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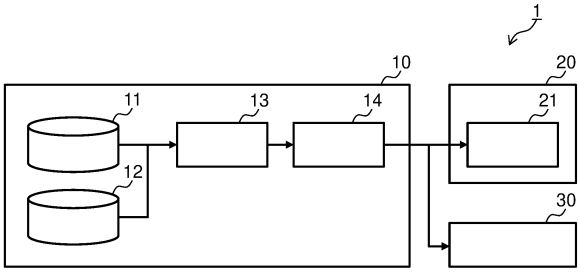
(54) TIMETABLE CREATING DEVICE, TRAIN CONTROL SYSTEM, AND TIMETABLE CREATING METHOD

(57) A diagram generating device 10 includes: a delay recovery effect storing unit 12 storing first restriction information indicating an effect capable of recovering a delay when the delay occurs, by allocating margin time to each of inter-station sections included in a train line; an energy characteristic storing unit 11 storing second restriction information indicating a characteristic of energy required by a train 20 traveling on each of the inter-station sections; a margin time allocation determining unit 13 determining allocation of margin time to each of the inter-station sections by allocating, to each inter-station section, first margin time in total time of margin time which can be allocated to the inter-station sections on the basis of the first restriction information and allocating second margin time in the total time to each inter-station section on the basis of the second restriction information; and a diagram generating unit 14 generating an operation diagram of the train 20 on the basis of the determined margin time for each of the inter-station sections.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a diagram generating device, a train control system, and a diagram generating method, and is suitably applied to a diagram generating device, a train control system, and a diagram generating method of generating an operation diagram of a train traveling on a train line.

Background Art

[0002] In driving of a railroad vehicle (train), the more the required time between stations is granted, the more energy required by a train travelling between the stations decreases and the higher the energy saving effect becomes. There is further a nature that the energy saving effect obtained by grant of required time varies among inter-station sections. There is a known method of improving the energy saving performance without changing the time required for an entire train line by, utilizing this nature, allocating longer required time to an inter-station section in which the energy saving effect is high.

[0003] For example, patent literature 1 describes a method of, when an operation situation changes, regenerating an operation diagram by re-allocating margin time on the basis of energy saving effects in inter-station sections in which a train travels after the change.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2017-017857

Summary of Invention

Technical Problem

[0005] In the conventional method of allocating longer required time to an inter-station section in which the energy saving effect is high, however, required time which is not so long is allocated to some inter-station sections. There is a problem such that a situation in which, when a delay occurs, it becomes difficult to recover the delay may happen. For example, in the system disclosed in the above-described patent literature 1, in the case where longer margin time is allocated to inter-station sections before a delay occurs, margin time which can be allocated to inter-station sections in which a train travels after the occurrence of the delay is not assured. There is, consequently, the possibility that the delay cannot be recovered even if the train travels at the highest speed after the occurrence of the delay, and punctuality cannot be maintained.

[0006] The present invention has been achieved in consideration of the above point and proposes a diagram generating device, a train control system, and a diagram generating method capable of generating an operation diagram by which punctuality can be easily maintained even in the case where a delay occurs during operation of a train by granting margin time to inter-station sections in consideration of the characteristic of energy necessary for a train travelling between stations and delay recovery effect.

Solution to Problem

[0007] In order to solve the above problems, the present invention provide a diagram generating device generating an operation diagram of a train travelling on a train line, and the diagram generating device includes: a delay recovery effect storing unit that stores first restriction information indicating an effect capable of recovering a delay when the delay occurs by allocating margin time to each of inter-station sections included in the train line; an energy characteristic storing unit that stores second restriction information indicating a characteristic of energy required by a train traveling on each of the inter-station sections; a margin time allocation determining unit that determines allocation of margin time to each of the inter-station sections by allocating, to each inter-station section, first margin time in total time of margin time which can be allocated to the inter-station sections on the basis of the first restriction information, and allocating second margin time in the total time to each inter-station section on the basis of the second restriction information; and a diagram generating unit that generates an operation diagram of the train on the basis of the margin time for each of the inter-station sections determined by the margin time allocation determining unit.

[0008] Further, in order to solve the above problems, the present invention provide a train control system which includes: a diagram generating device generating an operation diagram of a train travelling on a train line; an operation control device mounted on the train; and an operation management device managing operation of the train. In the train control system, the diagram generating device includes: a delay recovery effect storing unit that stores first restriction information indicating an effect capable of recovering a delay when the delay occurs by allocating margin time to each of inter-station sections included in the train line; an energy characteristic storing unit that stores second restriction information indicating a characteristic of energy required by a train traveling in each of the inter-station sections for each of the inter-station sections; a margin time allocation determining unit that determines allocation of the margin time to each of the inter-station sections by allocating, to each of the inter-station sections, first margin time in total time of margin time which can be allocated to each of the inter-station sections on the basis of the first restriction information and allocating second margin time in the total time to each of the inter-station sections on the basis of the

second restriction information; and a diagram generating unit that generates an operation diagram of the train on the basis of the margin time for each of the inter-station sections determined by the margin time allocation determining unit. The operation control device controls travel of the train so as to satisfy target travel time in an inter-station section designated by an operation diagram generated by the diagram generating unit, and the operation managing device controls operation and a track of the train on the basis of the operation diagram generated by the diagram generating unit.

[0009] Further, in order to solve the above problems, the present invention provide a diagram generating method by a diagram generating device generating an operation diagram of a train travelling on a train line. In the diagram generating method, the diagram generating device includes: a delay recovery effect storing unit that stores first restriction information indicating an effect capable of recovering a delay when the delay occurs by allocating margin time to each of inter-station sections included in the train line; an energy characteristic storing unit that stores second restriction information indicating a characteristic of energy required by a train traveling in each of the inter-station sections for each of the inter-station sections; a margin time allocation determining unit that determines allocation of margin time for each of the inter-station sections; and a diagram generating unit generating an operation diagram of the train. The diagram generating method includes: a margin time allocation step of determining allocation of margin time to each of the inter-station sections, by the margin time allocation determining unit, by allocating first margin time in total time of margin time which can be allocated to the inter-station sections to each of the inter-station sections on the basis of the first restriction information, and allocating second margin time in the total time to each of the inter-station sections on the basis of the second restriction information; and a diagram generation step of, by the diagram generating unit, generating an operation diagram of the train on the basis of the margin time for each of the inter-station sections determined in the margin time allocation step.

Advantageous Effects of Invention

[0010] According to the present invention, it is possible to generate an operation diagram in which punctuality can be easily maintained even in the case where a delay occurs during operation of a train.

Brief Description of Drawings

[0011]

FIG. 1 is a block diagram illustrating a configuration example of a train control system 1 according to an embodiment of the present invention.

FIG. 2 is a diagram for explaining energy characteristics.

FIG. 3 is a diagram illustrating an example of delay recovery effect information.

FIG. 4 is a diagram for explaining allocation of margin time to distances between stations.

FIG. 5 is a flowchart illustrating a process procedure example of a diagram generating process.

Description of Embodiments

[0012] Embodiments of the present invention will now be described with reference to the drawings.

[0013] The following description and the drawings are an example for explaining the present invention. To clarify the description, omission and simplification are made properly. All of combinations of characteristics described in the embodiment are not always necessary for means for solving the invention. The present invention is not limited to the embodiment. All of application examples matching the idea of the present invention are included in the technical scope of the present invention. In the present invention, a person skilled in the art can perform various additions, changes, and the like within the scope of the present invention. The present invention can be also carried out in other various modes. Unless otherwise limited, the number of components may be plural or single.

[0014] In the following description, there is the case of explaining processes performed by executing a program. When a program is executed by at least one processor (for example, a CPU) or more, predetermined process is performed by properly using a storage resource (for example, a memory) and/or an interface device (for example, a communication port) or the like. Consequently, the main body of the process may be a processor. Similarly, the main body of a process performed by executing a program may be a controller, a device, a system, a computer, a node, a storage system, a storage device, a server, a managing computer, a client, or a host having a processor. The main body (for example, a processor) of process performed by executing a program may include a hardware circuit performing a part or all of the process. For example, the main body of the process performed by executing a program may include a hardware circuit executing encryption and decryption or compression and decompression. The processor operates as function units realizing predetermined functions by operating according to a program. A device and a system including the processor are a device and a system including the function units.

[0015] The program may be installed from a program source to a device such as a computer. The program source may be, for example, a storage medium which can be read by a program distribution server or a computer. In the case where the program source is a program distribution server, the program distribution server may include a processor (for example, a CPU) and a storage resource, and the storage resource may further store a

distribution program and a program to be distributed. When the processor of the program distribution server executes the distribution program, the processor of the program distribution server may distribute a program to be distributed to another computer. In the following description, two or more programs may be realized as one program, or one program may be realized as two or more programs.

[0016] In the following description, characteristics between stations will be expressed like "an inter-station section having long inter-station distance" or "an inter-station section in which regulation speed is high". In the case where a target to be compared is not clearly described, those characteristics may use, as a reference, an average value in inter-station sections, a predetermined threshold, or a threshold determined by a predetermined calculation method.

[0017] First, components of a train control system 1 according to an embodiment of the present invention, and the functions of the components will be described.

[0018] FIG. 1 is a block diagram illustrating an example of the configuration of the train control system 1 according to an embodiment of the present invention. As illustrated in FIG. 1, the train control system 1 is configured by having a diagram generating device 10, a train 20, and an operation managing device 30. As the details will be described later, in the train control system 1, the diagram generating device 10 generates an operation diagram (hereinafter, diagram) by allocating required time to inter-station sections on the basis of the energy characteristics and delay recovery effects, and transmits the generated diagram to the train 20 and the operation managing device 30.

[0019] The diagram generating device 10 has an energy characteristic storing unit 11, a delay recovery effect storing unit 12, a margin time allocation determining unit 13, and a diagram generating unit 14.

[0020] The diagram generating device 10 is realized by, for example, a computer having a processor, a memory, a storage device, and an input/output device. In this case, the functions of the margin time allocation determining unit 13 and the diagram generating unit 14 are realized when the processor expands a program stored in the storage device or the like to the memory and executes it. The functions of the energy characteristic storing unit 11 and the delay recovery effect storing unit 12 are realized by storing predetermined data in the storage device or the memory.

[0021] The energy characteristic storing unit 11 has a function of storing energy characteristic information indicating energy characteristic of each inter-station section with respect to the characteristic of energy (energy characteristic) required by the train 20 traveling between stations.

[0022] FIG. 2 is a diagram for explaining the energy characteristics. The energy characteristic in the embodiment is expressed by energy (for example, power consumption amount) required by a train traveling in an inter-station section to which margin time is given with respect to the margin time. FIG. 2 illustrates the relationship between the margin time on the horizontal axis and the power consumption amount on the vertical axis as an example of general energy characteristics. The horizontal axis of FIG. 2 may be required time obtained by adding margin time given to an inter-station section and time (fastest time) required when a train travels at the fastest speed in the inter-station section.

[0023] The result of the power consumption amount varies depending on the margin time, and also varies depending on an inter-station section. Consequently, the diagram generating device 10 preliminarily calculates power consumption amounts for a plurality of margin times for each inter-station section on the basis of past records, or in accordance with simulation or the like, and stores the calculation results as information indicating the energy characteristics (energy characteristic information) into the energy characteristic storing unit 11. Another configuration may be employed that the energy characteristic information generated on the outside of the diagram generating device 10 is stored in the energy characteristic storing unit 11.

[0024] As illustrated in FIG. 2, generally, the energy characteristic has a tendency that the longer the margin time is given, the more the necessary energy (power consumption amount) decreases. In other words, there is a tendency that the longer the required time obtained by adding fastest time to the margin time is, the more the necessary energy (power consumption amount) decreases. When the necessary energy decreases, the energy saving effect becomes higher. Further, there is a known nature such that the energy saving effect with respect to the margin time (it can be replaced by required time) varies among inter-station sections.

[0025] In consideration of the characteristic and the nature, the margin time allocation determining unit 13 allocates a longer margin time to an inter-station section having excellent energy saving performance on the basis of the energy characteristic of each of inter-station sections. As the "inter-station section having excellent energy saving performance", concretely, an inter-station section having many downward slopes, an inter-station section having a small number of curbs (having many straight paths), an inter-station section whose distance is long, an inter-station section in which limiting speed is high, an uncomplicated inter-station section in which limiting speed is constant, and the like can be assumed.

[0026] The delay recovery effect storing unit 12 has a function of storing delay recovery effect information indicating a delay recovery effect for each of inter-station sections with respect to an effect of recovering a delay (delay recovery effect) in an inter-station section when a delay occurs in the train 20 in the inter-station section. In the embodiment, an inter-station section having high delay recovery effect is an inter-station section to which longer margin time is allocated when a delay occurs, thereby increasing the probability capable of recovering

the delay.

[0027] As the delay recovery effect information, for example, the following delay recovery effects can be set. In the case where an inter-station section in which a delay tends to occur can be assumed, by allocating longer margin time to the inter-station section, the delay recovery becomes easier. Consequently, the delay recovery effect in the inter-station section is set to be high. In the case where an inter-station section in which a delay tends to occur cannot be assumed, by allocating longer margin time to an inter-station section on the termination side, margin time which is used for delay recovery when a delay occurs can be assured. Consequently, the delay recovery effect in the inter-station section on the termination side is set to be high. Therefore, as examples of an inter-station section having high delay recovery effect, a predetermined number of inter-station sections on the end side of a train line, an inter-station section in which the frequency of occurrence of a delay in the past is high, an inter-station section in which the number of curbs is small, an inter-station section just before a station at which the number of passengers transferring to another line is large, and the like are assumed.

[0028] A concrete value of each of the delay recovery effects in the delay recovery effect information is determined in consideration of operation data in the past and the past experiences of command staffs. In the case where the delay recovery effect varies depending on the time zones such as rush hour in the morning and off-time in the daytime, the delay recovery effects may be set as different values by the time zones. In the case where the delay recovery effect varies depending on the degree of a delay which occurs, the delay recovery effect may be set as different values by the degrees of delay.

[0029] The value of the delay recovery effect which is set in the delay recovery effect information may be a fixed value which is calculated in advance on the basis of the past record or the like or a variable value which is calculated in real time. In the case of changing the value in real time, a setting and a change may be performed in consideration of the operation situation and the congestion situation. Also in the case of using a fixed value, the value may be periodically corrected in accordance with the usage situation of passengers and a change in the environment.

[0030] FIG. 3 is a diagram illustrating an example of delay recovery effect information. Delay recovery effect information 100 illustrated in FIG. 3 is an example of the delay recovery effect information stored in the delay recovery effect storing unit 12 and has data fields of fields 101 and 102.

[0031] In FIG. 3, in the field 101, a plurality of inter-station sections included from the starting station to the end station are indicated in the travel order of the train 20. In the field 102, the delay recovery effect in the inter-station section indicated in the field 101 is indicated. Concretely, for example, in the case of FIG. 3, a record of "1" as the value of the field 101 indicates that the delay recovery effect in the first inter-station section (the section from the starting station to the first station) is "10". A record of "2" as the value of the field 101 indicates that the delay recovery effect in the second inter-station section (the section from the first station to the second station) is "20". The value of the delay recovery effect which is set in the field 102 is an index value. In the case of the above example, it means that the delay recovery effect in the second inter-station section is twice as high as that in the first inter-station section.

[0032] The margin time allocation determining unit 13 has a function of determining margin time allocated to each inter-station section on the basis of the energy characteristic information stored in the energy characteristic storing unit 11 and the delay recovery effect information stored in the delay recovery effect storing unit 12. Concretely, the margin time allocation determining unit 13 allocates margin time to each of inter-station sections while allocating longer margin time to an inter-station section having excellent energy saving performance on the basis of the energy characteristic indicated by the energy characteristic information, allocates margin time to each of the inter-station sections while allocating longer margin time to an inter-station section having high delay recovery effect on the basis of the delay recovery effect indicated by the delay recovery effect information, and determines total time of those margin times in the inter-station sections as margin time allocated to each of inter-station sections. In the allocation of margin time based on the energy characteristic, a conventional technique as disclosed in the patent literature 1 can be used.

[0033] It is sufficient to determine the split ratio between the margin time allocated on the basis of the delay recovery effect and the margin time allocated on the basis of the energy characteristic in accordance with requirement specifications of punctuality and the energy saving performance. For example, in the case of placing emphasis on the punctuality, it is sufficient to increase the ratio of the margin time allocated to the delay recovery effect. In the case of placing emphasis on the energy saving performance, it is sufficient to increase the ratio of the margin time allocated to the energy characteristic amount. The split ratio of allocating to the energy characteristic may be increased within "the range in which the influence is not exerted on a delay and punctuality" which can be determined by the past record. The reason is that, even when margin time is excessively given to an inter-station section in which a record of delay is little, the actual delay recovery effect is low.

[0034] FIG. 4 is a diagram for explaining allocation of margin time to inter-station sections. An allocation time determination table 200 illustrated in FIG. 4 is table data as an example of allocation of margin time to each inter-station section by the margin time allocation determining unit 13, and has data fields 201 to 205.

[0035] In FIG. 4, the field 201 indicates an inter-station section, and the field 202 indicates a delay recovery effect in the inter-station section indicated in the field

101. The values in the fields 201 and 202 are the same as the values in the fields 101 and 102 of the delay recovery effect information 100 illustrated in FIG. 3.

[0036] The field 203 indicates allocated time (time A) of margin time based on the delay recovery effect. The value in the field 203 is calculated when the margin time allocation determining unit 13 allocates margin time which can be allocated as the delay recovery effect amount to each inter-station section in accordance with the delay recovery effect (the value in the field 202) of each inter-station section indicated by the delay recovery effect information.

[0037] The field 204 indicates allocated time (time B) of margin time based on the energy characteristic. The value in the field 204 is calculated when the margin time allocation determining unit 13 allocates margin time which can be allocated as the energy characteristic amount to each inter-station section in accordance with the energy characteristic (refer to FIG. 2) of each inter-station section indicated in the energy characteristic information.

[0038] The "margin time which can be allocated as the delay recovery effect amount" and the "margin time which can be allocated as the energy characteristic amount" are calculated by splitting the total margin time which can be allocated in accordance with the above-described "split ratio".

[0039] The field 205 indicates the margin time (total time) finally allocated to the inter-station section. The value in the field 205 is calculated by totaling the value in the field 203 and the value in the field 204 by the margin time allocation determining unit 13.

[0040] As described above, as illustrated in FIG. 4, the margin time allocation determining unit 13 can determine allocation of margin time to each inter-station section on the basis of two pieces of restriction information which are the energy characteristic and the delay recovery effect.

[0041] In the embodiment, the margin time allocation determining unit 13 is not limited to the determination of the allocation of margin time to each inter-station section on the basis of the two pieces of restriction information which are the energy characteristic and the delay recovery effect, and may determine allocation of margin time to each inter-station section by adding another restriction information or replacing the restriction information with another restriction information.

[0042] For example, as third restriction information, the degree of requirement of punctuality according to the number of users (the number of passengers) may be added. Concretely, a restriction to fix required time or prevent delay is placed on an inter-station section in an inter-station section in which the number of users is large. In this case, it is sufficient to give longer margin time preferentially to an inter-station section within a section in which the passenger demand is high. With respect to an inter-station section in the section in which the passenger demand is high, required time may be fixed by giving margin time to the inter-station section in advance and excluding the inter-station section from inter-station sections as objects to which margin time is allocated by the margin time allocation determining unit 13.

[0043] For example, as fourth restriction information, a request to avoid the influence on a following train due to grant of margin time may be added. The influence on a following train due to grant of margin time means a situation such that the train 20 travels while reducing speed in an inter-station section to which margin time is granted and, as a result, a following train also has to travel while reducing speed. Therefore, in the case of adding the fourth restriction information, the margin time allocation determining unit 13 has to allocate margin time to each of inter-station sections in the operation of the train 20 while assuring punctuality of a following train. A threshold (limit time) of margin time at which the influence on a following train can be avoided can be calculated in advance from record data in the past, simulation, and the like for each inter-station section.

[0044] In the case of employing the fourth restriction information, for an inter-station section in which the influence tends to be exerted on a following train, it is considered that the margin time allocation determining unit 13 suppresses margin time to be granted. On the contrary, under a condition that a delay is allowed within a range of exerting no influence on a following train, longer margin time may be allocated to the inter-station section so that the energy characteristic becomes excellent. As a result of the above, while maintaining punctuality of a following train, the delay recovery effect or energy characteristic (energy saving effect) in the present train can be increased.

[0045] The above-described another restriction information (third restriction information and the fourth restriction information) may be stored in the energy characteristic storing unit 11 or the delay recovery effect storing unit 12 in the diagram generating device 10.

[0046] The diagram generating unit 14 has a function of generating a diagram on the basis of margin time for each inter-station section determined by the margin time allocation determining unit 13. Concretely, the diagram generating unit 14 sets a value obtained by adding margin time of an inter-station section determined by the margin time allocation determining unit 13 to the highest-speed time in the inter-station section as target travel time (that is, target diagram) in the inter-station section. Since a conventional general diagram generating function can be used for a diagram generating process after a target diagram for each inter-station section is set, detailed description is omitted.

[0047] The train 20 is a railroad vehicle which travels according to the diagram generated by the diagram generating device 10 and has, at least, an operation control device 21.

[0048] The operation control device 21 has a function of controlling travel of the train 20 so as to satisfy target travel time in accordance with the diagram generated by the diagram generating unit 14. Concretely, the operation

control device 21 generates a plurality of speed targets (travel patterns) and controls operation of a train so as to follow any of the travel patterns on the basis of the target travel time of the diagram.

[0049] The operation control device 30 has a function of managing operation of the train 20. For example, the operation managing device 30 controls a ground facility (for example, the direction of a point switch or the like) and controls the track in each station of the train 20 to make the train 20 travel on a railway track designated by the diagram. In the case where a fluctuation occurs in the operation situation due to a delay of a preceding train or the like and a change from the diagram generated first becomes necessary, the operation managing device 30 instructs the diagram generating device 10 to re-generate a diagram, and notifies the train 20 of the diagram re-generated by the diagram generating device 10. Alternatively, the operation managing device 30 may re-generate a diagram on the basis of the current situation and notify the train 20 of the diagram. In those cases, the operation control device 21 of the train 20 controls travel of the train 20 in accordance with the re-generated diagram.

[0050] Generation of a travel pattern for making the train 20 travel may be calculated by the operation control device 21 as described above, or a result of calculation made by the operation managing device 30 may be notified to the train 20 (the operation control device 21).

[0051] Next, the diagram generating procedure in the train control system 1 according to the embodiment will be described.

[0052] FIG. 5 is a flowchart illustrating an example of the procedure of a diagram generating process. The diagram generating process is executed by the diagram generating device 10. The process of FIG. 5 is executed, for example, before start of operation of the train 20.

[0053] According to FIG. 5, first, the margin time allocation determining unit 13 calculates the total value of margin time of all of inter-station sections in a train line as a target of diagram generation (step S11).

[0054] Subsequently, the margin time allocation determining unit 13 splits, in accordance with a predetermined split ratio, the total value of the margin time calculated in step S11 into margin time to be allocated to the delay recovery effect amount and margin time to be allocated to the energy characteristic amount (step S12). As described above, the split ratio is determined according to, for example, required specifications of punctuality and energy saving performance. In the case where restriction information other than the energy characteristic and the delay recovery effect exists, the split ratio is determined in consideration of the restriction information as well.

[0055] Subsequently, the margin time allocation determining unit 13 allocates the margin time to be allocated to the delay recovery effect amount calculated in step S12 to the inter-station sections in accordance with the delay recovery effects in the inter-station sections indicated by the delay recovery effect information stored in the delay recovery effect storing unit 12 (step S13). In step S13, in allocation of the margin time to all of inter-station sections, the margin time allocation determining unit 13 allocates the margin time to each of the inter-station sections in accordance with the degree of the delay recovery effect (refer to the field 203 in FIG. 4).

[0056] Subsequently, the margin time allocation determining unit 13 allocates the margin time to be allocated to the energy characteristic amount calculated in step S12 to each of the inter-station sections in accordance with the energy characteristic of each of the inter-station sections indicated by the energy characteristic information stored in the energy characteristic storing unit 11 (step S14). In step S14, in allocation of the margin time to all of the inter-station sections, the margin time allocation determining unit 13 allocates the margin time to each of the inter-station sections in accordance with the degree of the energy saving performance (refer to the field 204 in FIG. 4).

[0057] Subsequently, the diagram generating unit 14 totals, with respect to each of the inter-station sections, the margin time allocated in step S13, the margin time allocated in step S14, and the fastest time in the inter-station section, and sets the total value as target travel time in the inter-station section to generate a target diagram of the train line (step S15). The generated diagram is notified to the train 20 and the operation managing device 30, and the diagram generating process is finished.

[0058] The above is the procedure of generating a diagram in the train control system 1 according to the embodiment. Since the diagram generating process is executed before operation of the train 20 as described above, in allocation of required time while placing emphasis on energy saving performance, at the time of generating a diagram before operation, by allocating longer margin time preferentially to an inter-station section having high delay recovery effect, even if a delay occurs during operation, the probability that the delay can be recovered by using the margin time can be increased, and the effect of maintaining punctuality can be expected.

[0059] The diagram generating process illustrated in FIG. 5 may be executed in the case where a delay occurs during operation of the train 20. In this case, to the inter-station sections included in the remaining section at the present time point (that is, each of the inter-station sections from the present location point of the train 20 to the end terminal) as targets to which the margin time is to be given, the margin time allocation determining unit 13 re-allocates the total margin time remaining at the present time point to the inter-station sections. On the basis of the margin time re-allocated to the inter-station sections and the fastest time, the diagram generating unit 14 re-generates a diagram. By executing the diagram generating process during the operation of the train 20 as described above, the remaining margin time is collected and re-allocated so as to grant longer margin time preferentially

to an inter-station section having high delay recovery effect in consideration of the energy saving performance. In such a manner, the required time according to the operation situation can be re-allocated. The probability that a delay can be recovered is increased by using the margin time in the following operation, and an effect of maintaining punctuality can be expected.

List of Reference Signs

[0060]

1: train control system
10: diagram generating device
11: energy characteristic storing unit
12: delay recovery effect storing unit
13: margin time allocation determining unit
14: diagram generating unit
20: train
21: operation control device
30: operation managing device

Claims

1. A diagram generating device generating an operation diagram of a train travelling on a train line, comprising:

a delay recovery effect storing unit that stores first restriction information indicating an effect capable of recovering a delay when the delay occurs by allocating margin time to each of inter-station sections included in the train line;
an energy characteristic storing unit that stores second restriction information indicating a characteristic of energy required by a train traveling on each of the inter-station sections;
a margin time allocation determining unit that determines allocation of margin time to each of the inter-station sections by allocating, to each inter-station section, first margin time in total time of margin time which can be allocated to the inter-station sections on the basis of the first restriction information, and allocating second margin time in the total time to each inter-station section on the basis of the second restriction information; and
a diagram generating unit that generates an operation diagram of the train on the basis of the margin time for each of the inter-station sections determined by the margin time allocation determining unit.

2. The diagram generating device according to claim 1, wherein

the margin time allocation determining unit determines the first margin time and the second margin time from the total time in accordance with a ratio determined by a predetermined method,
allocates the first margin time to each of the inter-station sections so that longer margin time is granted to an inter-station section in which an effect capable recovering the delay is high, on the basis of the first restriction information, and
allocates the second margin time to each of the inter-station sections so that longer margin time is granted to an inter-station section in which the energy saving performance is high, on the basis of the second restriction information.

3. The diagram generating device according to claim 2, wherein
the first restriction information is that an inter-station section on the end point side of the train line is an inter-station section in which an effect capable of recovering the delay is high.

4. The diagram generating device according to claim 2, wherein
the first restriction information is that an inter-station section in which frequency of occurrence of a delay in the past is high is an inter-station section in which an effect capable of recovering the delay is high.

5. The diagram generating device according to claim 2, wherein
the first restriction information is that an inter-station section before a station where the number of transfers to another train line is large is an inter-station section in which an effect capable of recovering the delay is high.

6. The diagram generating device according to claim 2, wherein
the margin time allocation determining unit determines the ratio of determining the first margin time and the second margin time from the total time in accordance with a specification of requiring punctuality or energy saving performance.

7. The diagram generating device according to claim 1, further comprising

third restriction information indicating the degree of requirement of punctuality according to the number of users of the train, wherein
the margin time allocation determining unit allocates the margin time so that required time in an inter-station section within a section in which the number of users is large is fixed or does not increase on the basis of the third restriction information.

8. The diagram generating device according to claim 1, further comprising

fourth restriction information indicating limit time which does not exert influence on a following train due to allocation of margin time to each of the inter-station sections, wherein
the margin time allocation determining unit determines allocation of margin time to each of the inter-station sections within a range of the limit time on the basis of the fourth restriction information.

9. The diagram generating device according to claim 1, wherein

when a delay occurs during operation of the train, the margin time allocation determining unit determines, with inter-station sections included in the remaining section of the train line at the present time point being as targets of allocation of margin time, to re-allocate toral time of margin time allocated to the inter-station sections as the targets of allocation on the basis of the first and second restriction information, and
the diagram generating unit re-generates an operation diagram of the train on the basis of the margin time for each of the inter-station sections to which the re-allocation is determined.

10. A train control system comprising:

a diagram generating device generating an operation diagram of a train travelling on a train line;
an operation control device mounted on the train; and
an operation management device managing operation of the train, wherein
the diagram generating device comprises:

a delay recovery effect storing unit that stores first restriction information indicating an effect capable of recovering a delay when the delay occurs by allocating margin time to each of inter-station sections included in the train line;
an energy characteristic storing unit that stores second restriction information indicating a characteristic of energy required by a train traveling in each of the inter-station sections for each of the inter-station sections;
a margin time allocation determining unit that determines allocation of the margin time to each of the inter-station sections by allocating, to each of the inter-station sections, first margin time in total time of margin time which can be allocated to each of the inter-station sections on the basis of the first restriction information and allocating second margin time in the total time to each of the inter-station sections on the basis of the second restriction information; and
a diagram generating unit that generates an operation diagram of the train on the basis of the margin time for each of the inter-station sections determined by the margin time allocation determining unit,
the operation control device controls travel of the train so as to satisfy target travel time in an inter-station section designated by an operation diagram generated by the diagram generating unit, and
the operation managing device controls operation and a track of the train on the basis of the operation diagram generated by the diagram generating unit.

11. A diagram generating method by a diagram generating device generating an operation diagram of a train travelling on a train line,
the diagram generating device comprising:

a delay recovery effect storing unit that stores first restriction information indicating an effect capable of recovering a delay when the delay occurs by allocating margin time to each of inter-station sections included in the train line;
an energy characteristic storing unit that stores second restriction information indicating a characteristic of energy required by a train traveling in each of the inter-station sections for each of the inter-station sections;
a margin time allocation determining unit that determines allocation of margin time for each of the inter-station sections; and
a diagram generating unit generating an operation diagram of the train,
the method comprising:

a margin time allocation step of determining allocation of margin time to each of the inter-station sections, by the margin time allocation determining unit, by allocating first margin time in total time of margin time which can be allocated to the inter-station sections to each of the inter-station sections on the basis of the first restriction information, and allocating second margin time in the total time to each of the inter-station sections on the basis of the second restriction information; and
a diagram generation step of, by the dia-

gram generating unit, generating an operation diagram of the train on the basis of the margin time for each of the inter-station sections determined in the margin time allocation step.

FIG. 1

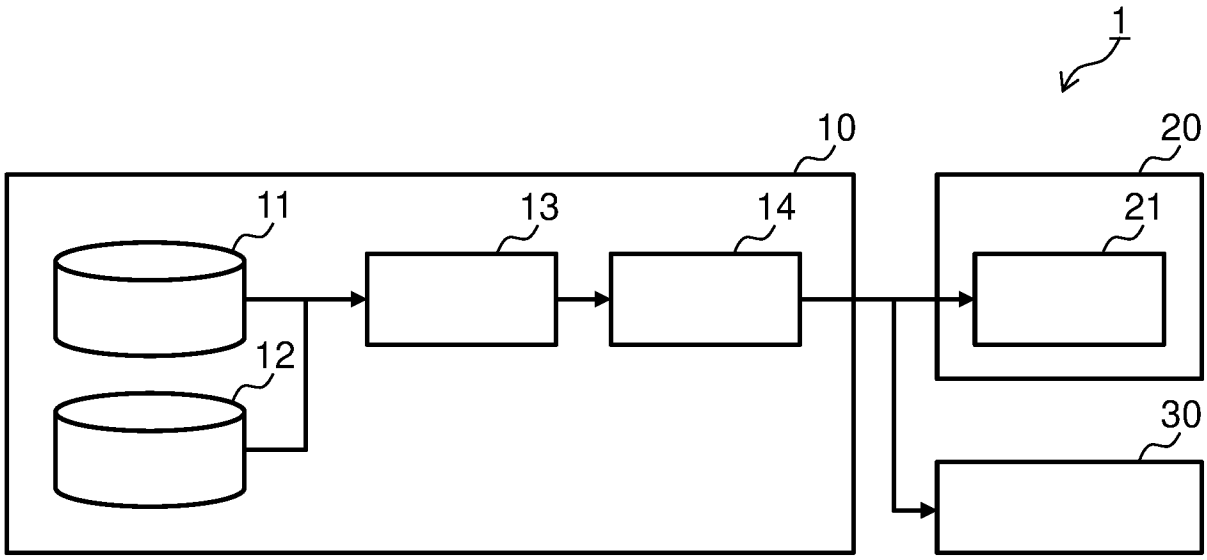


FIG. 2

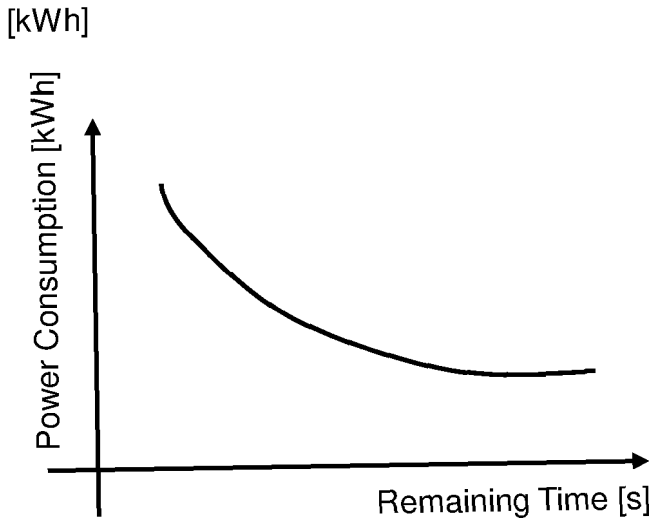


FIG. 3

100

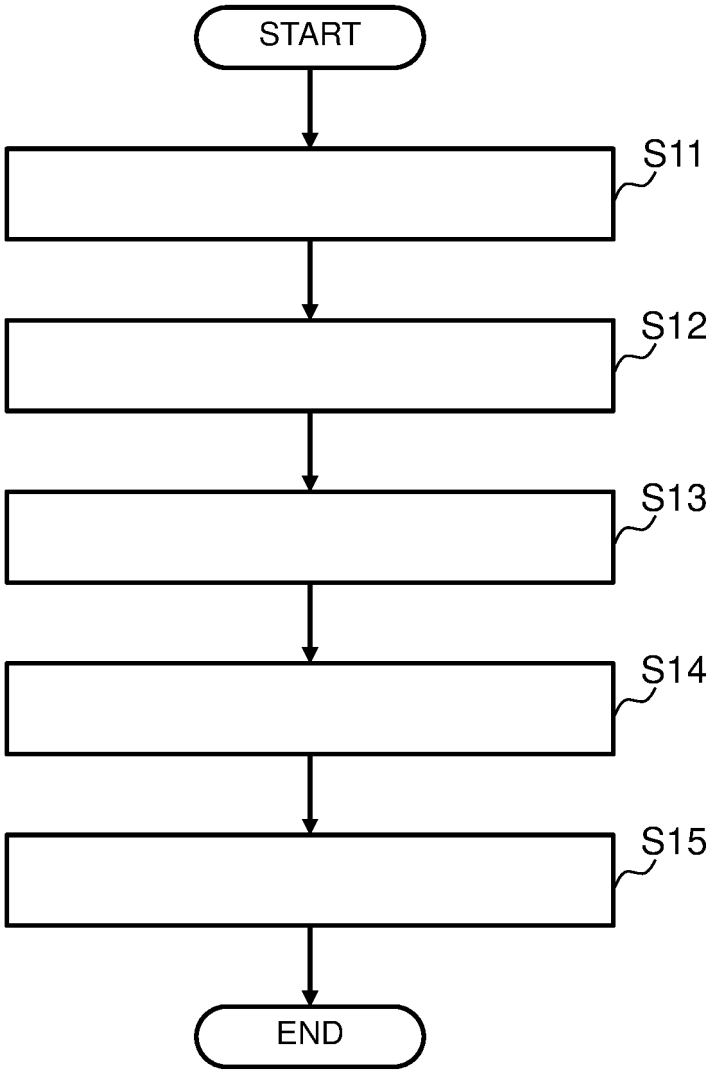
101 Section	102 Delay Recovery Effect
1	10
2	20
3	10
4	40
5	50
...	...
...	...

FIG. 4

200

201 Section	202 Delay Recovery Effect	203 Time A [s]	204 Time B [s]	205 Total Time [s]
1	10	5	10	15
2	20	10	6	16
3	10	5	10	15
4	40	20	6	26
5	50	25	4	31
...	...	...	...	...
...	...	...	...	...

FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/011564

A. CLASSIFICATION OF SUBJECT MATTER

B61L 27/12(2022.01)i
FI: B61L27/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61L27/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2017-17857 A (TOSHIBA CORP) 19 January 2017 (2017-01-19) entire text, all drawings	1-11
A	JP 2015-107687 A (TOSHIBA CORP) 11 June 2015 (2015-06-11) entire text, all drawings	1-11
A	JP 2011-173529 A (HITACHI LTD) 08 September 2011 (2011-09-08) entire text, all drawings	1-11
A	JP 2017-210181 A (HITACHI LTD) 30 November 2017 (2017-11-30) entire text, all drawings	1-11

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 2023	**23 May 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/011564

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2017-17857 A	19 January 2017	(Family: none)	
JP 2015-107687 A	11 June 2015	WO 2015/083751 A1 EP 3078565 A1	
JP 2011-173529 A	08 September 2011	(Family: none)	
JP 2017-210181 A	30 November 2017	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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