

HUMAN RESOURCE ALLOCATION METHOD BASED ON ADVANCED PLANNING AND SCHEDULING

TECHNICAL FIELD

5 The present disclosure relates to the technical field of order processing, and specifically to a human resource allocation method based on advanced planning and scheduling.

BACKGROUND

10 In many industries, order processing still relies on manual scheduling, such as in the field of maintenance services, where after receiving an order, it is necessary to manually arrange for maintenance personnel to perform maintenance work at a designated location. This manual arrangement lacks timeliness, slows response rates to orders, fails to utilize downtime between orders, and struggles with frequent order fluctuations across regions. Manual order processing undermines optimal utilization of human resources. Moreover, as workforce scheduling
15 increasingly demands fairness and efficiency, manual methods prove inadequate for balancing the fairness and efficiency.

 Current solutions typically involve sorting orders, then matching the sorted orders with corresponding personnel, generating scheduling plans, and finally creating delivery routes for the
20 orders based on the scheduling plans and default algorithm models. Current schemes cannot adaptively adjust the scheduling method, making it impossible to flexibly and quickly reformulate scheduling schemes based on actual conditions.

 Advanced planning and scheduling (APS) is primarily used to address production scheduling
25 and dispatching issues in manufacturing and has not been applied to industries requiring mobile workforce allocation, such as engineering logistics, in-home air conditioning maintenance and installation, and relocation services.

SUMMARY

30 An objective of the present disclosure is to provide a human resource allocation method based on advanced planning and scheduling that enables flexible formulation of scheduling schemes.

To achieve the aforementioned objective, the present disclosure provides a human resource allocation method based on advanced planning and scheduling, including the steps of: obtaining planning and scheduling information, where the planning and scheduling information includes order data, human resource data, and traffic data; obtaining a target scheduling mode and corresponding adjustment parameters for the target scheduling mode; obtaining a scheduling scheme data model corresponding to the target scheduling mode and a functional relationship between order completion time and required human resources; and substituting the planning and scheduling information into the scheduling scheme data model and the functional relationship between order completion time and required human resources, and solving a target mathematical model for scheduling schemes corresponding to the target scheduling mode in combination with the adjustment parameters to obtain a target scheduling scheme.

As can be seen from the above scheme, according to the present disclosure, the corresponding target scheduling mathematical model is determined by selecting the target scheduling mode, and the planning and scheduling information is substituted into the data model of the target scheduling mathematical model and the functional relationship between order completion time and required human resources, thus combining the selected adjustment parameters to solve the target scheduling mathematical model to obtain the target scheduling scheme. The present disclosure allows flexible selection of the target scheduling mode and adjustment parameters to impose different constraints based on actual needs, thereby generating different target scheduling schemes without manual order arrangement, ensuring automatic order configuration and efficient human resource allocation.

Further, the adjustment parameters include a target human resource arrangement module and a target constraint.

It can be seen that by selecting the target human resource arrangement module to constrain the available human resource data, and by selecting the target constraint to constrain the order data, the resulting target scheduling scheme is more in line with the actual needs.

Further, the target constraint is one of: job-based priority planning, event-based resource utilization maximization planning, resource-constrained planning, time-based demand and supply planning, or transportation/travel time optimization-based planning.

Further, the target human resource arrangement module is one of: a workflow module, a discrete module, a hybrid workflow-discrete module, or a project management module.

Further, the target scheduling mode is one of: a rule-based method, a sorting-based method, a heuristic graph search method, or an intelligence-based scheduling method.

5 Further, after the target mathematical model for scheduling schemes corresponding to the target scheduling mode is solved in combination with the adjustment parameters, the target scheduling mode is adjusted, and the target scheduling scheme is obtained after scheduling plan confirmation information is received.

10 It can be seen that operators can change the target scheduling mode and/or adjustment parameters to obtain different scheduling schemes, thereby selecting the target scheduling scheme that meets the requirements.

15 Further, after the target mathematical model for scheduling schemes corresponding to the target scheduling mode is solved in combination with the adjustment parameters, further processing is performed by adjusting the scheduling mode, and the target scheduling scheme is obtained after scheduling plan confirmation information is received.

20 It can be seen that order scheduling information can be processed not only by selecting different scheduling modes but also by integrating different scheduling modes to obtain a better target scheduling scheme.

Further, the planning and scheduling information is obtained from a data center, the data center storing the human resource data of different time periods.

25 It can be seen that the available human resource data for a specific time period is extracted to match the order data.

30 Further, after the target scheduling scheme is obtained, processing information is pushed to an employee terminal device according to the target scheduling scheme, and the employee terminal device displays the processing information in a visual manner.

It can be seen that the implementation of the target scheduling scheme can be facilitated.

35 **BRIEF DESCRIPTION OF DRAWINGS**

FIG. 1 is a system framework diagram of a human resource allocation system according to the present disclosure.

FIG. 2 is a flowchart executed by a scheduling center according to the present disclosure.

FIG. 3 is an example diagram of applying a heuristic graph search method according to the present disclosure.

The present disclosure will be further described with reference to the accompanying drawings and embodiments.

DETAILED DESCRIPTION

The present disclosure provides different scheduling schemes by obtaining planning and scheduling information and selecting and setting scheduling modes, human resource arrangement modules, and constraints, thereby realizing a human resource allocation method based on advanced planning and scheduling.

This embodiment is implemented based on advanced planning and scheduling-related technologies.

Referring to FIG. 1, a human resource allocation system implementing this embodiment includes a data center 1, a scheduling center 2, and an employee terminal device 3.

Data transmission between the data center 1 and the scheduling center 2, as well as between the scheduling center 2 and the employee terminal device 3, can be achieved through wired or wireless networks.

The data center 1 is configured to store planning and scheduling information, which includes order data, human resource data, and traffic data. The order data is generated based on user orders and includes, but is not limited to, estimated order processing time, order address, order required arrival time, order date, etc. The human resource data includes, but is not limited to, employee start time, employee end time, employee starting point, etc. The traffic data includes road information, commuting time between locations, etc.

The scheduling center 2 is configured to obtain stored planning and scheduling information from the data center 1 and allocate human resources according to the obtained planning and scheduling information based on the selected target scheduling mode, target human resource arrangement module, and target constraint, thereby obtaining the target scheduling scheme. The scheduling center 2 pushes processing information to the employee terminal device 3 based on the target scheduling scheme. The processing information includes specific orders processed, routes, etc. The terminal device 3 provides a visualized graphical user interface to display the processing information, facilitating employees to handle orders with the processing information.

In an alternative embodiment, the data center 1 and the scheduling center 2 may be integrated as a whole.

The scheduling center 2 maintains several types of constraints, human resource arrangement modules, and scheduling modes in advance. The scheduling modes correspond to mathematical models of scheduling schemes, which can output scheduling schemes based on input planning and scheduling information, constraints, and human resource arrangement modules. The constraints and human resource arrangement modules serve as adjustment parameters to modify the scheduling schemes output by the scheduling mode. The constraints impose restrictions on order data, while the human resource arrangement modules impose restrictions on human resource data. One scheduling mode corresponds to multiple optional constraints and multiple optional human resource arrangement modules. For different scheduling modes, their respective optional constraints and human resource arrangement modules may be the same or different.

The mathematical model for scheduling schemes includes a scheduling scheme data model and a functional relationship between order completion time and required human resources. For different mathematical models for scheduling schemes, their respective scheduling scheme data models and functional relationships between order completion time and required human resources may be the same or different.

The scheduling scheme data model includes multiple modeling parameters, specifically: working time, processing time, idle time, waiting time, transition time, order address, order request time, order date, employee start time, employee end time, employee starting point, estimated traffic

time, estimated commuting time between orders, road information, employee capacity limitation, employee real-time location, etc. These modeling parameters can be used based on actual situations, or additional modeling parameters beyond the above can be added as needed. Based on these modeling parameters, the model results reflecting scheduling schemes can be transmitted in XML configuration files, JSON format, or through a user interface (UI). The selected human resource arrangement module can achieve high alignment between the actual situations and the plans and optimize human resource arrangements.

An example but not exhaustive list of data content for the scheduling scheme data model is described in Table 1 below:

Table 1. Example Data Content of the Scheduling Scheme Data Model

No.	Data name	Description
1	Working time	Order
2	Processing time	Time required to process an order
3	Idle time	Rest time required per employee
4	Waiting time	Waiting time between orders
5	Transition time	Employee commuting time
6	Order address	Work location of an order
7	Order request time	Work time specified by an order
8	Order date	Work date specified by an order
9	Employee start time	Shift start time of employees, which may be assigned by the company or self-reported by the employees
10	Employee end time	Shift end time of employees, which may be assigned by the company or self-reported by the employees
11	Employee starting point	Departure location of employees, generally assumed to be the address reported at the time of employment
12	Estimated traffic time	Total travel time from location A to location

		B, etc., by real-time transportation means according to traffic software
13	Estimated commuting time between orders	Time and method for moving from location A to location B by real-time transportation means according to traffic software
14	Road information	Real-time road information from traffic software, such as traffic congestion or accidents
15	Employee capacity limitation	According to company records or employee reports, the maximum number of orders each employee can handle
16	Employee real-time location	Real-time location of employees based on GPS
17		

The scheduling scheme data model includes the functional relationship between order completion time and required human resources. The general functional relationship is as follows:

5 $F(X), X = \{x_i(\text{OrderTime}_i(\text{Workers}_{in}, \text{Precedence}_i)_i, \text{Workers}_{in}) \in x \mid i = 1, 2, 3, \dots, N\}$, where x_i refers to the date and time of each order, OrderTime_i refers to the estimated required time or duration for the order on that day, Workers_{in} refers to the number of workers n) completing the order during OrderTime_i for x_i , which is the independent variable of x_i ; while Workers_{in} is the number of workers allocated for x_i to process the order, with the precondition for sequence i being Precedence_i ; and N is the total number of orders for the day.

10 The constraint is: $C_i, i = 1, 2, 3, \dots, k$, where k is the number of constraints. In the general function $F(X)$, the goal is to find the optimal combination of x that minimizes $F(X)$, while the constraint C_i additionally considers extra preconditions beyond the general factors such as location, time, distance, etc., as mentioned above.

15 In the mathematical model for scheduling schemes, it generally further includes a cost function, a time function, a resource allocation function, and a priority function. For the cost function, in many scheduling problems, the objective is to minimize the total costs. The costs may include production costs, transportation costs, storage costs, etc. The cost function can be expressed as a function, such as $C = C(p) + C(T) + C(s)$, where $C(p)$ is the production costs, $C(t)$

is the transportation costs, and $C(s)$ is the storage costs. For the time function, in scheduling problems, we typically need to consider the runtime of jobs. The time function can be expressed as $T = f(x)$, where x is the attributes of the job (e.g., workload, difficulty level, etc.), and f is a function describing how these attributes affect the time. For the resource allocation function, in scheduling problems, we need to allocate resources based on job requirements. The resource allocation function can be expressed as $R = g(x)$, where x is the job requirements, and g is a function describing how resources are allocated based on the requirements. For the priority function, in some cases, we may need to schedule jobs based on their priority. The priority function can be expressed as $P = h(x)$, where x is the attributes of the job (e.g., deadline, importance, etc.), and h is a function describing how these attributes affect the priority. The above functions can exist independently or influence each other. For example, the time function and resource allocation function may affect the cost function, while the priority function may influence the resource allocation function, requiring configuration and adjustments based on specific circumstances.

In this embodiment, there are six types of constraints, namely: job-based priority planning, event-based resource utilization maximization planning, resource-constrained planning, time-based demand and supply planning, or transportation/travel time optimization-based planning.

The job-based job priority planning adopts a one-job-at-a time sequential method, used to handle order priorities and leave idle buffer time to resolve feasible constraints and optimization for reasonable delivery dates. This method schedules based on the priority of each order or job. The priority may be determined based on factors such as the urgency of the order, profit, or customer importance. For example, a production department may prioritize orders with the highest profit or the earliest delivery dates. The order rules can first sort jobs based on priority, and each assigned job follows these rules.

The event-based resource utilization maximization planning adopts a one-operation-at-a-time sequential method, which can handle detailed scheduling, even split job loads to maximize resource utilization, optimize idle time, minimize production/operation cycles, and achieve the fastest response to order delivery dates. This method reevaluates and adjusts the production plan at each critical event (e.g., employee availability or employee arrival) to maximize resource utilization. For example, if an employee has additional idle time due to early order completion or order cancellation, the system may immediately adjust or identify jobs that the employee can start

as soon as possible.

Resource-based (TOC) constraint planning: this method, based on the theory of constraints (TOC), focuses on identifying and managing bottlenecks or constraints in the production process.

5 For example, if a particular region has an unusually large number of orders while the workforce remains unchanged, a bottleneck may arise during order processing.

Resource-feasible planning: this approach considers all resource constraints (including machines, employees, and materials) to create a feasible production plan. For example, if the
10 inventory of maintenance parts is limited, the plan will ensure that the available stock is not exceeded; or for certain large components, more than one person may need to be assigned to handle the maintenance or transportation.

Time-based (historical, current, future) demand and supply planning: this method uses
15 historical data along with current and future demand forecasts to create a production plan. For example, if inspection orders are concentrated during a specific period, such as a higher volume of inspection orders at the end of the year, the plan will ensure that there are enough personnel available to handle orders in the next cycle.

20 Transportation/travel time optimization-based planning: this method takes transportation or travel time into account to optimize the production plan. For instance, based on a first departure point chosen by the personnel, the plan will prioritize order locations that are relatively closer.

In addition to prioritization, other possible sorting criteria include early completion leading
25 to early release and minimizing idle time. From a mathematical perspective, not all rules are optimizations; each rule represents a different strategy and focus in planning. Herein, the job-based priority planning aims to complete the most important jobs as quickly as possible.

After organizing variables based on the above constraints for scheduling, we can emphasize
30 that the job-based priority planning is designed to complete the most critical jobs promptly. This means that during job arrangement and execution, higher-priority jobs will be given precedence to ensure their early completion. This prioritization strategy helps ensure the timely completion of

critical jobs, thereby enhancing overall production efficiency and meeting important demands.

In this embodiment, there are four types of human resource arrangement modules: a workflow module, a discrete module, a hybrid workflow-discrete module, and a project management module.

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The workflow module primarily addresses sequence optimization issues. For example, employees may need to follow a specific route to pick up maintenance parts before arriving at the maintenance site to work. If there are any changes (for example, an employee is sick or a machine breaks down), it may be necessary to reschedule the entire process.

10

The discrete module primarily addresses the optimization scheduling problem of multiple orders and multiple resources. For example, the equipment requiring maintenance includes mechanical, electronic, and software components, necessitating different maintenance personnel with varying skills. In this case, human resource scheduling will need to consider how to most effectively allocate personnel and corresponding maintenance orders, while also taking into account the multiple skills possessed by employees.

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The hybrid process-discrete module primarily solves the optimization problems of both sequence and scheduling simultaneously. For example, a piece of equipment has multiple issues requiring maintenance and needing to be inspected and repaired in a specified order. In this scenario, scheduling will need to consider how to most effectively allocate employees and corresponding maintenance orders. In this case, human resource scheduling will need to consider how to most effectively allocate workers and parts to simultaneously meet all order requirements.

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The project management module primarily addresses the problems of resource constraints and the minimization of cost and time. For example, maintenance orders need to be completed by a specified date or time, and there may be other resource constraints (such as workers, parts, etc.). The human resource scheduling will need to consider how to minimize cost and time while satisfying all constraints.

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In this embodiment, there are four scheduling modes: a rule-based method, a sorting-based method, a heuristic graph search method, or an intelligence-based scheduling method.

The rule-based method uses dispatching rules, which are simple, easy to implement, and have low computational complexity, and have already been practically applied in this planning to achieve a more scientifically effective schedule under a set of constraints, such as reducing waiting time and improving order processing data.

Rule-based method: this method relies on predefined rules to determine the execution sequence of jobs. These rules may be based on priority, due date, required resources, etc. Applicable scenarios: when the sequence of work can be determined by clear, fixed rules, this method is effective.

The specific process is generally as follows: (1) Identify all jobs: List all jobs that need to be completed. For example, a maintenance process includes: A. Retrieve maintenance tools, B. Retrieve maintenance parts, inspect, perform maintenance. (2) Set rules: Determine the scheduling rules. These rules may be based on priority, due date, required resources, etc. For example, the rule might be: first complete jobs requiring special equipment, then complete jobs closest to their due dates. (3) Apply rules: Sort jobs according to the set rules. For instance, if job A requires special equipment for maintenance, it can only be used in the morning. (4) Allocate resources: Based on the sorting results, allocate resources (e.g., staff, equipment, etc.) to each job. For example, personnel with mechanical expertise are assigned to mechanical maintenance jobs. (5) Execute and monitor: Begin executing the schedule and continuously monitor progress. If any issues arise (e.g., maintenance tool or equipment failure, employee sick leave, etc.), adjustments to the schedule may be necessary. (6) Evaluate and adjust: After completing the schedule, evaluate the results and adjust the rules as needed. For example, if a certain type of order is frequently delayed, it may be necessary to modify the rules or adjust the required time or resources.

The sorting-based method first establishes a feasible order processing sequence, then determines the start time for each order and optimizes the sequence, which includes techniques such as local search and genetic algorithms.

Sorting-based method: this method relies on sorting jobs to determine their execution sequence. Sorting can be based on various factors, such as order priority or due dates. For example, in a call center, incoming calls may be sorted based on their urgency or the importance of the

customer. Sorting-based scheduling ensures that the most important calls are handled first. This method is effective when jobs can be sorted based on comparable attributes, such as priority or due dates. The specific process is generally as follows: (1) Identify all jobs: List all jobs that need to be completed. For example, customers are categorized into high-level, mid-level, low-level, etc.

5 (2) Set sorting criteria: Determine the criteria to be used for sorting jobs. These criteria may be based on priority, due date, required time, etc. For example, the sorting criteria could be: process the highest-priority orders first, followed by the next-highest-priority orders. (3) Perform sorting: Sort jobs according to the set criteria. For instance, if order A has the highest priority, then order A may be placed at the top of the queue. (4) Allocate resources: Based on the sorting results,

10 allocate resources (e.g., customer service representatives) to each job. For example, assign specified maintenance personnel or more experienced technicians to handle high-level customers. (5) Execute and monitor: Begin processing incoming calls and continuously monitor progress. If any issues arise (e.g., maintenance personnel sick leave or increased personnel requirements for an order), adjustments to the sorting may be necessary. (6) Evaluate and adjust: After completing

15 the schedule, evaluate the results and adjust the sorting criteria as needed. For example, if the highest-priority orders frequently experience long waiting times, the sorting criteria may need to be adjusted to ensure these orders are processed more quickly.

The heuristic graph search method, specifically, first constructs a feasible solution and

20 iteratively improves the suboptimality of the solution using implicit enumeration-based search methods, including beam search to identify constraint limitations and perform scheduling and planning. As data volume increases (due to incomplete market application but potential occurrence), filter beam search is employed to address machine issues. Optimized sorting based on the A* priority tree search method incorporates improvements including but not limited to two

25 approaches: a) expanding only a limited number of nodes during the search; and b) using a weighted balancing function. The function calculates the priority of each node: $f(n) = g(n) + h(n)$, where $f(n)$ is the comprehensive priority of the node, adjusted based on module parameters, and the node with the lowest comprehensive value is selected; $g(n)$ represents the node, indicating the starting point of the employee's departure location; and $h(n)$ is the estimated total cost of the node's

30 distance to the employee's final order, where $h(n)$ and $f(n)$ can be adjusted based on the aforementioned modeling parameters.

Heuristic graph search (A* algorithm search) continuously selects the node with the smallest estimated distance H and constructs the shortest path according to the $f(n)$ parameter requirements

of the module. Referring to FIG. 3, "Heuristics" represents the total time units for each order combined with labor, etc., and each order paired with an employee represents one occurrence of this figure, which will be repeated continuously as data volume increases. For simplicity, FIG. 3 illustrates only one instance of the method rather than a summary of all node methods.

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Heuristic graph search method: this method employs graph search algorithms to determine the optimal job execution sequence. Heuristic graph search typically utilizes a technique called heuristics to guide the search, which can significantly improve efficiency. Example: In terms of transportation, determining the best driving route or optimal order processing route. Applicable Scenario: This method is effective when the sequence of jobs needs to consider multiple factors and requires finding the optimal solution. The specific process is generally as follows: (1) Construct a graph model: Model all jobs and their relationships as a graph. Each job is a node, and the relationships between jobs (e.g., dependencies or costs) are edges. For example, in logistics and transportation, a delivery or maintenance location is a node, and the distance or time between two points can be an edge. (2) Define a heuristic function: Set a heuristic function to estimate the cost from a node (job) to a target node. The heuristic function can be set based on actual conditions, such as using straight-line distance or expected traffic conditions to estimate costs. (3) Perform graph search: Use graph search algorithms (e.g., A* search) to find the lowest-cost path. This path represents the optimal job execution sequence. (4) Allocate resources: Based on the search results, allocate resources (e.g., maintenance personnel) to each job. For example, deliveries can be scheduled according to the sequence determined by the search results. (5) Execute and monitor: Begin executing the schedule and continuously monitor progress. If any issues arise (e.g., traffic congestion or vehicle failure), it may be necessary to re-perform the graph search to adjust the schedule. (6) Evaluate and adjust: After completing the schedule, evaluate the results and adjust the graph model or heuristic function as needed. For example, if actual delivery times frequently exceed expectations, the heuristic function may need to be adjusted to estimate costs more accurately.

Intelligence-based scheduling methods, such as the current application of Intelligent Scheduling and Information System (ISIS) in manufacturing, have only recently begun to apply artificial intelligence to scheduling problems. Knowledge-based scheduling methods employ expert systems to automatically generate schedules or assist humans in scheduling. A common feature is that when the resource conditions supporting activities are specific (triggered by decision points), the system determines which rules to apply based on internal data. Since labor variables

for employees are entirely different from those in manufacturing, employee labor variables are specifically set here, as detailed in the modeling parameter settings.

Intelligence-based scheduling method: this method uses artificial intelligence (e.g., machine learning or optimization algorithms) to determine the optimal job execution sequence. For instance, based on historical order records, intelligent scheduling can learn and predict future personnel and part demands as well as resource allocation. Applicable Scenario: This method is effective when the job sequence requires consideration of large amounts of data and variables and needs continuous adjustment and optimization.

The aforementioned scheduling methods are not mutually exclusive. In many cases, multiple scheduling methods can be combined to achieve the best scheduling. For example, a company may use rule-based scheduling to determine the basic work sequence and then employ intelligent scheduling for fine-tuning and optimization.

Referring to FIG. 2, this embodiment is implemented by the scheduling center 2 executing a computer program, specifically including the following steps:

S1: Set up a mathematical model for scheduling schemes.

Herein, different mathematical models for scheduling schemes are set up according to different scheduling schemes, and several optional constraints and human resource arrangement modules are configured for each mathematical model for scheduling schemes. The mathematical models for scheduling schemes, constraints, and human resource arrangement modules are as described in the introduction to the scheduling center above and will not be repeated here.

S2: Obtain planning and scheduling information.

Herein, the planning and scheduling information for a set time period (day, week, month, etc.) can be obtained, thereby acquiring order data, available human resource data, and traffic data for that period.

S3: Obtain a target scheduling mode and a target human resource arrangement module and a target constraint corresponding to the target scheduling mode.

5 Herein, an operator of the scheduling center selects the target scheduling scheme from multiple scheduling schemes provided on a visual graphical user interface of the scheduling center and chooses the target human resource arrangement module and target constraint for the target scheduling scheme.

10 S4: Obtain a scheduling scheme data model corresponding to the target scheduling mode and a functional relationship between order completion time and required human resources.

15 S5: Substitute the planning and scheduling information into the scheduling scheme data model and the functional relationship between order completion time and required human resources, and solve a target mathematical model for scheduling schemes corresponding to the target scheduling mode in combination with the target human resource arrangement module and the target constraint to obtain a preliminary scheduling scheme.

S6: Determine whether scheduling plan confirmation information has been received.

20 Herein, after reviewing the preliminary scheduling scheme, the operator at the scheduling center decides whether to adopt the preliminary scheduling scheme. If the operator confirms the adoption, they input the scheduling plan confirmation information, and the process proceeds to step S7. If the preliminary scheduling scheme is not adopted, the process returns to step S3 to adjust the preliminary scheduling scheme by changing the target scheduling mode, target human resource arrangement module, or target constraint until the requirements are met.

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S7: Output the preliminary scheduling scheme as a target scheduling scheme.

30 The target scheduling scheme may be displayed using visualization techniques, such as on a graphical user interface combined with Gantt charts or other relevant diagrams. Thus, the planning and scheduling information adopts the target planned scheduling scheme for scheduling, which includes pushing processing information corresponding to different employees in the target

scheduling scheme to their terminal devices. This allows the employee terminal devices to visually display the processing information, enabling employees to complete the corresponding orders according to the processing information.

5 This embodiment can be applied to industries requiring the allocation of human resources for on-site order processing, including but not limited to maintenance, building inspection, in-home education (e.g., in-home tutoring), postal services (e.g., mail delivery), emergency services (e.g., ambulance or fire services), food delivery order processing (based on known manpower and order times), delivery services for large e-commerce platforms, and other logistics, construction, or
10 industries requiring simultaneous processing of multiple orders or workflows with on-site services.

This embodiment emphasizes scheduling logic constraints, resource capability constraints, tight coupling between human resources and order workflows, various optimization rules, calculating the earliest and latest possible start times, reallocatable and substitutable human
15 resources, reallocatable and substitutable enterprise resources, buffer considerations in scheduling, cost constraints, handling uncertain processes and statistical probability theory, shortest paths, and integrating various mathematical methods into planning, as well as comparative analysis of multiple optimization schemes. The goal of planning modeling is to be as simple as possible while representing reality in detail as needed—in other words, simplicity without overlooking important
20 real-world constraints. The predictive model is used to forecast future conditions and explain the relationship between inputs and outputs in complex systems.

In addition, a scheduling scheme often has several criteria at the same time, and there are conflicts between the objectives. There is no clear optimal solution for a preferable selection of
25 the scheduling schemes. For example, to minimize customer wait time and employee attendance time while maximizing employee idle time, in this case, there is no optimal solution (i.e., all three objectives cannot be optimized simultaneously). The approach to handling such multi-objective problems is to set one objective within an acceptable minimum or maximum range and then optimize another objective.

30 The human resource allocation method based on advanced planning and scheduling in this embodiment can be implemented using a computing device, which may include, but is not limited to, a processor and a memory. Those skilled in the art will understand that the computing device

may include more or fewer components, or combine certain components, or include different components, such as input/output means, network access means, buses, etc.

For example, the processor may be a central processing unit (CPU), or other general purpose processors, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or other programmable logic devices, discrete gates or transistor logic devices, discrete hardware components, etc. The general-purpose processor may be a micro-controller or the processor may be any conventional processor. The processor is the control center of the computing device, connecting all parts of the device through various interfaces and circuits.

The memory may be configured to store computer programs and/or modules, and the controller implements various functions of the computing device by running or executing the computer programs and/or modules stored in the memory and calling the data stored in the memory. For example, the memory may mainly include a program storage area and a data storage area, where the program storage area may store an operating system and application program(s) required by at least one function (such as an audio receiving function and a speech-to-text conversion function), etc.; and the data storage area can store data (such as audio data and text data) created from the use of a mobile phone. In addition, the memory may be a high-speed random access memory, or a non-volatile memory, such as a hard disk, internal storage, a plug-in hard disk, a smart media card (SMC), a secure digital (SD) card, a flash card, at least one disk memory device, a flash memory device, or other volatile solid-state memory devices.

The above-mentioned integrated modules of the computing device may be stored in a computer-readable storage medium when implemented in the form of functional units of software and sold or used as an independent product. Based on this understanding, all or part of the processes in the embodiments of the human resource allocation method based on advanced planning and scheduling may also be executed by a computer program instructing relevant hardware. The computer program may be stored in a computer-readable storage medium, and when executed by a controller, the computer program may implement the steps of the aforementioned embodiments of the human resource allocation method based on advanced planning and scheduling. Herein, the computer program includes computer program code, which may be in the form of source code, object code, an executable file or in some intermediate forms, etc. The storage

medium may include: any entity or device capable of carrying computer program code, a recording medium, a USB flash drive, a removable hard disk, a magnetic disk, an optical disk, a computer memory, a read-only memory (ROM), a random access memory (RAM), an electrical carrier signal, a telecommunication signal, a software distribution medium, etc. It should be noted that the content
5 contained in the computer-readable medium can be appropriately added or omitted according to the requirements of legislation and patent practices within a jurisdiction. For example, in some jurisdictions, according to legislation and patent practices, the computer-readable medium does not include electrical carrier signals and telecommunication signals.

10 The aforementioned embodiments of the human resource allocation method based on advanced planning and scheduling may also be implemented via a computer program product, which includes computer instructions stored in a computer-readable storage medium. The processor of the computer device reads the computer instructions from the computer-readable storage medium, and the processor executes the computer instructions, enabling the computer
15 device to perform the various steps of the aforementioned human resource allocation method based on advanced planning and scheduling.

CLAIMS

1. A human resource allocation method based on advanced planning and scheduling, comprising the steps of:

5 obtaining planning and scheduling information, wherein the planning and scheduling information comprises order data, human resource data, and traffic data;

obtaining a target scheduling mode and corresponding adjustment parameters for the target scheduling mode;

10 obtaining a scheduling scheme data model corresponding to the target scheduling mode and a functional relationship between order completion time and required human resources; and

substituting the planning and scheduling information into the scheduling scheme data model and the functional relationship between order completion time and required human resources, and solving a target mathematical model for scheduling schemes corresponding to the target scheduling mode in combination with the adjustment parameters to obtain a target scheduling scheme.

15 2. The human resource allocation method based on advanced planning and scheduling of claim 1, wherein

the adjustment parameters comprise a target human resource arrangement module and a target constraint.

20 3. The human resource allocation method based on advanced planning and scheduling of claim 2, wherein

the target constraint is one of: job-based priority planning, event-based resource utilization maximization planning, resource-constrained planning, time-based demand and supply planning, 25 or transportation/travel time optimization-based planning.

4. The human resource allocation method based on advanced planning and scheduling of claim 2, wherein

30 the target human resource arrangement module is one of: a workflow module, a discrete module, a hybrid workflow-discrete module, or a project management module.

5. The human resource allocation method based on advanced planning and scheduling of any one of claims 1 to 4, wherein

the target scheduling mode is one of: a rule-based method, a sorting-based method, a

heuristic graph search method, or an intelligence-based scheduling method.

6. The human resource allocation method based on advanced planning and scheduling of claim 5, wherein

after the target mathematical model for scheduling schemes corresponding to the target scheduling mode is solved in combination with the adjustment parameters, the target scheduling mode is adjusted, and the target scheduling scheme is obtained after scheduling plan confirmation information is received.

7. The human resource allocation method based on advanced planning and scheduling of claim 5, wherein

after the target mathematical model for scheduling schemes corresponding to the target scheduling mode is solved in combination with the adjustment parameters, further processing is performed by adjusting the scheduling mode, and a target scheduling scheme is obtained after scheduling plan confirmation information is received.

8. The human resource allocation method based on advanced planning and scheduling of claim 7, wherein

the planning and scheduling information is obtained from a data center, the data center storing the human resource data of different time periods.

9. The human resource allocation method based on advanced planning and scheduling of claim 8, wherein

after the target scheduling scheme is obtained, processing information is pushed to an employee terminal device according to the target scheduling scheme, and the employee terminal device displays the processing information in a visual manner.