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(54) **METHOD AND APPARATUS FOR ESTIMATING TRAIN LOCATION**

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(60) Provisional application No. 60/449,849, filed on Feb. 27, 2003.

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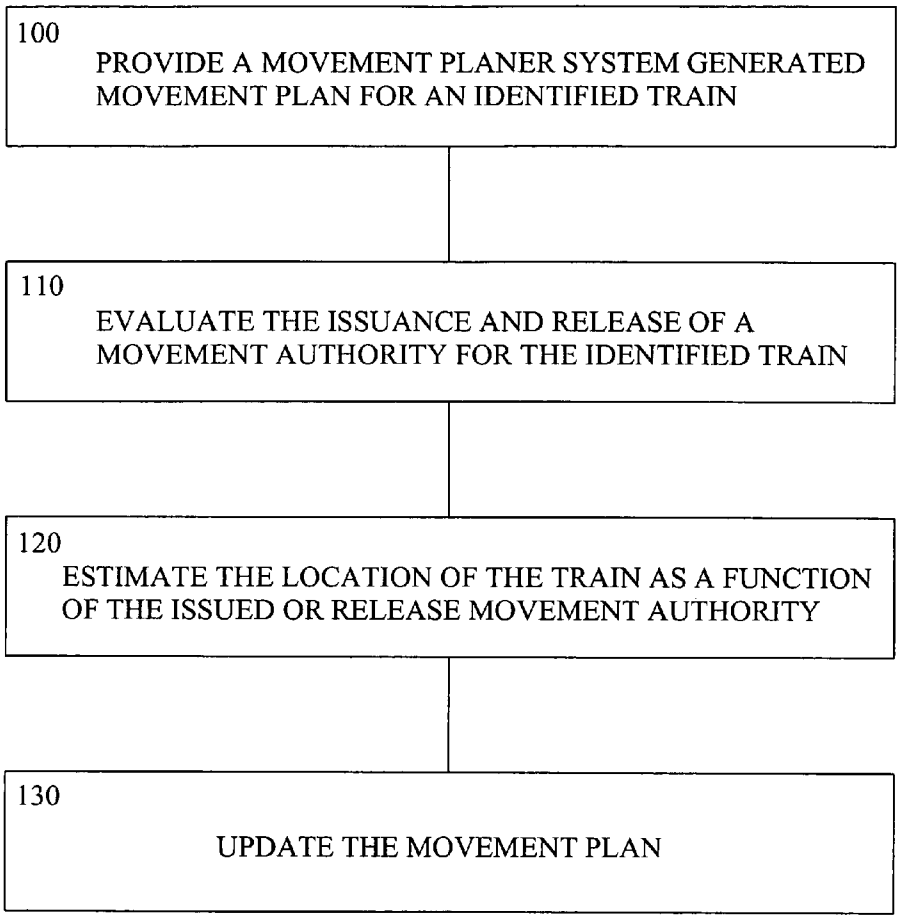
(57) **ABSTRACT**

A scheduling system and method for moving plural objects through a system described as a freight railway scheduling system. The scheduling system utilizes a cost reactive resource scheduler to minimize resource exception while at the same time minimizing the global costs associated with the solution. The achievable movement plan can be used to assist in the control of, or to automatically control, the movement of trains through the system. The estimation of the location of trains in track warranty locations where track sensor and GPS indications are not available is made based on the movement planners and the form-based movement authorities issued to each trains. Certain user interactions are interpreted as a specific train location.



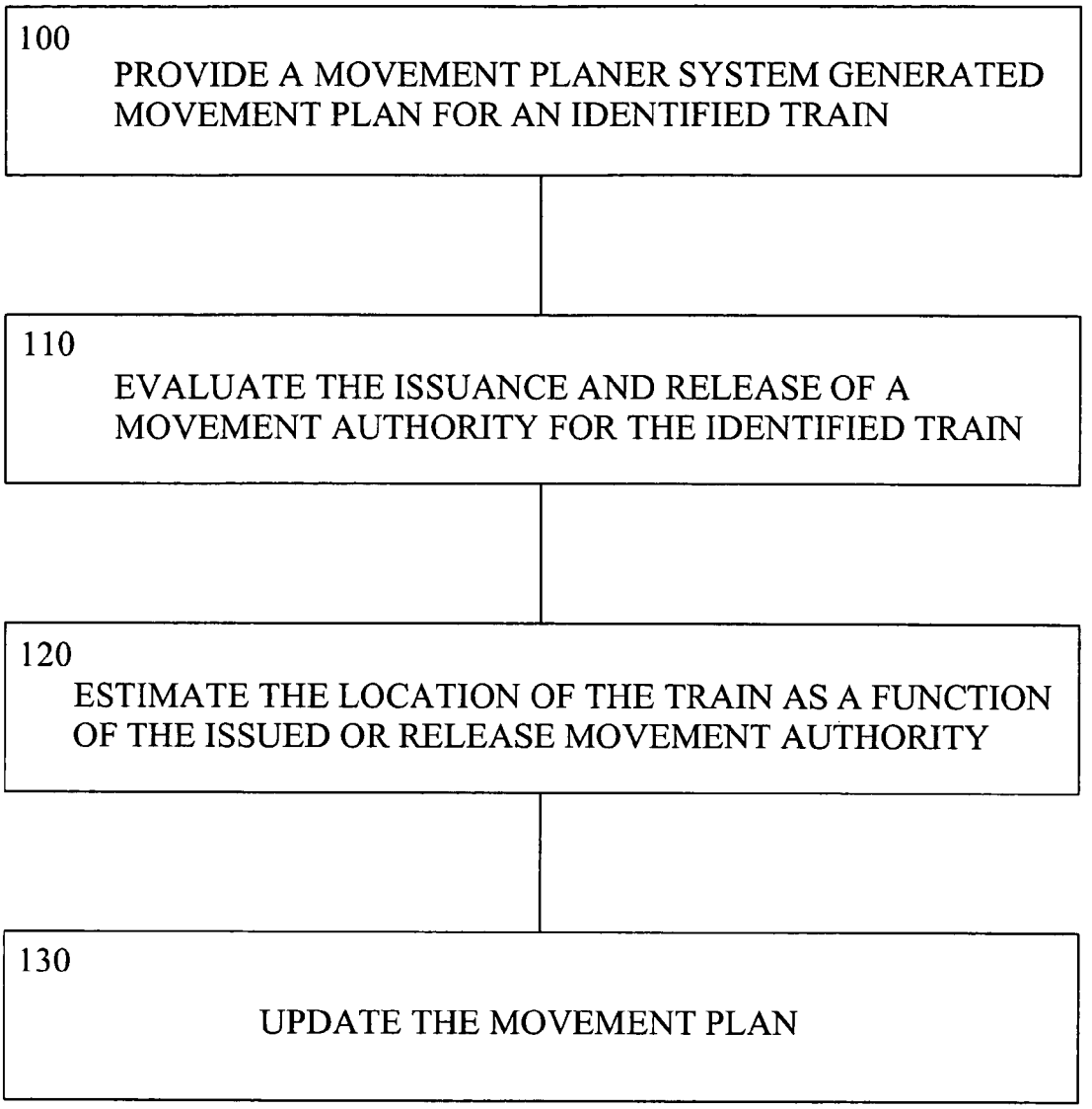

100
PROVIDE A MOVEMENT PLANER SYSTEM GENERATED MOVEMENT PLAN FOR AN IDENTIFIED TRAIN
110
EVALUATE THE ISSUANCE AND RELEASE OF A MOVEMENT AUTHORITY FOR THE IDENTIFIED TRAIN
120
ESTIMATE THE LOCATION OF THE TRAIN AS A FUNCTION OF THE ISSUED OR RELEASE MOVEMENT AUTHORITY
130
UPDATE THE MOVEMENT PLAN

FIGURE 1

METHOD AND APPARATUS FOR ESTIMATING TRAIN LOCATION

RELATED APPLICATIONS

[0001] This application is also a continuation in part of application Ser. No. 10/785,059 filed Feb. 25, 2004, claiming the benefit of U.S. Provisional Application 60/449,849 filed on Feb. 27, 2003.

[0002] This application is also one of the below listed applications being concurrently filed:

[0003] GEH01 00166 Application Serial No. _____ entitled "Cost Reactive Scheduler And Method For Managing Unpredictable Local Trains";

[0004] GEH01 00167 Application Serial No. _____ entitled "Method And Apparatus For Optimizing Maintenance Of Right Of Way";

[0005] GEH01 00168 Application Serial No. _____ entitled "Method And Apparatus For Coordinating Railway Line-Of-Road and Yard Planners";

[0006] GEH01 00169 Application Serial No. _____ entitled "Method And Apparatus For Selectively Disabling Train Location Reports";

[0007] GEH01 00170 Application Serial No. _____ entitled "Method And Apparatus For Automatic Selection Of Train Activity Locations";

[0008] GEH01 00171 Application Serial No. _____ entitled "Method And Apparatus For Congestion Management";

[0009] GEH01 00172 Application Serial No. _____ entitled Method And Apparatus For Automatic Selection Of Alternative Routing Through Congested Areas Using Congestion Prediction Metrics"; and

[0010] The disclosure of each of the above referenced applications including those concurrently filed herewith is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0011] The present invention relates to the scheduling of movement of plural units through a complex movement defining system, and in the embodiment disclosed, to the scheduling of the movement of freight trains over a railroad system, particularly to the estimating of the location of the trains in the railroad system.

[0012] Systems and methods for scheduling the movement of trains over a rail network have been described in U.S. Pat. Nos. 6,154,735, 5,794,172, and 5,623,413, the disclosure of which is hereby incorporated by reference.

[0013] As disclosed in the referenced patents and applications, the complete disclosure of which is hereby incorporated herein by reference, railroads consist of three primary components (1) a rail infrastructure, including track, switches, a communications system and a control system; (2) rolling stock, including locomotives and cars; and, (3) personnel (or crew) that operate and maintain the railway. Generally, each of these components are employed by the use of a high level schedule which assigns people, locomotives, and cars to the various sections of track and allows them to move over that track in a manner that avoids collisions and permits the railway system to deliver goods to various destinations.

[0014] As disclosed in the referenced applications, a precision control system includes the use of an optimizing scheduler that will schedule all aspects of the rail system, taking into account the laws of physics, the policies of the railroad, the work rules of the personnel, the actual contractual terms of the contracts to the various customers and any boundary conditions or constraints which govern the possible solution or schedule such as passenger traffic, hours of operation of some of the facilities, track maintenance, work rules, etc. The combination of boundary conditions together with a figure of merit for each activity will result in a schedule which maximizes some figure of merit such as overall system cost.

[0015] As disclosed in the referenced applications, and upon determining a schedule, a movement plan may be created using the very fine grain structure necessary to actually control the movement of the train. Such fine grain structure may include assignment of personnel by name as well as the assignment of specific locomotives by number and may include the determination of the precise time or distance over time for the movement of the trains across the rail network and all the details of train handling, power levels, curves, grades, track topology, wind and weather conditions. This movement plan may be used to guide the manual dispatching of trains and controlling of track forces, or provided to the locomotives so that it can be implemented by the engineer or automatically by switchable actuation on the locomotive.

[0016] The planning system is hierarchical in nature in which the problem is abstracted to a relatively high level for the initial optimization process, and then the resulting course solution is mapped to a less abstract lower level for further optimization. Statistical processing is used at all levels to minimize the total computational load, making the overall process computationally feasible to implement. An expert system is used as a manager over these processes, and the expert system is also the tool by which various boundary conditions and constraints for the solution set are established. The use of an expert system in this capacity permits the user to supply the rules to be placed in the solution process.

[0017] Of significant value in planning train movement is the evaluating of the current location of the train, i.e., is the train on, ahead or behind schedule. Train location reports may be automatically issued by sensors along the line of road, but such sensors may be few in number and are expensive and difficult to maintain. Train location reports are required to be submitted by train personnel at periodic intervals, but voice communication by radio is subject to all of the idiosyncrasies of radio wave communications and dependant on the attention of the train personnel. Train location reports may be automatically submitted using on board systems such as GPS, but such equipment is not available on all trains or in all environments and is expensive. The information in these reports as to the location of a train is used as it becomes available to automatically update the planned movement of the trains.

[0018] In some prior art systems, the trains were equipment with sensors which allowed dead reckoning techniques

to be performed to estimate the location of the trains. For example, if the location of a train is determined through a fix based on a location determination system such as a wayside transponder, GPS, or other fix determining system, an onboard sensor such as a wheel counter can be used in conjunction with a track database to determine the velocity of the train along the track and thus estimate the position of the train along its planned movement path.

[0019] However, it is common for trains not to access to location determination systems and thus the location of train may not be known absent some communication from the crew as to the location of the train. Without an estimate of the train location, dispatchers are hesitant to schedule resources which could case conflict with the train. In addition, with an estimate of the location of the train, automated scheduling systems can not be used to plan the continued movement of the train.

[0020] There are areas known as track warrant territory where the movement of the trains is controlled by the dispatcher by the issuance of form-based track authorities, e.g., the authority for a specific train to be on a specific section of track in a specified period of time. Such authorities may allow movement of the train over a large area and the location of the train at a specific moment in time may differ significantly from the location planned for that train at that time. The issuance of such track authorities as requested by the train provides a valuable clue as to the location of the train and provides an opportunity for the dispatcher to adjust the limits of issued authorities and to issue additional authorities. Reference to the issuance of such authorities may improve the estimate of train location and thus increase the efficiency of the system. The use of the issuance and the release of movement authorities has not previously been used to estimate the location of trains.

[0021] It is an object of the present invention to improve the ability of the dispatcher to estimate the location of the trains under his control. This improvement is achieved by the use of information based on the issuance of movement authorities by the dispatcher in conjunction with the release of movement authorities by the crew of the train.

[0022] The issuance and release of track warrants of authorities as requested by the train may be used as an estimate of train location by the movement planner to more accurately plan the movement of the train over the rail network.

[0023] These and many other objects and advantages of the present invention will be readily apparent to one skilled in the art to which the invention pertains from a perusal of the claims, the appended drawings, and the following detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWING

[0024] **FIG. 1** is a flow chart of the use of the issuance and release of movement authorities to estimate the location of a train for use in a movement planner.

DETAILED DESCRIPTION

[0025] With reference to **FIG. 1**, a movement plan may be provided by identifying the activities required to move plural trains through a network of track, by assigning resources to each of the identified activities, and by creating a movement plan optimizing movement of the trains through the system as a function of cost of the identified activities and assigned resources **100**. While the movement planner may automatically receive train location reports communicated from certain trackside equipment, or on-board equipment, many trains are not provided with on-board equipment or are operating gin areas without trackside locating systems. Territories where there is very little trackside equipment capable of sensing the passage of a train are known as "track warrant territory". Although there may be no equipment to determine the location of the train, the issuance or the release of the movement authority may be used by the movement planner to estimate the movement of the train. For example, a sequence of movement orders may be necessary to move a train from Point A to Point C. One movement authority may give a train permission to use the main track between Point A and intermediate Point B. A second movement authority may give permission for the train to use the main track between intermediate Point B and final Point C. When the train releases the movement authority between Point A and intermediate Point B, this information can be used to estimate that the train is located in the track section between intermediate Point B and final Point C. The release of a movement authority can automatically be transmitted to the movement planner to be evaluated **110**. An estimate of the location of the train can be based on the issuance or release of the movement authority **120**. The movement planner can use this estimate to update the movement planner for the railway system **130**.

[0026] In the absence of such a location estimate, the dispatcher may not feel comfortable planning the movement of the train and the movement planner is not provided with information with which to update the movement plan for the train.

[0027] In part, the estimate of train location is based on the movement plan itself. The movement planner may consider the planned operating characteristics of the train, the time at which the track authority or warrant was issued, the specific contents of the authority such as temporary and permanent speed restriction, and the power, length, and weight of the train in estimating how far the train should have traveled since entering the section of track for which the form-based authority was issued.

[0028] The estimate may be based in significant part of the contents of the form-based movement authority itself, i.e., the authority may be for "work", "proceed", "hold main", "clear main", "not in effect until arrival of another train", etc. For example, a movement authority may direct a train to clear the main at siding XYZ. Upon release of the movement authority, the planner can estimate that the train is at siding XYZ, and allocate the main to other resources. Such valuable location information has not previously been provided to the movement planner.

[0029] In another example, the movement planner may take advantage of the conditional movement authorities that may be issued to a train. For example, a movement authority may be issued to train **1** to proceed along the main track and then to siding A and another movement authority may be issued to train **2** to proceed along main track to point A and a third authority may be issued that once train **1** arrives at siding A for train **2** to proceed along the main track to point B. The release of the movement authority for train **2** to point

A indicates to the movement planner that train **1** has reached siding A and the train **2** is between point A and point B.

[**0030**] As an other example historical data can be used to in conjunction with the issuance and relapse of movement authorities to provide important feedback to the dispatcher. For example, if train A is issued a movement authority to travel along the main from point A to point B, it can be estimated based on historical data that such a route typically takes 30 minutes to traverse. If the movement authority is released by the train after 5 minutes, this can be identified as an anomaly that requires further investigation by the dispatcher.

[**0031**] When the location of the train is in a yard or terminal, there may be no movement along the line-of-road for prolonged periods of time. Historical data available from the yard authorities may be used to estimate the time of departure of the train from the yard and thus impact the estimate.

[**0032**] The information used by the movement planner in providing the estimate is of course supplemented by any information contained in radio communications received from on-board train personnel. Such information is received by the dispatcher and entered into the movement planner. In the past, the bulk of the information used by the dispatcher is information automatically communicated to the movement planner and is thus indirectly communicated to the dispatcher. Now, the issuance of the warrant is automatically and electronically communicated to the movement planner.

[**0033**] As the estimate of train location improves, the dispatcher is able to modify or reissue track warrants and thereby improve the efficiency of the system.

[**0034**] While preferred embodiments of the present invention have been described, it is understood that the embodiments described are illustrative only and the scope of the invention is to be defined solely by the appended claims when accorded a full range of equivalence, many variations and modifications naturally occurring to those of skill in the art from a perusal hereof.

What is claimed is:

1. A railway scheduling system in which a movement plan is generated by a movement planner to schedule the movement of the trains along the railway system, comprising:

(a) issuing a track warrant authorizing the train to occupy a section of track;

(b) releasing a track warrant authority when the train has left the section of track;

(c) estimating the location of the train as a function of the release of the track warrant;

(d) updating the movement plan as a function of the estimated location of the train.

2. The system of claim 1 wherein the estimate is based in part of the pattern of form-based movement authorities.

3. A method of estimating the location of train that is operating pursuant to the issuance of a track warrant authorizing the movement of the train comprising the steps of:

(a) building a data base of the historical time required for a train to perform an activity; and

(b) evaluating the release of a track warrant against the historical performance to identify an anomaly in the performance of a train.

4. In a railroad system in which plural trains are moved along a network of railway tracks pursuant to the issuance of a movement authority under control of a scheduling computer prepared movement plan that assigns resources to activities and considers the cost of each activity and assigned resources in scheduling the movement of trains over the tracks,

the improvement comprising:

(a) estimating the position of a train as a function of a the release of the movement authority; and

(b) updating the movement plan as a function of the estimated position.

5. The method of claim 1 wherein the step of releasing the track warrant is communicated electronically to the movement planner.

6. The method of claim 1 wherein the step of issuing the track warrant is communicated electronically to the movement planner.

7. The method of claim 1 further comprising the step of estimating the location of a train as a function of a release of a track warrant for another train.

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