define our problem in a context of the point-to-point routing problem with stochastic arrival time as the crucial variable in our work. We do not focus on the reliability of each edge but consider the network as a complete system and study the reliability of travel between a pair of origin-destination nodes. This is primarily to pre-select routes so that they have the highest chance of arriving on time and within a given time budget to avoid the errors of deterministic routing. The main uncertainty factors in this regard are:

- Deterministic point-to-point routing inaccurate predictions.
- Unpredictability on travel time on each of the links.
- Variations in the dependability of arrival on a given travel-time budget.

Scribe Question 2: Key Random Variables and Uncertainty Modeling

At this stage, we have determined a number of important quantities that acts unpredictable:

- The time spent travelling is a random variable that is strictly positive.
- On-time Arrival Probability: This is the primary in optimising the route of the user.
- Travel Time Budget: A fixed temporal constraint T that dictates the feasibility of the journey.

At this stage, the uncertain components are operated with general probability distributions, rather than fixed, time-dependent functions. The assumption is that the distribution of traffic, although being unpredictable, is time-invariant and exogenous.

Scribe Question 3: Probabilistic Reasoning and Dependencies

Our current understanding has revealed that there are a number of variables, which depend on the stochastic nature of the network:

- The Path Reliability is calculated by convoluting the distribution of all the edges on a path.
- The Policy-based SOTA solution affects the Optimal Path Choice.
- The Probability of success in a node is a function of the remaining time budget. Probability formulas are significant in this model. Specifically, such dependencies like Admissibility are essential; the optimal policy is a maximum of any predetermined route, so that the A* search could get an optimal solution.

Scribe Question 4: Model-Implementation Alignment

At this level we have the conceptual notion of the implementation. We know that:

- The model is implemented in C++.
- It contains beforehand determination of activation potentials by preprocessing using Arc-Potentials.
- It employs a Zero-Delay Convolution (ZDC) method to speed up the process of the calculation of probability integrals.

  However, at this milestone, we suppose model assumptions, including the independence of the link travel times, will have a direct influence on the implementation design. Future achievements will be more about scaling such stochastic techniques to networks in continental scale.

Scribe Question 5: Cross-Milestone Consistency and Change

We have at this moment a conceptual cognition of the implementation. We know that:

- The model is conducted in C++.
- It involves discretization of continuous-time equations into intervals of Δt.
- It is close to the mathematical model as far as the Pathfinding and Preprocessing algorithms are concerned. However, at this milestone, we have not yet addressed the relaxation of the Markov property for road networks. The support of the current policy heuristic has been made to ensure that the search space is not expanded exponentially.

Scribe Question 6: Open Issues and Responsibility Attribution

Several questions have not been answered at the very outset:

- Scalability for regional or continental-sized networks.
- Relaxation of the Independence Assumption between links
- The performance of the algorithm in "worst-case" stochastic scenarios. Sharing of responsibility:
  - One of the members of the group is interested in defining the problem and the theoretical background of reliability metrics.
  - The other looks at the high-level organization of the algorithm used in the study, which is the allowable heuristic of the A+ search.
  - We also changed the code structure and configured experiments, including experiments on a real network data.

End of Submission