Turning Big Spatial Data Into Smart Routing

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***Abstract*—This poster presents the *PreGo* system for smart touring services. PreGo is smart in the sense that it enables its users to consider many preferences, (e.g., distance, travel time, services, attractions, safety), in their routing queries. The recommended route is completely personalized based on each user's weights for each of the routing preferences.**

I. Introduction

Conventional routing engines recommend routes between given source and destination locations based on the travel time cost. Sometimes, the user has the choice to avoid highways or choose among three different routes. However, drivers tend to look for routing services that go beyond paths with shortest travel time or distance. The user study in [3] shows that users would prefer route that has more services and points of interests over the fastest one during the weekend shopping trip. They would also choose the safest route, (e.g., less number of cars accidents), over the shortest route in their return home at night. From this study, we can infer that different routing preferences can be considered in addition to the travel distance and the travel time. It is also obvious that routing preferences differ from a person to another and depends on the time of the day as well as the day of the week.

Here in this work, we initially express the smart routing query problem as a multi-preference personalized routing problem. The multi-preference refers to enabling users to specify more than one preference, (e.g., travel time, distance, services, attractions, risk), in their routing queries. In this context, personalization refers to the fact that these preferences are subject to change from a user to anther and from to time to time for each single user. Then, we systematically design a solution, the *PreGo*[1] system, that enables variety of big spatial data to be maintained, accessed and analyzed along with the underlying road network graph. We also depict the *PreGo* system architecture and its internals and utilization.

II. The PreGo System

This poster presents *PreGo*, a full-fledged system for smart routing service. The smartness of *PreGo* comes from the fact that the computation of the optimal path is driven by a weighted set of user's preferences. The user is given a set of knobs to adjust the weights of routing preferences according to their priorities. *PreGo* is also dynamic over the time of the day. *PreGo* leverages a dynamic data rich road network graph called the Attribute Time Aggregated Graph, (*ATAG*) data structure [5].

[1]The name *PreGo* has two parts, *Pre* for preferences or preferred and *Go* that refers to route. *Prego* is also an Italian word that means *You are welcome!* or *Please!*.

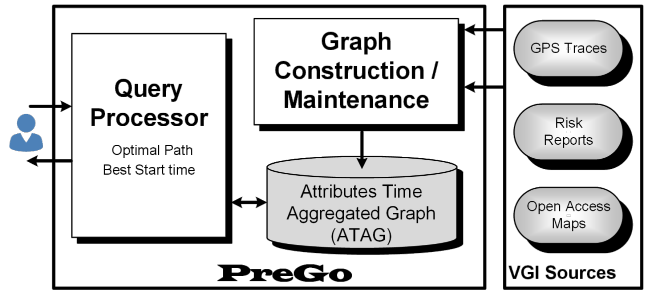


Fig. 1. The System Architecture

A. *PreGo Merits*

(1) *PreGo* finds the best route according to a user's set of preferences. (2) *PreGo* does not depend on a static snapshot of the underlying road network. Rather, it computes the best route taking into consideration various cost elements at different time instances of the day. (3) For users with flexible trip start times, *PreGo* recommends a trip *start time* such that user's preferences are best fulfilled. (4) Personalization parameters are controlled by each user's preference weights. (5) *PreGo* is internally crafted to scale up to large road network graphs, a wide range of time sensitive preferences, and heavy routing workloads.

B. *System Architecture*

The architecture of the *PreGo* system is given in Figure 1. *PreGo* employs the (*ATAG*) structure to store extracted knowledge, (e.g., travel time or risk on a graph edge), from various types of spatial data.

C. *ATAG Structure*

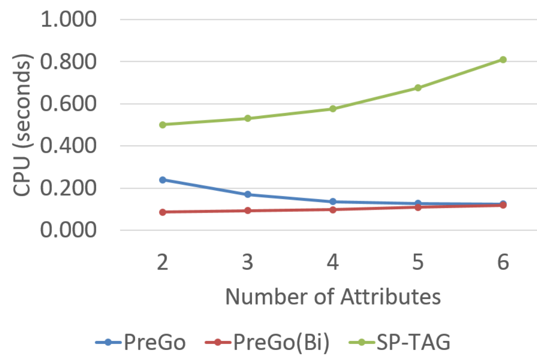
In *ATAG*, each edge has multiple attributes, each of which corresponds to a user's preference. Each attribute is fine grained to multiple intervals. Each interval corresponds to a time slot of the day. This structure is constructed and periodically updated from big spatial data sets, e.g., GPS trajectories, open access maps, events, points of interests, accidents reports, etc.

D. TP_SP *Algorithm*

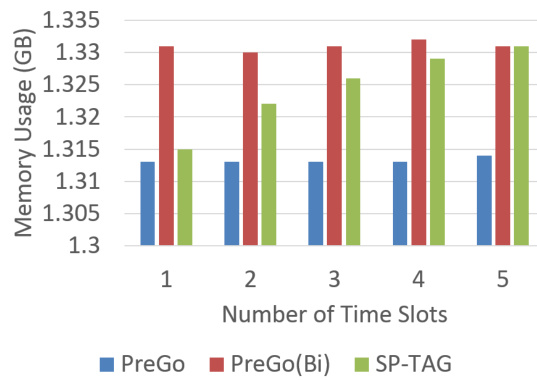
Inside *PreGo*, we developed the Time Parameterized Multi-Preference Shortest Path (*TP_SP*) algorithm that processes multi-preference routing queries through a single traverse of the *ATAG* structure. In case user's start time is flexible, *PreGo* recommends the best start time for a route that fits the user's preferences. To further reduce the query response time, *PreGo* adopts a *bidirectional TP_SP* algorithm that processes the routing query from the two ends at the same time. For more details about the *PreGo* internals and our vision of smart routing services, readers are referred to our related work [4], [3], [2], [6].

E. User Interface

Figure 4 provides the user interface for the *PreGo* system. In , Figure 4(a), users can enter their start and destination locations by either clicking on the map or inserting the addresses. They also have the option to specify a desired future time to start their trip. In addition, each user has the ability to adjust the *PreGo* internal algorithms based on his/her needs. That is done by tuning the weight of each routing preference, (e.g., time, risk, services). Once a query is received at the *PreGo* back-end, the *ATAG* structure is navigated by the *TP_SP* algorithms and best path(s) are returned to the user. Sometimes, one path is found to satisfy all user's desired preferences. Other times, several paths are returned as each of them is the best in one or more preferences. As shown in Figure 4(b), the green route is the safest, the blue is the shortest distance, and the red is the fastest in travel time.



(a) Scalability with Number of Attributes

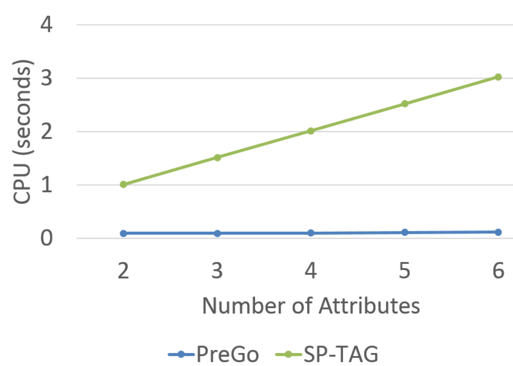


(b) Scalability with Time Slots of the Day

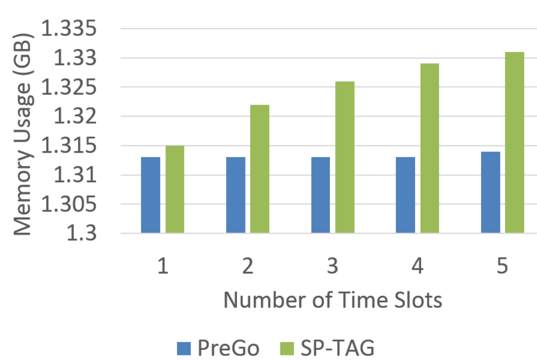
Fig. 2. Best Path, Performance Evaluation (CPU Time)

III. Experimental Evaluation

The purpose of these experiments is to evaluate the efficiency and the scalability of the proposed algorithms within the *PreGo* framework in terms of two factors; CPU time and memory consumption. To provide a sound experimental evaluation of the proposed *TP_SP* algorithm and its bidirectional and best-start time versions, we need to compare its performance in terms of CPU time and memory consumption with a comparable algorithm. We compare the *TP_SP* algorithms developed in*PreGo* against the most competitive work, the *SP-TAG* algorithm [1]. The experiments provide that the efficiency of the routing algorithms inside *PreGo* significantly outperforms the *SP-TAG* in both CPU time and memory overhead, Figure 2 for best path queries and Figure 3 for best start time queries. Minor exception is for the *TP_SP* memory overhead with few number of time slots.



(a) Scalability with Number of Attributes



(b) Scalability with Number of Attributes

Fig. 3. Best-Start Time, Performance Evaluation (CPU Time)

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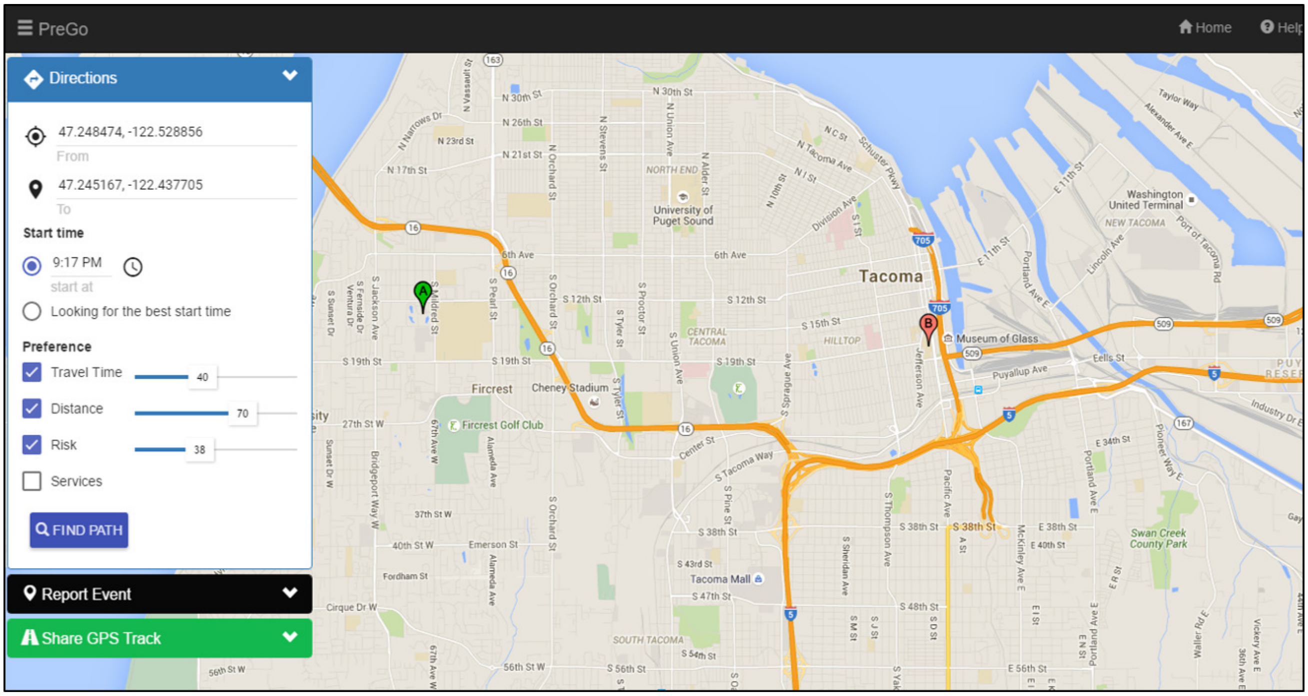
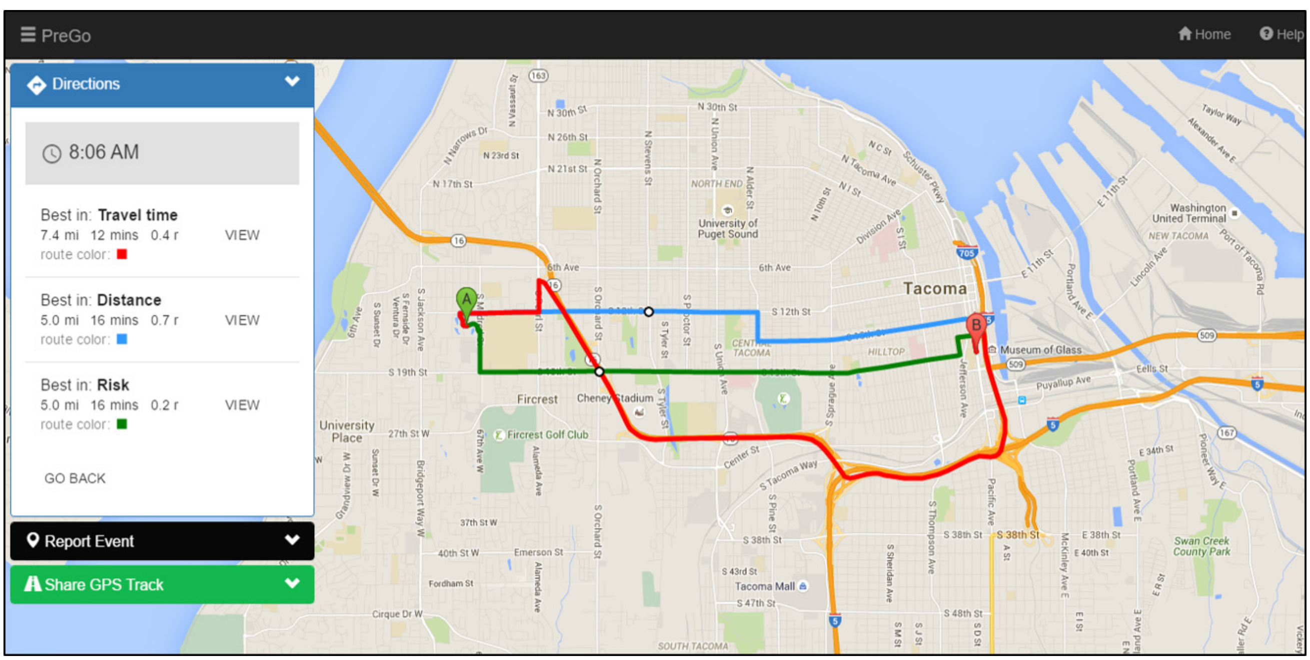


(a) Forming a Personalized Routing Query



(b) Returned Routing Options

Fig. 4. PreGo GUI