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(54) **Predictive vehicular traffic management solution**

(57) A predictive vehicular traffic management solution composed of a navigation client to be operated on board the vehicles and a Central system to which the clients are connected that uses a traffic simulator and a routing engine to guide vehicles to their destination through a route optimized for both trip duration and road network efficiency.

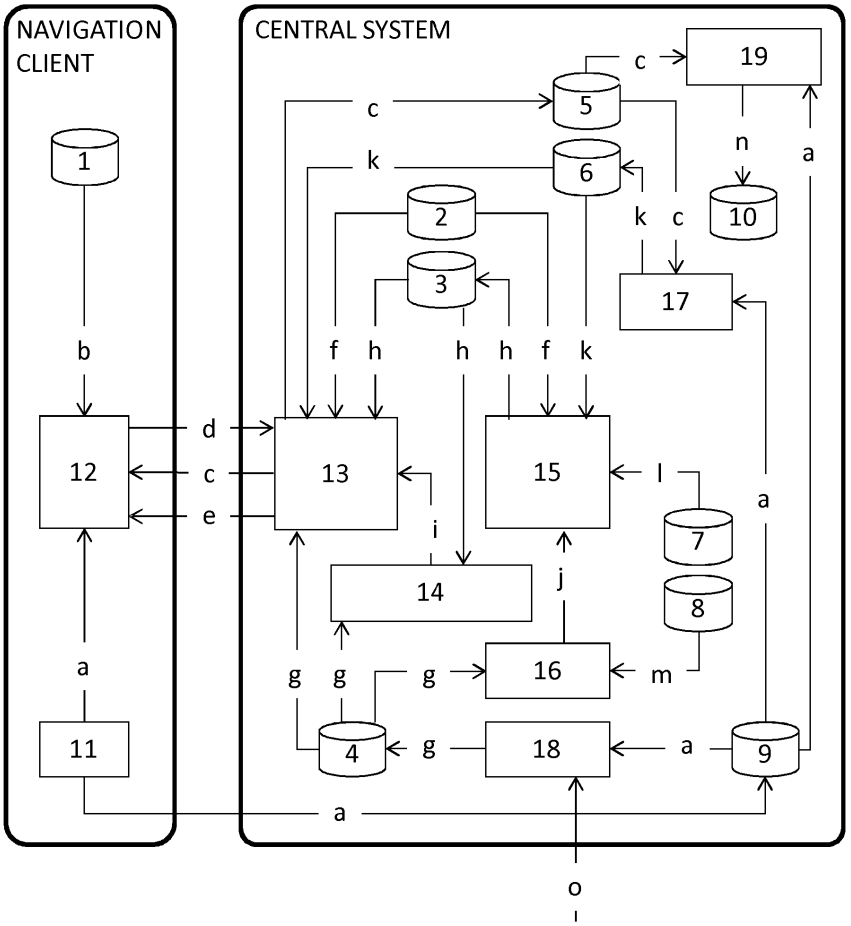

Fig 1

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Description

Field of the Invention

[0001] This invention concerns a centralized traffic management system able to guide vehicles to their destination providing to on-board navigation clients a route optimized for trip duration and road network efficiency on the basis of predicted road occupancy

Background of the Invention

[0002] Portable or vehicle embedded Navigation systems are widely used nowadays by many drivers, and they determine in most cases the route actually followed by the driver in order to get to the desired destination. These systems use position information acquired through a GPS receiver and a vectorial map representing the existing road network inclusive of some static road characteristics to guide the driver to destination through a route that fulfills a predefined set of criteria. The guidance is provided by showing the current vehicle position on the map and suggesting the required maneuvers along the journey.

[0003] The algorithms used to calculate the suggested route provide a deterministic solution usually based on the shortest or fastest route criteria and do not typically consider actual traffic conditions that will be encountered along the road as the route is followed.

[0004] Some event based traffic information is nowadays broadcasted through Traffic Message Channel (TMC) in the countries where this service is available or through equivalent systems to deliver traffic and travel information to connected devices. Some recent navigation systems, that offer dynamic route guidance, can receive and decode the TMC messages to identify problems and then re-calculate an alternative route to avoid the notified incident or congestion.

[0005] Near real time "crowdsourced" traffic speed information is also collected by some Internet application providers from GPS equipped handsets. This information is then made available either as an overlay to browsable maps or through a specialized navigation client application.

[0006] Some traffic services provider offer state of the art historical, real time and predictive traffic speed data and off-board routing engines that use predicted speeds for road segments to be traveled along the trip.

[0007] Despite the current availability of reliable positioning technology, of real time, historical and predicted traffic speed data, of sophisticated routing algorithms, of affordable mobile broadband and high performance computing no comprehensive solution for centralized dynamic route assignment to private and commercial traffic has been successfully implemented.

[0008] The urban and motorway traffic is still the result, in the best case, of the implementation of "individually optimal" travel strategies. This results in travel times, fuel consumption and generated pollutants higher than could been achieved by pursuing a "system optimal" solution.

[0009] Even in case traffic speed conditions would be evaluated using current or predicted traffic conditions along the route derived from event information and/or crowdsourced GPS positions, current vehicle navigation algorithms are not able to forecast the impact of the directions provided by navigation systems on the overall traffic.

[0010] As the adoption of navigation systems increases more and more vehicles will follow routes calculated by independent entities thus contributing to overload the supposed "fastest" routes. This is especially valid for commuter traffic where large amounts of traffic flow with some degree of time correlation from one area to the other. In the best case algorithms implemented by these systems will be able to reactively respond to congestion or roadblock events by calculating alternative routes.

[0011] The overload of road segments included in the mostly used itineraries leads to the increase of the vehicle density above the critical density thus resulting in reduced flow (throughput), jamming, and therefore reduced aggregated throughput of the road infrastructure.

[0012] Existing roadway networks could be utilized much more efficiently to meet traffic demand if traffic density for each road could be maintained always below the critical density threshold.

[0013] Wireless vehicular cooperative systems where route calculation and assignment is performed by a central controlling entity have been investigated as an attractive solution to support road traffic management, thereby contributing to the goal of safer, cleaner, and more efficient and sustainable traffic solutions.

Summary of the Invention

[0014] The invention here presented implements a possible solution to the roadway network throughput maximization problem which enables vehicles to globally reach their destination in the shortest possible time by using the maximum roadway capacity.

[0015] This is implemented as a new type of navigation system implemented centrally and providing individual routes to navigation client applications on board the vehicles, where the route will be calculated based on time-dependant traffic density and speed conditions forecasts.

[0016] This solution implements Dynamic Traffic Assignment (DTA), using a "User Optimum" approach, which means that the central system will assign to every user its own fastest route given his Origin-Destination pair. The delays used for route calculation will be predicted, under the assumption that the central navigation system is able to reliably predict speed and density for each road, in every moment of a predefined future timeframe. The prediction leverages both average traffic data, and the implicit contribution of guided vehicles to the forecasted traffic.

[0017] The effectiveness of such a solution in maxi-

mizing the road network capacity is dependant from the degree of adoption by the drivers using the same road network, whereas the effectiveness in terms of fastest routing given the actual evolution of traffic conditions in the area remains independent from the above parameter.

[0018] The traffic prediction will be performed using a traffic simulator using as inputs both "background" traffic flows and discrete vehicle routes previously assigned by the routing engine. Vehicles behavior will be individually characterized using a vehicle database. Background traffic will be predicted using both historical measurements and real time traffic data by combining them using a time dependent weighting strategy. Simulations shall be run for the predefined forward time span with extreme high frequency, in order to be able to generate extremely dynamic forecasts able to incorporate the consequences of sudden events like accidents or jams.

[0019] Simulation results will include vehicle density and speed for every road segment in the map, which associated to static or weather dependant critical density threshold will enable the road infrastructure capacity maximization strategy previously described.

[0020] The central routing engine will be using a shortest path algorithm used to calculate each single client route, using a map associated with the latest simulation predicted parameters, and the route will be sent to the client application that will guide the driver.

[0021] Real time vehicle positions will be collected from the GPS receiver of the client device in order to both update the origin of the vehicle route used in the simulation and check the compliance of the driver to the assigned route.

[0022] The above information is combined with other traffic data (GPS and NON-GPS) coming from sources external to the system, in order to generate of Real Time traffic estimates and in order to detect unforeseen jamming events by comparing forecasted and actual speeds in every road.

[0023] Detection of one of these events will cause the system to reroute all the vehicles which have the impacted road on their route and for which the approach time is greater than the minimum required to execute an effective maneuver.

[0024] Non compliances to the assigned route will also trigger the calculation of a new route by the central routing engine, and will be stored in a specific database in order to support compliancy rewarding policies which might be implemented from a driver/traffic management entity contractual perspective.

[0025] Recalculated routes, are used as soon as these are available, to perform simulations replacing the outdated ones.

Brief Description of the Drawings

[0026] These and other characteristics of the invention will be clear from the following description of a preferential form of embodiment, given as a non-restrictive example, with reference to the attached drawings wherein:

Fig. 1 is a block diagram of the overall solution composed of a client application, server application components and databases along with major data flows among them

Detailed description of a preferential embodiment

[0027] With reference to the Fig 1, the following databases (physical or logical) would be required to implement the above described invention embodiment:

1. The Client Map database would be required to visualize driver routes in the context of the local topography as well as to provide maneuver assistance to the driver as in any conventional GPS navigation system. The client map version needs always to be synchronized with the central map used by the routing engine.
2. The Central Map database would store the map used both by the Routing Engine and by the Traffic Simulator. Older map versions could be used for routing only to accommodate for progressive client map updates.
3. The Predicted Traffic database would store forecasted vehicular speed and density related to road segments available in the map used for the simulation, maintained for the maximum simulation duration time in the future to enable optimal route calculation, and for a predefined duration time in the past to be used by the congestion detection application component.
4. The Real Time Traffic database would store the most recent estimation of vehicular speed and density related to road segments available in the map used by the congestion detection application component.
5. The Assigned Routes database would store both original baseline routes and routes resulting from a re-calculation triggered by the central system or by the navigation client due to the actual position deviating from baseline route.
6. The Simulation Routes database would store routes where road segments which have been already traveled are removed, using current vehicle position, thus enabling a simulation limited to future time only.
7. The Vehicle database would store both standardized vehicle type characteristics and personalized correction factors of those to be used by the traffic simulator.
8. The Historical Traffic database storing available historical information related to road segments, characterized with hourly/daily/weekly/seasonal variations.
9. The Track Point database would store current and previously received subscriber vehicles GPS posi-

tions provided to the Simulation Routes Updater application, and accessible by the Route Compliancy Check application.
10. The User Account database would store individual subscriber account information inclusive of actual route compliance information.

[0028] With reference to the Fig 1, The following application components (physical or logical) would be required to implement the above described invention embodiment:

11. The GPS Receiver client side application component would generate track points defining accurately client position which are used by the navigation client and sent to the central track point database.
12. The Navigator client side application component, installed on a portable device or embedded in the vehicle would provide graphical and audio route guidance based on the locally stored map, GPS records generated by the GPS receiver and routes received from the central routing engine calculated upon user's origin destination pair routing request. Trip duration updates based on changing forecasted speeds on road segments included in the route would be received and presented.
13. The Routing Engine server side application component would use a shortest path algorithm to calculate each single client route, using the topographic map data associated with the latest simulation predicted traffic parameters. The route calculation can be either triggered by the navigation client due to a new trip request or a route deviation, or by the Congestion Detector application component.
14. The Congestion Detector component would detect major differences between forecasted & near real time data, in order to trigger the reroute all the vehicles which have the involved road segment(s) on their route where the approach time is greater than the minimum required to execute an effective maneuver.
15. The Traffic Simulator would generate time dependent, predicted speed and density parameters for each road segment in scope using both "background" traffic flows and discrete future routes representing the remaining segments of routes previously assigned by the routing engine. Simulations would be run with such a frequency, in order to be able to dynamically incorporate the consequences of sudden events like accidents or jams.
16. The Background Traffic Generator application component would generate traffic flows suitable for simulation calculated correlating both historical measurements and real time traffic data by combining them using a time dependent weighting strategy.
17. The Route Updater application component would trim currently assigned routes into simulation routes by removing road segments which have been already traveled.
18. The Route Compliance Analyzer application component would detect deviation of the actual route from the centrally assigned baseline route in order to enable rewarding policies for disciplined users.
19. The Current Traffic Generator application component, would calculate near real time average speed and density parameters for road segments in scope using both positioning data records available from subscribers and other external real-time traffic data sources.

Claims

1. A predictive vehicular traffic management solution comprised of:

- A central system calculating individually optimized routes between current position and requested destination using time dependant predicted road traffic conditions
- Navigation client applications running on portable devices to be operated on board the vehicles, using those routes to guide the driver to follow the above mentioned route, and periodically reporting actual position information to the central system

characterised in that predicted road traffic conditions (density and speed) are generated through a traffic simulator that uses as inputs:

- "Background" traffic flows predicted using both historical measurements and real time traffic data
- Portions to be traveled of discrete vehicle routes previously assigned by the routing engine which are continuously updated based on current position updates.

2. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a map database applicable to the geographical area in scope **characterised in that** it stores road segments static critical density thresholds and both real-time and forecasted vehicular speed and density maintained for:

- The maximum simulation duration time in the future
- A predefined duration time in the past to be used by roadblock/congestion events detection algorithm.

3. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a routing engine application using predicted

traffic speeds to determine the optimal route and provide accurate trip duration estimates **characterised in that** it does not include road segments close to saturation in calculated routes in order not to contribute to the determination of a congestion status on that segment.

4. A predictive vehicular traffic management solution according to claim 1 wherein said navigation client applications provides graphical and audio route guidance based on a locally stored map and GPS, or equivalent system, generated positioning information **characterised in that** it receives centrally calculated routes upon user's origin destination pair routing request as well as trip duration updates based on changing forecasted speeds on road segments included in the route.

5. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a congestion detector application **characterised in that** when major differences between forecasted & real-time data suddenly arise, which are evidence of a sudden roadblock due to accident or other similar events it recalculates and sends a new route to all those vehicles which have the same segment on their route and whose approach time is longer than the minimum required to execute an effective maneuver but shorter than a predefined duration.

6. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a traffic simulator generating predicted road segments speeds and densities through micro simulation techniques **characterised in that** it uses both routes calculated and assigned by the routing engine, updated based on the best estimate of the real time position, and fictitious car flows generated to account for traffic not controlled by the system.

7. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a background traffic prediction application to account for traffic not controlled by the system **characterised in that** predicted background traffic flows are calculated correlating historical traffic flows data with real time traffic data and available contingent event/incident information for each road in the model. The importance of real time versus historical is decreasing as a function of time distance from present.

8. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a vehicle database **characterised in that** it stores both standardized vehicle type characteristics and personalized correction factors of those to provide more realistic simulation results.

9. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a simulation routes updater **characterised in that** it trims currently assigned routes into simulation routes by removing road segments which have been already traveled according to the current vehicle position.

10. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a GPS Track Point Database storing current and previously received GPS determined subscriber vehicles positions according to predefined record maintenance policies.

11. A predictive vehicular traffic management solution according to claim 1 wherein said central system includes a route compliance analyzer application component in order to enable rewarding policies for disciplined users that would cooperate to traffic management system objectives.

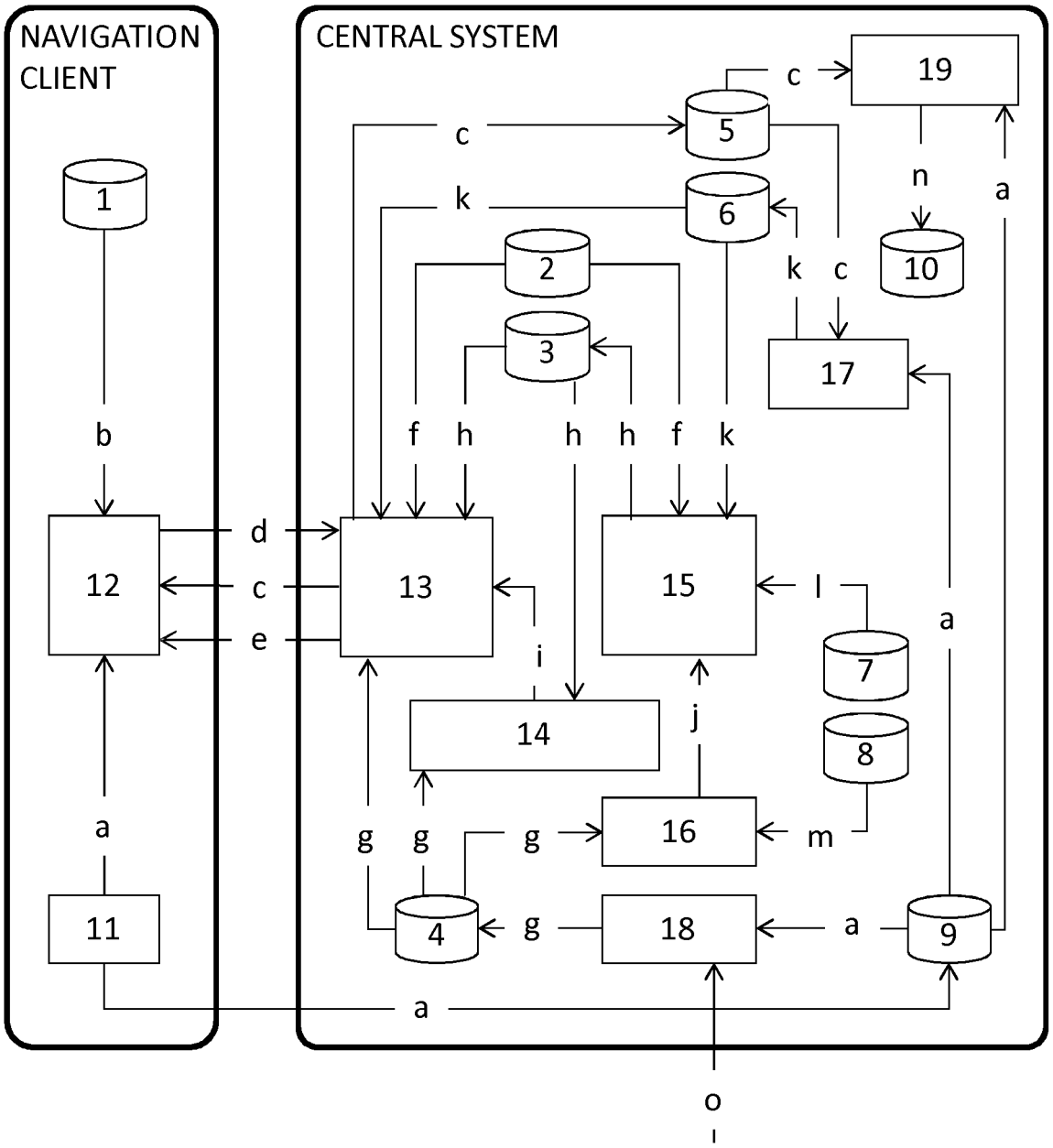
NAVIGATION CLIENT
CENTRAL SYSTEM
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Fig 1

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EUROPEAN SEARCH REPORT

Application Number
EP 11 16 2763

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2010/107394 A1 (ST ELECTRONICS INFO COMM SYSTE [SG]; CHAN SIEW KEONG [SG]; CHEN JUN DO) 23 September 2010 (2010-09-23) * paragraphs [0011], [0034], [0106], [0114]; figures 1-6 * -----	1-11	INV. G08G1/0968
X	US 2008/255754 A1 (PINTO DAVID [US]) 16 October 2008 (2008-10-16) * paragraphs [0031], [0035], [0038], [0118]; figures 1-18 * -----	1-11	
			TECHNICAL FIELDS SEARCHED (IPC) G08G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23 September 2011	Créchet, Patrick

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 16 2763

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23-09-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010107394 A1	23-09-2010	NONE	
US 2008255754 A1	16-10-2008	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82