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INCREASING THE EFFICIENCY OF CACHE MECHANISM BY PATH PLANNING

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ABSTRACT:
Online driving direction services offer fundamental functionality to mobile users, and such services see substantial and increasing loads as mobile access continues to proliferate. Cache servers can be deployed in order to reduce the resulting network traffic. Multi Geography Route Planning (MGRP) where the geographical information may be spread over multiple heterogeneous interconnected maps. We first design a flexible and scalable representation to model individual geographies and their interconnections. We characterize parallel versions of path planning algorithms, such as the Dijkstra's Algorithm. Programming language comparisons are done to analyze fine grain scalability and efficiency using a single socket shared memory multicourse processor. We empirically evaluate DEA* on multiple-worker routing problems where the exact edge cost is calculated by invoking an external multi-modal journey planning engine. The requirement of timeliness is even more challenging when an overwhelming number of path planning queries is submitted to the server. As the response time is critical to user satisfaction with personal navigation services, it is a mandate for the server to efficiently handle the heavy workload of path planning requests. To meet this need. With lightweight preprocessing our technique answers long distance queries across continental networks significantly faster than previous approaches towards the same problem formulation. The empirical results indicate that the MGRP algorithm with the proposed utility based caching strategy significantly outperforms the state of the art solutions when applied to a large university campus data under varying conditions.
Index Terms: Spatial Database, Path Planning, Cache, road networks, shortest paths, caching,

1. INTRODUCTION

Due to advances in big data analytics there is a growing need for scalable parallel algorithms. These algorithms encompass many domains including graph processing, machine learning, and signal processing. However, one of the most challenging algorithms lie in graph processing [1]. The path is coming up with algorithms, love the far-famed Dijkstra's algorithmic program fall within the domain of graph analytics and exhibit similar problems [2]. These algorithms area unit has specified a graph containing several vertices, with some neighboring vertices to make sure property, and area unit tasked with finding the shortest path from a given supply vertex to a destination vertex [3].Assuming that the graph metric is fixed or does not change too often, these techniques offer very fast queries at considerate preprocessing effort, enabling route planning services that serve millions of users per day [4] [5].We present Delayed Expansion A* (DEA*), an A* variant that performs efficient, dynamic edge cost computations, during heuristic search. With admissible estimates of exact edge costs, DEA* can delay the computation of exact edge costs [6]. This way, DEA* reduces the number of exact edge computations while always producing optimal solutions. Besides the main DEA* algorithm, we describe several search enhancements such as dominance-based pruning, and caching [7]. These works mostly optimize workloads across multiple sockets and nodes, and mostly constitute either complete shared memory or message passing (MPI) implementations. In the case of single node setup, a great deal of work has been done for

GPUs [8]. These works analyze sources of bottlenecks and discuss ways to mitigate them [9].We refer to the problem of path planning over such geographies as multi-geography route planning (MGRP). The goal is to determine the least cost weighted paths from sources to destinations where sources and destinations may reside in different geographies [10]. These geographies may be heterogeneous, may represent space using different models different coordinate representations consider another example of a meta-simulation platform that models a campus level evacuation triggered by an extreme event and conducts detailed response processes [11]. Mobile users are increasingly using online driving direction services as they are free of charge and do not require purchase and installation of up-to-date map data on mobile devices [12].

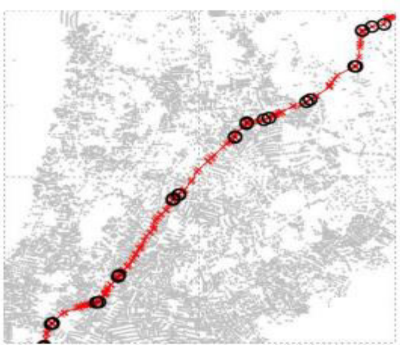

Figure 1: Shortest path

2. RELATED WORK

Caching has been studied extensively for database systems and web search engines the traditional caching model, each query requests a specific data item, and the cache only supports exact matches [13]. On the other hand, in the semantic caching model each cached query result is associated with a validity range, and it can be used to answer and refine any query that intersects its validity range [14].Web-based map services typically implement approximate shortest paths; much effort is placed on being able to render maps at multiple scales to answer user queries. Typically, shortest paths are determined on either on single large homogeneous maps, or on multiple resolutions of the same underlying representation [15]. Unlike existing web based route support systems, and intelligent transportation systems that primarily focus on outdoor maps, multi geography path planning in our case must integrate multiple indoor and outdoor maps that are heterogeneous and possibly overlapping [16].Deferred evaluation (DE) has been studied in satisfying domain independent planning. When generating a successor of a node, DE sets the heuristic value of the successor to that of the parent, thus deferring the successor evaluation [17]. As opposed to DEA*, this related work assumes that edge costs are readily available, and suboptimal solutions are allowedthe similarity to DEA* is that edge costs can be expensive to compute. A key difference is that auction-based techniques are suboptimal [18].Many techniques have been proposed for further acceleration. Nearly all of these divide the work into two phases: In a preprocessing phase the graph is augmented with auxiliary data that is then exploited during the query phase for faster shortest path or distance retrieval [19].To upgrading the hit proportion, a bonus esteem capacity is employed to attain the ways that from the question logs could, the value of developing a store is high since the framework should calculate the advantage values for all Subways in a very full-way of inquiry results [20].

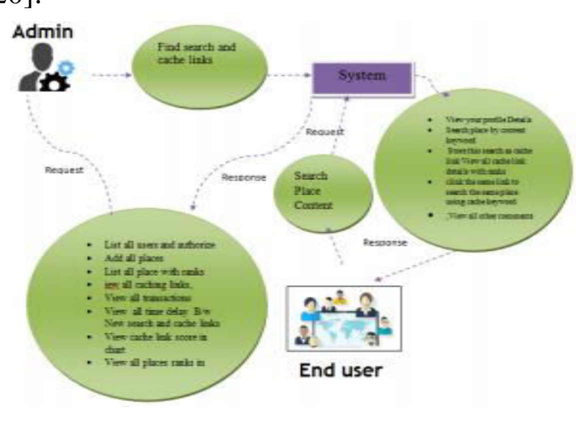

Figure 2. System data flow diagram

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3. SYSTEM MODEL

4.

We adopt the standard client-server architecture the setting cache server is placed in-between the mobile clients and an online shortest path service. Upon receiving a shortest path query the cache server checks whether there is a cache hit. If yes then it returns the result [21]. Otherwise, it forwards to the online shortest path service and eventually returns the result path computed by the service. We assume that the dominant cost is that of the network traffic between the cache server and the shortest path service. Thus, our objective is to maximize the hit ratio of the cache server. While the shortest path service may deploy a shortest path index for its own performance reasons the introduction of such an index does not improve the cache hit ratio and is orthogonal to our work [22]. Unlike previous work this paper utilizes concise shortest paths to improve the hit ratio of caching. We elaborate on concise shortest paths and their operations and we present caching methods for them As a remark, two issues are orthogonal to this paper. First, we reuse existing data structures for the caching of shortest paths to reduce the CPU overhead for maintaining cache structures. Second we assume that the edge weights maintained at the online shortest path service are independent of time [23].

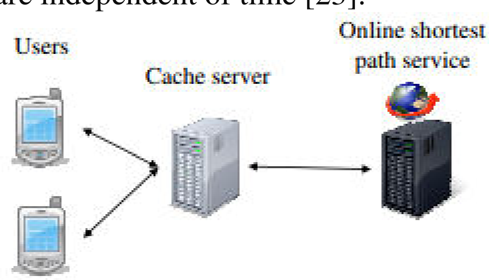

Figure 3: Client server architecture

5. DIJKSTRA'S ALGORITHM AND STRUCTURE

Dijkstra is optimal algorithm, is the de facto baseline used in path planning applications several heuristic based variations exist that trade-off parameters such as parallelism and accuracy. Dijkstra's algorithm consists of two main loops, an outer loop that traverses each graph vertex once, and an inner loop that traverses the neighboring vertices of the vertex selected by the outer loop. The most efficient generic implementation of Dijkstra's algorithm utilizes a heap structure, and has a complexity of O(E + V logV) [24]. The neighboring vertex with the minimum distance cost is selected as the next best vertex for the next outer loop iteration. Consequently, these iterations translate into parallelism, with the graph's size and density dictating how much parallelism is exploitable. We discuss the parallelization in subsequent subsections.

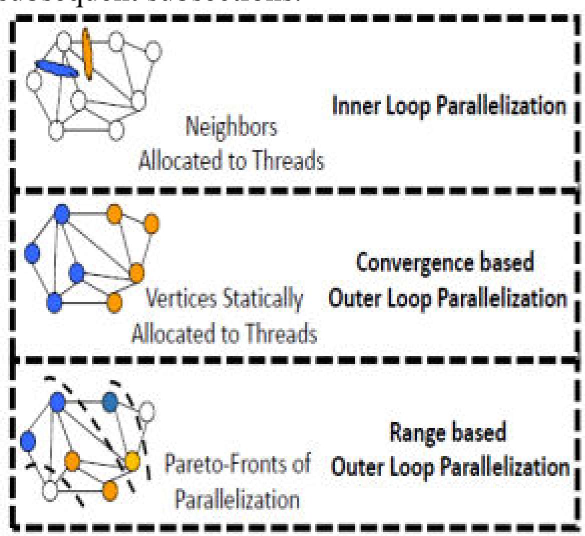

Fig.4. Dijkstra's Algorithm

Our goal is to select as few core nodes as possible while restricting growth in the number of core arcs to describe three steps performed in succession to remove nodes from the core, reducing its size and thus accelerating shortest path queries. After Step 3, we refer to the core as TopoCore-IS, where IS stands for independent set [25].

Step 1: Removing Dead-Ends First, we compute the disconnected components of the input graph, employing a linear-time algorithm

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Each dead end like structure is its own tiny component. We keep every node in the core that is contained in the largest disconnected component.

Step 2: Removing Chains Consider the graph induced by all core nodes. Note that removing a node with only two neighbors from the core, while adding shortcuts between its neighbors, does not increase core arc size. We identify such chains and add shortcut arcs to the core that bypass them, removing bypassed nodes from the core. Note that the resulting may contain multicar.

Step 3: Removing Degree-3 Nodes Ideally, It is therefore beneficial to remove degree-3 nodes from the core for a reduction in queue operations during search. We deal with multi-arcs by defining the node degree as the number of incident arcs.

6. DELAYED EXPANSION A*

We present our algorithm DEA*. Consider a problem P where edge costs are expensive to compute. As said earlier, examples could include edges representing a travel leg, from an origin to a destination, in a multi-modal travel network characterized by uncertainty [26]. If A* is used to solve such a problem P, every time when A* traverses1 an edge in the search graph, the exact cost of that edge has to be available. Often an optimal solution is found with no need to compute accurate costs for all generated nodes. Solve such a problem P, every time when A* traverses1 an edge in the search graph, the exact cost of that edge has to be available. A* could compute these costs on demand, and cache the results for a future reuse [27].

Algorithm DEA* Input: n0

1. Initialize OPEN ← ∅, g(n0) ← 0, (∀n 6= n0; g(n) ← ∞)
2. insert(n0, OPEN), Mark s0 as standard (i.e., not temporary)
3. while OPEN 6= ∅ do
4. n ← deleteMin(OPEN)
5. if n has a duplicate n 0 ∈ CLOSED and g(n 0) ≤ g(n) then
6. Continue
7. else if n is temporary then
8. g(n) ← g(parent(n)) + ca(parent(n), n)
9. Adjust s(n), h(n), f(n) based on ca
10. insert(n, OPEN), Mark n as standard (i.e., not temporary)
11. Continue
12. else
13. Add n to CLOSED, Update g(n) in CLOSED if better g-value is found
14. if n is a goal then
15. Extract and return solution
16. Generate successors(n) based on ch
17. for each m ∈ successors(n) do
18. gh ← g(n) + ch(n, m)
19. g(m) ← gh, parent(m) ← n
20. insert(m, OPEN), Mark m as temporary

7. MULTI-GEOGRAPHY MODELING

In this section we describe a multi-geography model that encapsulates different geographies connecting them topologically to provide a global view of the space. We start by covering issues related to individual geographies to explain possible hierarchical organizations of multi geographies is define the concept of an overlay network and formalize the MGRP problem [28]. Finally we cover the self-containment requirement imposed by the algorithm is enables more structured and efficient path planning. The Multi-geography G = {G1, G2, . . . , G|G|} is a set of |G| geographies. Geographies in G are heterogeneous and can be of varying formats and resolutions. Typicallyeach geography has a set of entrance and exit points, such that a path can exit geography only at the exit point and enter the geography only at an entrance point. For instance, the set of doors in a building can serve as a set of entrance and exit points of the

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building, assuming the only way to get inside a building is through a door [29].

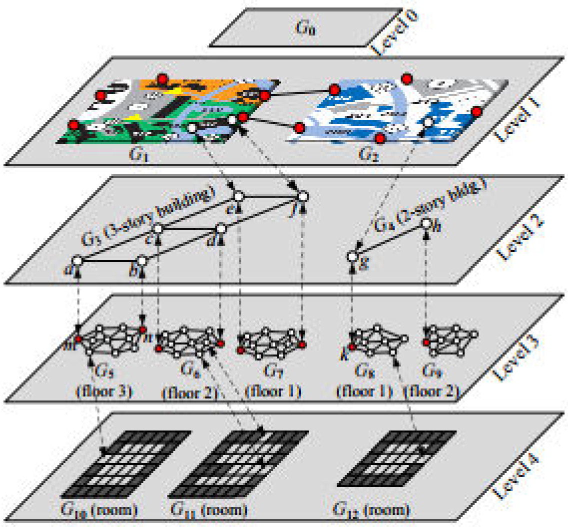

Figure 5: Multi-Geography Model

Given a hierarchical, layered multigeography G = {G1, G2, . . . , G|G|}, where Gi ∈ G is self-contained and points, Psrc ∈ Gi, Pdst ∈ Gj , Gi, Gj ∈ G, find the least cost path, LCP. Our approach to solving MGRP builds upon A*, a goal based path planning algorithm typically employed for grids [25]. We chose to base our solution on the A* technique as compared to traditional approaches such as Dijkstra due to its greater efficiency in terms of the search space explored. Key elements of our approach to solve the multi-geography route planning problem include [30]:

1. Abstracting out details of individual geographies by designing and utilizing overlay network.
2. Optimizing representation of the overlay network by identifying and removing unnecessary nodes and links.
3. Using a hierarchical adaptation of A* algorithm to prune the search space
4. Exploiting path caching strategies to help to further improve the A* algorithm

We next describe the techniques that leverage the hierarchy to reduce the search space for more efficient path planning.

8. EXPERIMENTAL RESULTS

We evaluate DEA*'s performance in the MWRP and in domain-independent planning. Experiments are conducted on an Intel Xeon CPU cluster, with a time and memory limit of one hour and 1.5 million in-memory states per instance. We generated a total of 180 instances with the real road-map and transportation data from three European cities In each instance. They do not contain unrealistic configurations. The map roughly contains an area within a radius of 10km, 6km, and 10km from the city center in Dublin, Montpellier and Rome, respectively. In these maps, the locations of workers W and the locations of patients P are randomly selected within a 2km radius circle in the city center. Appointment times are randomly set. We implemented DEA* on top of the cost-optimal Fast Downward planner based on the landmark-cut heuristic. We selected domains with non-unit action costs from the optimal tracks in past International Planning Competitions.

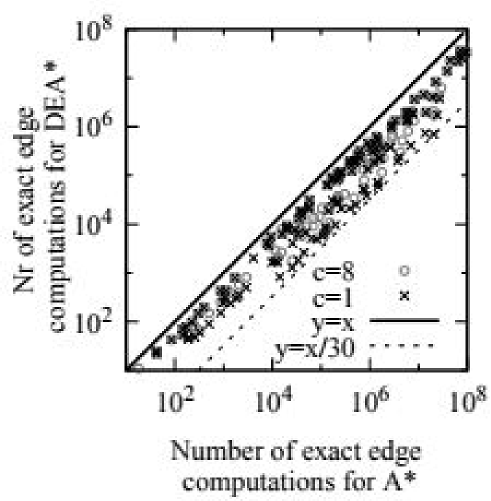

Figure 6: DEA* vs A* in domain independent planning

9. CONCLUSION

The main advantage of the Personalized Route Planning is that costs are individually adjusted for every user and every query in a very flexible way. We provided an NP-hardness result for MWRP. We evaluated the performance of DEA* in MWRP and in domain-independent planning. The results demonstrate a significant performance improvement of DEA* as compared to A*. We study different parallelization of Dijkstra's algorithm for single node machines, and analyze algorithmic and architectural bottlenecks for each parallelization strategy. We have presented a multi-geography planning algorithm that effectively uses cached data that utilizes two utility based caching strategies. We evaluated our solution on a real world dataset that corresponds to a large university campus. The propose notion of a generic concise shortest path that enables a tradeoff between the path size and the number of queries that can be answered by the path. Then we develop static and dynamic caching techniques for generic concise shortest paths. As future work, Factored Planning could incorporate ideas from DEA*. This framework automatically decomposes the input problem and solves each sub problem to convert the sub plans into macro actions. DEA* could improve this potential bottleneck by replacing the sub problem solving with a partial computation of the plan.

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