Prescriptive Spatiotemporal Mobile Analytics for Delivery Service

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Abstract

Spatiotemporal domains with mobile agents have seen a lot of attention in the field of automated planning. An evidence of such interest is the share of transportation domains among IPC domains. Nevertheless, these domains remain extremely challenging for existing domain-independent planners. One reason for that is the grounding problem that rises in these domains – any realistic size problem in grounded representation becomes too large for a planner to handle. When adding features such as fuel, capacity, or time to the domain, even small problems pose a challenge to a general purpose classical planner.

Delivery service problem is such a variant of transportation with an added temporal aspect. In the delivery service problem, trucks are moving on a map to collect and deliver packages. In contrast to the classical transportation domain, here packages have pickup and delivery deadlines. A solution prescribes a course of action to each agent, respecting all pickup/delivery deadlines. In real-life applications, while the solution is being executed, new requests for pickups arrive, some with short deadlines. As a consequence, the current solution must be modified to comply with these requirements. We suggest a solution to the delivery service problem as follows: when a solution modification is needed, we detect a (small) subset of vehicles to participate in the solution modification. We then apply heuristic search techniques to obtain a new solution for these vehicles. We incrementally improve the solution quality within a given time limit (until the next decision point is reached by executing agents).

Delivery Services

Delivery company provides its services to private and business sectors. The company manages a fleet of delivery trucks, that pick up and deliver packages from / to customer locations, while guaranteeing pick-up / delivery within a specific time interval. The company makes its services available to customers through a dedicated mobile application.

The company is interested in improving operational efficiency by lowering the solution cost, as reflected by fuel consumption, overall driving time, and the size of the fleet in use. In addition, the company wants to improve the quality of service to customers. In order to do so, the company introduces two new services. First, it introduces a "pick-up within 1 hour" service for premium customers. Second, it starts sending mobile notifications to customers prior to the arrival of the delivery truck to their locations.

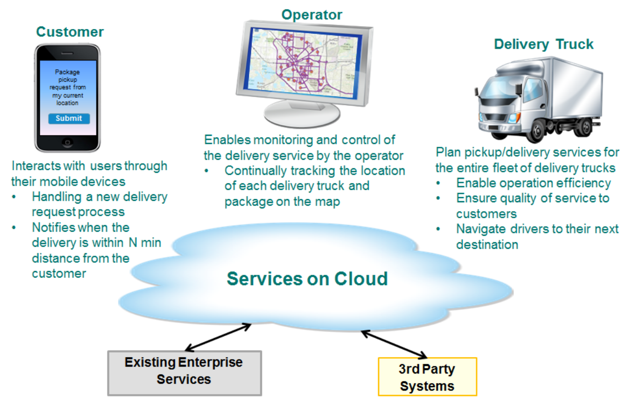


Figure 1: Delivery services system overview.

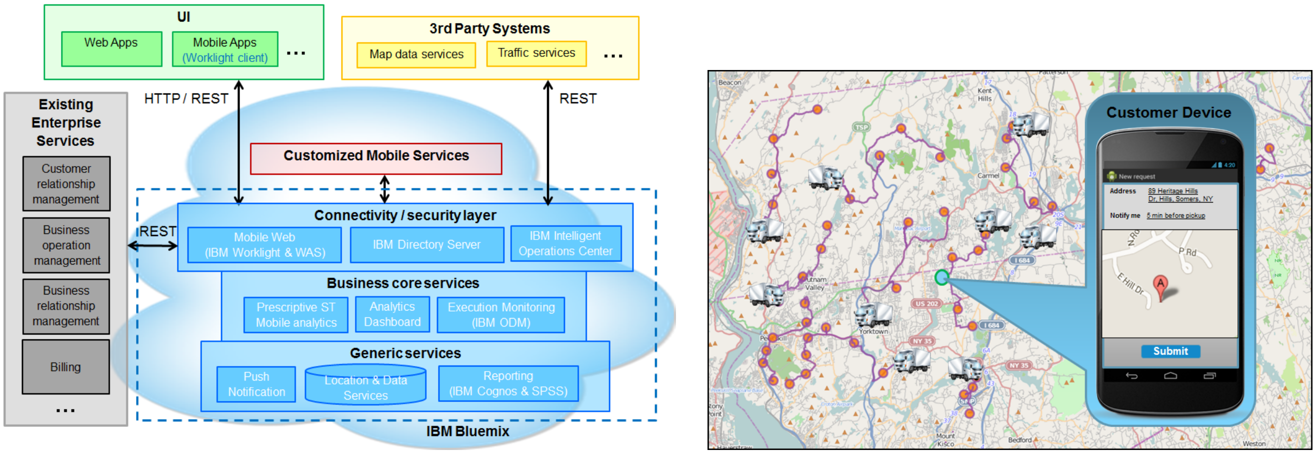
In the delivery services domain, packages are moved between locations using delivery trucks. The major difference from the classical Logistics domain is the addition of time deadlines on package pick-up and delivery.

System overview

Figure 1 shows the overview of the delivery services system. The system interacts with customers through their mobile devices by either processing a new delivery request or sending notifications regarding the current delivery. It interacts with delivery truck drivers through their mobile devices, navigating drivers to their next destination. In addition, it enables monitoring and control of the delivery service by the operator.

The detailed description of the proposed solution architecture is shown in Figure 2a. We suggest exploiting an existing tool, such as the IBM Operational Decision Manager (IBM Corp. 2013), for plan execution monitoring and for trigerring the re-planning process. We use IBM Worklight (IBM Corp. 2012) for handling the mobile aspects of the system. For the operator view (shown in Figure 2b), we use IBM Interactive Maps Technology (IBM Corp. 2014b)[1]. We suggest exploiting IBM Intelligent Oper-

[1]A video clip with additional information is available at `http://researcher.watson.ibm.com/researcher/files/il-KATZM/ICAPS2014Demo.mp4`.



(a) (b)

Figure 2: Delivery services in detail: (a) possible solution architecture, and (b) operator view.

ATIONS CENTER (IBM Corp. 2014a) for the overall integration.

Demo scenario

Our current demo scenario describes the process for a single delivery service to a premium customer. In the first stage of the scenario, a new package pickup request is received from the customer. This request is from the premium customer and must be handled within one hour. Thus, the system detects a set of delivery trucks that can handle this request. Next, the system re-plans the routes for the selected trucks. The outcome plan must be valid, i.e., satisfy the following criteria: (A) All packages within a truck are delivered on time by that truck; and (B) the assignment of pickup requests can be rearranged betweem the trucks to match the required time constraints. Once such a plan is found, the drivers' mobile devices are updated with their new routes. The system navigates each driver to her next location. Additionally, the system defines a geo-trigger for the customer's location, and thus the customer will be notified before the delivery truck arrival.

Planning for delivery services

The planning component of delivery services performs replanning of deliveries for a subset of trucks. An event processing engine monitors new requests, as well as plan execution by the truck drivers, and triggers a replanning procedure, providing a set of new requests. The replanning procedure works as follows. First, a simple greedy algorithm selects a set of relevant trucks. A planning task is then created, containing these trucks and all the packages planned to be picked up or delivered by these trucks in the future, as well as the new requests. We developed a heuristic search-based domain-dependent planner. As such, the planner does not perform task grounding, thereby avoiding the possibly exponential blow-up in task representation size. Instead, it implements a domain-dependent successor generator and heuristic function. Our planner performs both optimal and satisficing search, in parallel. For optimal search, A* with an admissible domain-dependent heuristic, similar to the $h^{\max}$ heuristic (Bonet and Geffner 2001), is used. For satisficing search, an iterative procedure similar to the one deployed by the *LAMA* planner (Richter and Westphal 2010) is used, with the same heuristic as for the optimal search.

Future work

Grounding is known to be a bottleneck in any realistic size planning problems, especially in the presence of spatial and temporal information. As a result, avoiding full grounding is mandatory in real-life applications. We are therefore extending our planner to handle any classical planning problem with spatial and temporal aspects, possibly without grounding the spatial and temporal information, when the modeler allows us to model these aspects for her.

References

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