METHOD AND APPARATUS FOR ADAPTIVELY OPTIMIZING A LIMITED RESOURCE

FIELD OF INVENTION

[0001] The present invention relates broadly, but not exclusively, to methods for adaptively optimizing a limited resource.

BACKGROUND

[0002] Recommender systems are an important class of machine learning algorithms that offer "relevant" recommendation to a plurality of users to select a resource(s). In such recommendations, resources are ranked according to their relevance, and the most relevant resources are shown to each of the plurality of users for selection. Recommendation approach are generally divided into two main categories: collaborative filtering and content-based systems. Recently, hybrid recommender systems that combine two or more recommendation strategies with the goal of reinforcing their advantages and reducing their disadvantages or limitations become increasingly popular.

[0003] Currently, while machine learning technologies are widely applied in business (YouTube, Netflix, Amazon, etc.), Recommendation technique and processing is not as effective and efficient when utilised in real world context where a limited resource, known as bonded resource, or other constraints and limitation in the resource is present, for example when reserving airplane tickets, rooms, performance seats, EV charging point. Resource scarcity results in competition and conflicts between the selection of the plurality of users and many recommender systems are not designed to handle such situations.

[0004] As a result, recommender system also results in poor user experience. They create unnecessary anxiety or pressure to avoid missing out items. In addition, users may also encounter frequent errors trying to select the recommended limited resource due to First Come First Serve approach. On the other hand, service providers may incorporate reservation/temporary. However, this may result in opportunity costs in optimizing utilisation of the limited resource and/or maximizing revenues.

[0005] A need therefore exists to provide methods for adaptively optimizing a limited resource that addresses one or more of the above problems.

[0006] Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0007] In a first aspect, the present disclosure provides a method for adaptively optimizing a limited resource for a plurality of user including a first user and a second user, the method comprising: receiving a first selection of the limited resource from the first user, the first selection indicating how the first user would like to use the limited resource; comparing the first selection and a second selection from the second user, the second selection indicating how the second user would like to use the limited resource; and determining a selection recommendation of the limited resource based on the comparison of the first selection and the second selection, the selection recommendation indicating how the limited resource is best utilised.

[0008] In a second aspect, the present disclosure provides an apparatus for adaptively optimizing a limited resource for a plurality of users including a first user and a second user, the apparatus comprising: at least one processor; and at least one memory including computer program code; the at least one memory and the computer program code configured to, with at least one processor, cause the apparatus at least to: receive a first selection of the limited resource from the first user, the first selection indicating how the first user would like to use the limited resource; compare the first selection and a second selection from the second user, the second selection indicating how the second user would like to use the limited resource; and determine a selection recommendation of the limited resource based on the comparison of the first selection and a second selection, the selection recommendation indicating how the limited resource is best utilised.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

[0010] Fig. 1A depicts a schematic diagram illustrating how a limited resource may be utilised according to an embodiment.

[0011] Figs. 1B and 1C depict schematic diagrams illustrating selections of the limited resource illustrated in Fig. 1A from two types of customer according to an embodiment, respectively.

[0012] Fig. 2 depicts a flow chart illustrating processes of a conventional recommender system in utilizing a limited resource.

[0013] Fig. 3 depicts a system for adaptively optimizing a limited resource according to an embodiment.

[0014] Fig. 4A depicts a flow chart illustrating a process for adaptively optimizing a limited resource according to an embodiment.

[0015] Fig. 4B depicts a flow chart illustrating a process for adaptively optimizing a limited resource according to another embodiment.

[0016] Fig. 4C depicts a flow chart illustrating a process for adaptively optimizing a limited resource according to yet another embodiment.

[0017] Figs. 5A to 5I depict examples user interface for adaptively optimizing a limited resource

[0018] Figs. 6A and 6B depict a schematic diagram illustrating a process for adaptively optimizing a limited resource according to an embodiment.

[0019] Figs. 7A and 7B depict a schematic diagram illustrating a process for adaptively optimizing a limited resource according to another embodiment.

[0020] Fig. 8 depicts a schematic diagram of a computer system suitable for use to implement the systems shown in Fig. 3.

DETAILED DESCRIPTION

[0021] Embodiments of the present invention will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[0022] Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0019] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “receiving”, “calculating”, “determining”, “updating”, “generating”, “initializing”, “outputting”, “receiving”, “retrieving”, “identifying”, “dispersing”, “authenticating” or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0020] The present specification also discloses apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. The structure of a computer will appear from the description below.

[0021] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0022] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a computer effectively results in an apparatus that implements the steps of the preferred method.

[0023] Various embodiments of the present invention relate to methods and apparatuses for adaptively optimizing a limited resource. In various embodiments below, the term “resource” may refer to or be used interchangeably with the term “item”; and the term “limited” may

refer to or be used interchangeable with the term “bounded”, and the term user” may refer to or be used interchangeable with the term “customer”, “consumer” or buyer”. Fig. 1A depicts a schematic diagram illustrating how a limited resource may be utilised according to an embodiment. For the sake of simplicity, a limited resource refers to a capacity available of five slots is illustrated, namely slot 100a, slot 100b, slot 100c, slot 100d and slot 100e. Such five slots can be objects or items that have time, space and/or quantity constraints, for example five seats for a bus shuttle service departing at 5pm, five booking time slots for a common room. Conventionally, collaborative and personalized activity recommendation methods and systems will provide items recommendation based on location, time, group, preference and user’s selected item list(s). Such conventional method or system used in recommending a limited item (e.g. airplane tickets, rooms, performance seats, EV charging point) may cause anxiety / fear of missing out item (e.g. taken by users, out of stock) due to First Come First Serve approach. On the other hand, service providers who provide the limited item may suffer from lower utilization and conversion rate for example the service providers in corporate reservation/temporary for users but the users procrastinate from making final selection. However, incorporating Fear of Missing Out (FOMO) to encourage action is considered unethical.

[0023] Fig. 1B depicts a schematic diagram illustrating selections of the limited resource 100a-110e illustrated in Fig. 1A from two types of customer according to an embodiment. In this embodiment, selections of the limited resource, i.e. slots 100a-110e (e.g. five tickets each for a seat for a movie screening at a time in a theatre) offered by a service provider (a theatre operator) are received from two types of customers, namely trusted customer and risky customer. In an embodiment, a trusted customer may refer to a customer who is registered under a list accessible by the service provider, known to the service provide or which selection pattern is recognized by the service provider, and a risky customer may refer a customer who is new, unknown to the service provider or whose selection pattern is not recognized by the service provider offering the limited resource. In an arrangement, a risky customer may be one who has not honoured a selection. In this embodiment, a risky customer may request for or select 3 slots, e.g. slots 100a, 100b and 100c. Such request or selection of slots 100a, 100b and 100c from the risky customer may be received by a service provider and the service provide may temporality reserve the 3 slots 100a, 100b, 100c for the risky customer. Subsequently, a trusted customer, who wishes to request for or select more

than 3 slots (e.g. slots 100a, 100b, 100c and 100d), is unable to perform such request or selection as slots 100a, 100b and 100c are temporarily reserved for the risky customer. In this circumstance, if the risky customer cancels the request, the service provider will incur opportunity cost from not servicing the trusted customer. This depicts opportunity cost risks associated with the conventional recommender systems to be utilized in a real world context where a conflict in limited resource is present.

[0024] Fig. 1C depicts a schematic diagram illustrating selection of the limited resource 100a-11e illustrated in Fig. 1A from two types of customer according to an embodiment. In this embodiment, selections of the limited resource, i.e. slots 100a-100e (e.g. five tickets each for a seat for a flight from city A to city B departing at a specific time) offered by a service provider (e.g., an airline company) are received from two types of customers, namely a flexible customer and a constrained customer. In an embodiment, a flexible customer may refer to a customer whose selection of the limited resource is relatively easier to be altered due to a small volume of selected resource or by way of consent given by the customer; and a constrained customer may refer to a customer whose selection of the limited resource is relatively harder be altered probably due to sheer bulk of the selection or customer's preference (e.g. two tickets that are bought by a couple who wish to travel in same flight and to be seated next to each other). In this embodiment, three flexible customers may reserve three slots 100a, 100c, 100e respectively. Such request or selection of slots 100a, 100b and 100c from the three flexible customers may be received by a service provider and the service provider may reserve the 3 slots 100a, 100c, 100e for the three flexible customers respectively. Subsequently, a constrained customer who wish to request for or select two slots which are next to each other (e.g. 100d, 100e), as slot 100e is temporarily reserved for one of the three flexible customers. In this circumstance, the service provider does not manage to maximise utilisation from servicing both types of customer by optimising capacity allocation. This depicts inefficient utilisation risks associated with the conventional recommender systems to be utilized in a real world context where a conflict in limited resource is present.

[0025] Fig. 2 depicts a flow chart illustrating processes of a conventional recommender system in utilizing a limited resource. According to various embodiments of the present disclosure, resources can be categorized into bounded (or limited) resource e.g. seats, rooms and parking lots, 202 and unbounded resource 204 e.g. movies music and articles. Conventionally, at 206, a user may request for or select the bounded resource 202. The

service provider may receive such request or selection from the user and check if the resource is available and is not reserved. If so, at 208a, the service provider may confirm the selection of the bounded resource 202 from the user. Otherwise, if the resource is not available or is reserved, the service provider may decline the selection of the bounded resource 202 from the user, and return to 206. On the other hand, at 210, a service provider may recommend to selection of the bounded resource 202 to a user and reserve the selection for the user. Subsequently, at 212a, the user may accept the recommended selection of the bounded resource 202 or at 212b reject the recommended selection. It is noted that such convention recommender system does not adaptively optimize the bounded (limited) resource 202.

[0026] According to various embodiments of the present disclosure, a smart shopping cart alike with "pick, bid and commit" techniques are introduced and implemented to determine selection recommendation and adaptively optimizing a limited resource for a plurality of users. In various embodiments, a method for adaptively optimizing a limited resource for a plurality of user may comprise a picking process, a bidding process and a committing process. The picking process allows a user to select recommended items which indicates interest of the user at the items among the limited resource. Such process can be used to further improve recommendation for subsequent complementary and related items for the user. It also provides additional flexibility by allowing items of the limited resource to be selected by other users. Advantageously, this may avoid a reservation and first come first serve approach. Subsequently, a bidding process may be initiated when there are changes in constraint (e.g. resource no longer available), conflicts (e.g. other uses are also interested and have picked the same items), or more optimized situation (e.g. better available resource) occurs. During a bidding process, a smart conflict resolution process is coordinated and executed amongst affected users (e.g. the user and the other uses who also interested and have picked the same items). In particular, during the bidding process, the affected users are presented with selection options, allowing resource to be better utilized based on users' selections, decision and preferences. Advantageously, this provides an adaptive and interactive resource optimization process which likely to improves user satisfaction. Subsequently, a commit process may be carried out where the user may commit to the selection in the picking process or a proposed selection in the bidding process. As a result, by mitigating and managing possible conflicts early, the success rate will be increased and potential churn or cart abandonment by the affected users can be minimized during the

commit process. Advantageously, this adaptively optimizes and maximizes resource utilisation, and thus improves user satisfaction of the plurality of users.

[0027] Fig. 3 depicts a system 304 for adaptively optimizing a limited resource for a plurality of user according to an embodiment. In an example, the system may be described as bounded hybrid recommendation system which is configured to adaptively optimize a limited resource. The system 304 may comprise a constraint monitoring unit 306, a conflict/deconflict monitoring unit 308, a hybrid recommendation combiner unit 310 and an optimizer unit 312. The system 304 is in connection with a bounded resource database 302, the resource database storing a list of the limited resource, their availability and information that will be provided to a user when presenting recommendation. The system 304 is also in connection with four storage module storing four respective subset of resource database or list of the limited resource for each of the plurality of user: a bounded recommendation list module 314, a pick list module 316, a bid list module 318 and a commit list module 320. Such list modules are useful for the system 304 to track and update the status of the limited resource, for example if the limited resource is currently available, selected (staged), bid (allocated) or committed.

[0028] In various embodiments, a bounded recommendation list module 314 may store a list of limited resource recommended to or personalized for each user. Such bounded recommendation list module 314 may be generated by the hybrid recommendation combiner unit 310 using a combination of collaborative filter and content based algorithm, or any other recommendation algorithm. The list of recommended limited resource can be based on at least one parameter relevant to utilising the limited resource such as (a) popularity, availability and/or quantity of limited resource obtained from the bounded resource database 302, (b) current transaction details such as time information and location information, (b) user's profile information such as user behaviour, indicated preference(s), relationship with the service provider (e.g. prestigious member of the service) and/or historical transaction information relating to the limited resource. In an embodiment, the system 304 generates a personalized list of recommended limited resource for a user and relevant parameters (constraints, e.g. limited time, quantity, area) relating to utilizing the limited resource. Such parameters may be retrieved from the constraint monitoring unit 306. In another embodiment, the system 304 generates a list of limited resource comprising all limited resource available to a user. Yet in another embodiment, the system 304 generates a same list of the limited

resource is sent to a certain type of user or all users. For the sake of simplicity, two users, i.e. a first user and a second user are included in the following embodiments. It is appreciable that such system can be applied to a plurality of users comprising more than two users.

[0029] In an embodiment, a first user may access a personalized list of recommended limited resource from the bounded recommendation list module 314, and make a selection (hereinafter referred as a first selection) of at least one of the limited resource from the personalized list, such selection indicating how the first user would like to use the limited resource. In an embodiment, certain constraints (e.g. limited time, quantity or location) may be imposed to the personalized list of recommended limited resource, and the first user is suggested to make his/her selection within the constraints. The system may receive the first selection of the limited resource from the first user. In an embodiment, a notification may be received by the system 304 notifying the first selection. In an embodiment, upon receiving the first selection from the first user, the first selection will be staged in pick list module 316.

[0030] Subsequently, a second user may access a personalized list of recommended limited resource from the bounded recommendation list module 314, and make a selection (hereinafter referred as a second selection) of at least one of the limited resource from the personalized list, such selection indicating how the second user would like to use the limited resource. In an embodiment, certain constraints (e.g. limited time, quantity or location) may be imposed to the personalized list of recommended limited resource, and the second user is suggested to make his/her selection within the constraints. The system may receive the second selection of the limited resource from the second user. In an embodiment, a notification may be received by the system 304 notifying the second selection.

[0031] In an embodiment, upon receiving the second selection from the second user, the first selection and the second selection will be compared and determined if there are any possible constraint violations (e.g. the first user exceeded the time limit in selecting the resource), conflicts (e.g. any of the limited resource is present in two or more selections) and/or additional optimization (e.g. better yet cheaper resource available) by the system 304, for example the constraint monitoring unit 306, the conflict/deconflict monitoring unit 308 and the optimizer 3312 of the system 304. In various embodiments, the system 304 may retrieve one or more parameters (constraints) relating to the limited resource such as quantity, time

information and location information for such comparison and determination of any situations.

[0032] In various embodiments, should a situation such as a conflict is determined, the system 304 determine a selection recommendation indicating that the limited resource will be best utilized if the situation is resolved. Such selection recommendation may be presented to one or more users affected by the determined situation. Upon determining such selection recommendation for the one of more affected users, the system may further determine a list of possible selections for each of the affected user. In an embodiment, a possible selection may be a resource allocation proposal or option that allows the limited resource to be better utilized and an affected user to bid for. The list of possible selections for each of the affected user may be stored in bid list module 318 until the situation is resolved. The list of possible selections may be presented and proposed to one or more affected users, e.g. the first user and/or the second user.

[0033] In an embodiment, the system 304, for example the optimizer unit 312 of the system 304, may retrieve parameter such as profile information relating to a user, resource constraints and availability of the limited resource for determining selection recommendation and a list of possible selections for the user. Example of profile information may include at least one of historical transaction information of the user with the limited resource or the service provider offering the limited resource. In an embodiment, the optimizer unit 312 of the system 304 determine and optimize the selection recommendation and one or more optimized resource allocation option based on at least one of the retrieved parameters (constraints) relating to the limited resource and the profile information.

[0034] In an embodiment, the system 304 may retrieve an event type relating to the selection recommendation, such event type indicating how important an event in which the selection recommendation will be utilised. In various embodiments, a certain type of event will be regarded as important to generate a greater and more efficient utilization of limited resource and/or to reduce opportunity cost such as losing a loyal customer. Examples of event type include selection receive time, selection size/volume, historical transaction, cumulative number of transaction made by a user, user's loyalty, indicated preference etc. Returning to Fig. 1B, the system 304 may determine, based on events in the customer profile or and historical transactions (events) with the trusted user, that the risky customer is of higher

priority and importance level in which, if the risky customers make alteration to his/her selection, the selection recommendation will be better utilized (e.g. reduce opportunity cost of losing the trusted customer), therefore the system 304 may present the selection recommendation to the risky customer first rather than to the trusted customer. For another example, returning to Fig. 1C, the system 304 may determine, based on their small selection volume and/or their indicated preference to be re-allocated, that the flexible customers is of higher priority and importance level in which, if the flexible customers make alteration to his/her selection, the selection recommendation will be better utilized. Therefore, the system 304 may present the selection recommendation to the flexible customers first. In such embodiment, the optimizer unit 312 of the system 304 determine and optimize selection recommendation and one or more optimized resource allocation option based on the at least one of the retrieved parameters, the profile information and the event type.

[0035] In an embodiment, a forecast bid such as forecast demand for a resource or predicted selection of user may be used for determining and optimizing selection recommendation, the forecast bid being a selection that is likely to be received from a user or a certain type of user. Such forecast bid may be determined based on historical transaction information relating to the limited resource. For example, the restaurant operator may determine a forecast bid for two tables for four persons in restaurant Z based on similar demand observed in every weekend around lunch hour. Therefore, in determining a selection recommendation for a user who request for a table for two in restaurant Z in that period, the system may take into consideration of such forecast bid when determining and optimizing selection recommendation for the user, for example a table for four persons will not be presented as an resource allocation option presented to the user. Advantageously, such determination of selection recommendation based on forecast bid may be useful in avoiding predictable conflict, ensuring smooth operation of resource optimization and improving user satisfaction.

[0036] According to the present disclosure, when determining a list of possible selections (one or more resource allocation option). Each possible selection or a resource allocation option presented to a user has a corresponding incentive and trade-off which are determined by the system to incentivize the user to make such selection or option. In an embodiment, the user current selection (e.g. the first selection) will be included in the list of possible selection for the user (e.g. the first user). Such possible selection may not associate with any incentive and is provided to cater for an event that the user do not wish to make an alteration to his/her

current selection and would like to use the limited resource in accordance to his/her current selection.

[0037] In an embodiment, a user, i.e. the first user, or the second user, or both respectively, may receive a selection recommendation and a list of possible selections is presented to the user. The user may wish to make a further selection based on the selection recommendation and the list of possible selections presented. In an embodiment, the further selection can be one in the list of the possible selections. The system 304 may receive from the first user a reply message to the system 304 notifying the system 304 that the first user has made the further selection. For example, if the further selection includes a further selection of the limited resource, the system 304 may update the first selection of the first user stored the pick list module 316 to correspond to the further selection accordingly. On the other hand, the system 304 may not receive any reply message from the second user and determine that the second user alter his/her current selection, i.e. the second selection. As such, the system 304 may retain the second selection of the second user stored the pick list module 316.

[0038] In various embodiments, upon receiving the further selection, the system 304 may be configured to compare the further selection(s) and the selection recommendation(s) to determine if there is a conflict. In such comparison, the system 304 may be configured to compare the further selection against each possible selection present to a user, for example, by determining if the further selection of the limited resource made by the first user corresponds to a limited resource allocated in the possible selection presented to the first user. The system 304 may determine if the further selection received from the first user does not match with any of the list of possible selections presented to the first user, if so, the system 304 then detect that the further selection was not made in accordance with the selection recommendation. The system 304 may then check if there is any conflict between the further selection(s) and the selection recommendation(s). If so, the resource allocation and optimization process may be performed again based on the further selection, and an updated selection recommendation may be generated and presented to the first user and/or the second user. If the further selection received from the first user is determined to match one of the list possible selections presented to the first user, it is then detected that the first user accepts the selection recommendation.

[0039] In another embodiment, upon or after determining a selection recommendation for the first user and/or the second user, a further selection may also be received from another user different from the first user and second user, such as a third user. Such further selection (a third selection) from the third user may be stored in the pick list module 316, and retrieved to further optimize the selection recommendation. In various embodiments, the system 304 may compare the further selection and the selection recommendation to determine if there is a conflict. In such comparison, the system 304 may be configured to compare the further selection against each possible selection present to a user. If a conflict between the further selection and selection recommendation, e.g. a proposed resource allocation option presented to the first user, is detected, the selection recommendation may be further optimized and updated based on the further selection. An updated selection recommendation and an updated list of possible selections may be determined and presented to at least one of the first user, the second user and the third user. In an example, in the updated list of possible selections presented to the first user, the option detected with conflict may be excluded.

[0040] In various embodiments, when at least one of the affected users select or bid for a resource allocation option in accordance with the selection recommendation, the conflict between the selections of the affected users may be resolved. Upon determining that there is no constraint violation, conflict and other optimization of limited resource, a user may request to commit his/her current selection of the limited resource stored in the pick list module. For example, the first user request to commit the limited resource in updated first selection relating to the selection recommendation and the second user may request to commit to the second selection. The system 304 receives the commit request, retrieves the pick list of the user from the pick list module 316 and stores it in the commit list module 320.

[0041] In an embodiment, when the first user requests to commit to the selection recommendation, the system 304 may generate to the first user the incentive for accepting selection recommendation, the incentive corresponding to the proposed resource allocation option selected by the first user. Once a limited resource is committed by a user, the system 304 may update the bounded resource database 302 or the status of the limited resource such that the committed resource will not be recommended or allocated until it is made available. Such system allows adaptively optimize a limited resource for a plurality of users.

[0042] Fig. 4A depicts a flow chart illustrating a process for adaptively optimizing a limited resource according to an embodiment. In various embodiments, an apparatus may comprises at least one processor such as event processor 422 and at least one memory (not shown) including computer program code, the at least one memory and the program code configured to, with the at least one processor 422 cause the apparatus at least to carry out a method for adaptively optimizing a limited resource. The event processor 422 is in connection with the recommender unit 424, optimizer 426, resource database 402, four storage modules respectively storing a recommend list module 406, a pick list module 408, a bid list module 410 and a commit list module 412. The functions of the recommender unit 424, the optimizer unit 426, resource database 402, recommend list module 406, pick list module 408, bid list module 410 and commit list module 412 may be similar to those of the hybrid recommender combiner unit 306, the optimizer unit 312, bounded resource database 302, bounded recommendation list module 314, pick list module 316, bid list module 318 and commit list module 320 depicted in Fig. 3, respectively. The functions of the event processor 422 is to manage all events associated with the system such as recommendation, resource allocation and optimization, conflict handlings (pick, stage, bid commit), micro batch processing and communications with users as well as all operation functions to ensure smooth operations. In an embodiment, the recommended list 406 may store and track recommendation list generated by the recommender unit 424 for each of the users; the pick list 408 may store and track user selection of the limited resource; the bid list 410 may store and track the allocation of resources generated by the optimizer unit 426; and the commit list may store and track user commitment to the limited resource.

[0043] The process may start when a user such as a first user starts the application. In step 414, a request for recommendation of the limited resource may be received from the first user. In step 430, a “Show Recommendations” function may be activated by the event processor 422 and a request may be sent to the recommender unit 424. Data such as parameters (constraints) of the limited resource and profile information may be retrieved from resource database 402 and other relevant database (e.g. user profile and behaviour database). A personalized list of limited resource and their relevant constraints (e.g. limited time, quantity, area) may be generated using modified hybrid matrix factorization model representing subset of users and items as linear combination of their content features’ latent factor, stored in recommended list module 406 and presented to the first user. Meanwhile, another user such as a second user may start the application, and a request for

recommendation of the limited resource may be received from the second user. As such, step 430 may be carried out to generate a personalized list of limited resource with relevant constraints, store in the recommended list module 406 and present to the second user in a similar manner.

[0044] In step 416, the first user may pick resources from his/her personalized list of limited resource and in step 432, a first selection from the first user may be received. At step 432, a "Stage Request" function is activated and the first selection is stored along with the request in the pick list module 408. Meanwhile, the second user may pick resources from his/her personalized list limited resource, and similarly, in step 432, the second selection made by the second user is stored in the pick list module 408. The optimizer unit 426 may be activated by the event processor 422 to retrieve parameters and constraints such as resource information, availability of the limited resource, time information, location information to compare and monitor the limit resource in the selections stored in the pick list module 408. The optimizer unit 426 may be configured to carry out conditional operation to determine if there is any constraint violation, conflict and additional optimization in the selections. In step 434, it is determined if there are no situations in any of the first selection and the second selection. If there is no situation or conflict, the staging is success. The optimizer unit 426 may return empty result, and step 442 is carried out, where the first selection and the second selection are ready to commit by the first user and the second user respectively. If there is a situation such as a conflict between the first selection and the second selection, step 436 is carried out.

[0045] In step 436, an "Allocate Resource" function may be activated, and resource allocation and optimization may be carried out for each of the affected users such as the first user and the second user by the optimizer unit 426. Selection recommendation and a list of possible selections for the first user and/or the second user may be determined based on user request, parameters availability of the limited resource, time information, location information, profile information, an event type (or an importance level of an event in which the selection recommendation will be utilised) and/or a forecast bid (or predicted selection that is likely to be selected by and received from another user) through optimization algorithm by the optimizer unit 426. The list of possible selection for the first user and/or the second user may be stored in bid list module 410.

[0046] In an embodiment, in step 438, a “Perform Bid” function may be activated, and a message may be sent by the system 404 to notify the first user and/or the second user about the selection recommendation. The list of possible selection may be presented to the first user and/or the second user, allowing them to bid for any of their respective list of possible selections. In an embodiment, a possible selection in the list may be a resource allocation option which have corresponding incentive and trade-off, which are also presented together with the list to the first user and/or the second user to incentivize them for making such selection or resource allocation option.

[0047] In step 418, the first user may choose a further selection such as an allocated bid to re-allocate his/her selection according to one of the proposed resource allocation options in the list of possible selections. In step 438, a reply message relating to a bid for a resource allocation option may be received from the first user. In such embodiment, the first selection of the first user stored the pick list module 316 may be updated accordingly to correspond to the limited resource relating to the allocated bid.

[0048] In step 440, the optimizer unit 426 may be configured to carry out conditional operation to determine if there is any constraint violation, conflict and additional optimization in the further selection made by the first user against the selection recommendation. If there is a situation such as a conflict between further selection and the selection recommendation, the process may return to step 436 to further optimize the selection recommendation based on the further selection to generate an updated selection recommendation. If no conflict between the further selection and the selection recommendation is detected, the allocation may then be accepted. The process may then proceed to commit stage in step 442 where the further selection is ready to commit by the first user.

[0049] In step 420, the first user and/or the second user request to commit their selections stored in the pick list module 408. In step 442, the request to commit may be received from the first user and/or the second user. The selection may be retrieved from the pick list module 408 and stored in the commit list module 408 based on the user request. For example, the first user may wish to commit to the updated selection with the allocated resource and the second user may wish to commit to the second selection. In an embodiment, a step of ensuring that the time and resource constraints are met is carried out by the event processor 422. In step 444, it is determined if the commit is successful, for example, the payment are received from

the first user and the second user so as the transaction of the limited resource are completed the transaction, step 446 is carried out. In step 446, a step of updating the status of the committed resources in the resource database 402 is carried out and the process may end.

[0050] Returning to step 440, if it is determined that there is no bid or the bid is not accepted, or the first user and/or the second user make further selection that does not correspond to any proposed resource allocation options, the process may return to step 436.

[0051] Returning to step 442, if it is determined that the commit is unsuccessful, for example, no payment has been received or the user request to cancel the commitment, the process return to stage request In step 432 where the selections plurality of users are received, and conflicts among selections are determined.

[0052] Fig. 4B depicts a flow chart illustrating a process for adaptively optimizing a limited resource according to another embodiment. A personalized list of limited resource recommendation for a user stored in the recommended list module 406 may be retrieved, for example, when "Show Recommendation" function is activated when a user request for recommendation. The personalized list of the limited resource recommendation for the user may be determined if the recommendation is within constraints or parameters provided by the event processor 422. Such constraints or parameters may be based on the availability of the limited resource. If it is determined that recommendation is not within the constraint or parameters, in step 454, a step of notifying the event processor 422 regarding the constraint violation may be carried out.

[0053] A selection received from a user stored in the pick list module 408 may be retrieved, for example, when "Stage Request" function 432 is activated after the user has picked resources from the personalized list of limited resource recommendation. The selection received from the user may be determined if the selected resource of the selection is within the constraints at step 448, if there is any resource conflict with another selection from another user in step 452, and/or if there is any optimization possible (e.g. cheaper but better resource available) in step 456. If the selected resource is not within the constraints, a step of notifying the event processor 422 regarding the constraint violation may be carried out in step 450. If a conflict with another selection received from another user is determined, a step of notifying the event processor 422 regarding the conflict between the selections of the user

and the other user may be carried out in step 462. If a possible optimization is determined, information of the optimized recommendation is obtained from the optimizer unit 426 in step 458, and a step of notifying the event processor 422 of the available optimization may be carried out in step 460.

[0054] Selection recommendation and a list of possible selections that allow a user to bid for may be retrieved from the bid list module 410, for example, when a "Perform Bid" function 438 is activated. Similar to that from the pick list module 408, proposed optimized resource allocation option(s) in the list of possible selections may be determined if allocated resource of the proposed optimized resource allocation is within the constraints in step 448, if there is any resource conflict with a selection from any user in step in step 452 and/or if there is any optimization possible in step 456. If the allocated resource is not within the constraints, a step of notifying the user regarding the constraint violation may be carried out in step 450. If a conflict with a further selection received from another user is determined, a step of notifying the event processor 422 regarding the conflict between may be carried out in step 462. If a possible optimization is determined, information of the optimized recommendation is obtained from the optimizer unit 426 in step 458, and a step of notifying the event processor 422 of the available optimization may be carried out in step 460.

[0055] A user may submit a request to commit a list of limited resource stored in the pick list module 408 or a bid list 410 once the list of selected resource is determined to have no conflict with any list of the limited resource of any other user, thus a "Perform Commit" function 442 is activated. Before the user commit to the limited resource, it is determined if the resource is within time and resource constraints in step 448. If the resource is not within the time and resource constraints, in step 450, a step of notifying the event processor 422 regarding the constraint violation may be carried out.

[0056] In various embodiments, subsequent to notifying the event processor 422 in steps 450, 454 and 460, a micro batch processing step 462 may be carried out by the event processor 422. In step 428, a consolidated notification or message may be sent to the affected user. In one embodiment, subsequent to sending the notification or message, at least one of the functions "Show Recommendation" 430, "Stage Request" 432, "Perform Bid" and Perform Commit" 442 may be deactivated.

[0057] Fig. 4C depicts a flow chart illustrating a process for adaptively optimizing a limited resource according to yet another embodiment. There are six columns in Fig. 4c, i.e. “Showing Recommendation” 430, “Stage Request” 432, Allocate Resource” 436, “Perform Bid” 438, “Perform Commit” 442, “Update User” 463, each referring to a function for adaptively optimizing a limited resource. A block in each column corresponds to a step of activating the function corresponding to the column. In this embodiment, a “Update User” 463 function may refer to a function of processing a user selection and updating a user profile by an event processor configured to adaptively optimizing a limited resource The process may start when user A requests for recommendation for limited resource through application in step 464. In step 465, a “Show Recommendation” function 430 may be activated. In step 466, a personalized list of limited resource and/or constraints (e.g. limited time, quantity) for user A may be generated. In step 467, the system may present the personalized list of limited resource to user A, for example in this case, a list of resource 1-5 is recommended to user A. In step 468, a user B may request for recommendation for limited resource through application. In step 469, a “Show Recommendation” function may be activated. In step 470, a personalized list of limited resource for user B may be generated. In step 471. In step 471, the system may present the personalized list of limited resource (e.g. limited time, quantity) to user B, for example in this case, a same list of resource 1-5 and constraints presented to user A are also presented to user B.

[0058] Subsequently, in step 468, user A may pick resources 2 and 3 from the personalized list. The selection of resources 2 and 3 is received from user A, and in step 473, the selection received from user A is stored and staged. In step 474, the selection may be analysed and monitored for any possible constraints violation, conflicts and possible optimizations. In step 475, the selection of the user A may be updated or remained in the pick list module. In step 476, user B may pick resources 3, 4 and 5 from the personalized list. The selection of resources 3, 4 and 5 is received from user B, and in step 477, the selection received from user B is stored and staged. In step 478, the selection may be analysed and monitored for any possible constraints violation, conflicts and possible optimizations. The system may compare the selections of user A and user B and determine that there is conflict of resource 3. In step 479, the system may determine a selection recommendation that the resources 1 to 5 would be better utilized if such conflict is resolved. The system may notify user A and/or user B about the conflict status regarding their respective selections. In step 480, the system may retrieve parameters relating to utilizing the limited resource such as resource quantity, time

information, location information, other constraints and/or profile information from database and generate one or more proposed resource allocation option using optimization algorithm based on the retrieved parameters. In step 463, the system may retrieve an event type relating to the selection recommendation, for example, the event type indicating that the selection recommendation to be proposed to user A may generate better utilization of the limited resource or reduce opportunity cost risk relating to the limited resource, considering user A has smaller selection size than that of user B therefore there is higher chance of user A in accepting the selection recommendation. In step 482, the system may present the selection recommendation to user A, for example in this case, a list of allocated resources 1 and 2 is presented to user A.

[0059] In step 483, user A may make a further selection, for example, by accepting the allocated resources 1 and 2. In step 484, a reply message from user A notifying such further selection may be received and in step 485, the further selection may be compared against the selection recommendation presented to user A to determine if they are matched or there is a conflict. In step 486, a negotiating status with user A may be removed and the conflict on resource 3 is resolved the conflict status is removed.

[0060] In step 487, user A may request to commit to the allocated resources 1 and 2. In step 488, the request is received from user A. In step 489, it is determined if the commitment is successful, for example if the payment for the allocated resources 1 and 2 has been received. If so, in step 490, the system may notify user A of the successful commitment, and resources 1 and 2 may be removed or the status of the resources 1 and 2 may be updated in the resource database. In step 491, user B may request to commit the selected resources 3, 4, and 5. In step 492, the request is received from user B. In step 492, it is determined if the commitment is successful, for example, if the payment for the selected resources 3, 4 and 5 has been received, If so, in step 494, the system may notify user B of the successful commitment, and the resources 3, 4, 5 may be removed or the status of the resources 3, 4 and 5 may be updated in the resource database.

[0061] Figs. 5A to 5I depict examples user interface (UI) for adaptively optimizing a limited resource. Fig. 5A shows an example UI 500 presenting a list of recommended trip destinations is presented to a user based on the user's profile, current location, size of the group (or number of persons) and preferred departure time. In an example, a counting down

timer like 503, 505 may be shown in which each recommendation may be invalidated or refreshed. In this example, the user would like to request for a trip departing from One Raffles Place of four people with a pick up time between 11am to 12pm. A list of recommended trip destination 502, 504, 506, 508 is presented.

[0062] Fig. 5B shows an example of UI 510 presenting a list of available trip for selection. In this example, when the user picks Marina Bay Sand as destination, a list of available departure time 512 is presented, of which some are scheduled and some are still unscheduled. Fig. 5C shows an example UI 514 presenting additional location recommendations 516, 518, 520 may be based on the selected trip (departure from Marina Bay Sands). Fig. 5D shows an example UI 522 presenting a pick list of the user. In this example, a list of selected trips 524, 526, 528, 530 selected by the user and stored in the pick list for the user is presented. The UI 522 shows trip 524 which is ready to commit, trips 526, 528 which have conflict determined and trip 530 which is pending for confirmation.

[0063] Fig. 5E shows an example UI 532 when the user receives a selection recommendation such as an incoming bid for resource. The user may receive incoming bid for items that are not committed yet. Such incoming bid may be generated when a conflict is detected between the current selection of the user and a selection of one other user. In this incoming bid, the user is requested to release three seats from his/her current selected trip 526. Further, recommended alternatives 534 may be presented. The user may choose to continue holding the current selection 526, or make alteration to his/her current selection to one of the recommended alternatives 534 that still fits within their requirement and/or preference (e.g. nearby departure location and within scheduled time). Other possibilities include points or rewards system may be part of the bidding process and presented to the user (not shown). For example, the user who chooses to make alteration to his/her current selection will be rewarded with incentive such as loyalty points.

[0064] Fig. 5F shows an example UI 536 when the user make a request for currently unavailable resource and generate an outgoing bid outgoing bid for the currently unavailable resource. In this example the user may choose to bid or request for two more seats in trip 528. The system will identify relevant user(s) and determine selection recommendation for the relevant. The system may also generate such as recommended alternatives to the currently unavailable trip 528 to the user as well as recommended alternatives to the relevant user(s)

for example to release the two seats in trip 528, so as to increase the rate of success. Similarly, other possibilities include points and rewards system may be part of the bidding process. For example, the user who chooses to make alteration to his/her current selection will be rewarded with incentive such as loyalty points.

[0065] Fig. 5G shows an example UI 540 when a selection of the user does not meet the constraint. In some conditions, the trip 530 may not be confirmed due to constraints are not being met (e.g. bus is not scheduled yet). The system will continuously monitor all requested trip, and after sufficient or optimizing demand is met, the system will notify relevant users once the bus has been allocated for the trip 530. Otherwise, the system may generate and present recommend alternatives 542 closer to the scheduled departure time.

[0066] Fig. 5H shows an example UI 542 presenting an updated pick list of the user. In this example, the incoming bid to request received may be withdrawn as the one other user who requested for the three seats in trip 526 may choose an alternative trip recommended by the system. The outcoming bid may be unsuccessful as the one other user does not wish to make alteration to his/her selection of the two seats in trip 528. Trip 530 may be confirmed as sufficient demand is met. As conflict/bid/constraint has been resolved and no other constraints violation or conflict is determined, the status of each trip 526, 528, 530 is updated in the UI 542 accordingly. The UI 542 shows that these trips 524, 526, 530 are now ready to commit.

[0067] Fig. 5I shows an example UI 544 presenting details of a committed resource. In this example, the user may request to commit to trip 524 and proceed with the commit and payment process. Once the payment is received, a confirmation may be sent and details of the trip 524 may be presented to the user in the UI like 544. Upon commit, the resources will no longer be made available for pick by other users.

[0068] Figs. 6A and 6B depict a schematic diagram illustrating a process for adaptively optimizing a limited resource according to an embodiment. In this embodiment, five seats are available for a movie at 19:00 at Cinema X. User A with a family of three would like to request for three seats for the movie at 19:00 at the cinema. The system may recommend and present that there are five seats available. User A may select his/her preferred seats combinations, e.g. seats 600a, 600b, 600c, as illustrated in Fig. 6A. Such selection may be

received and staged in pick list module. 4 minutes later, user B with a family of four may request for four seats for the movie at 10:00 at the cinema. The system may recommend and present that the five seats are still available (three of which are staged). User B may still select his/her prefer seat combinations, e.g. seats 600b, 600c, 600d, 600e, as illustrated in Fig. 6A. Such selection may be received and staged in pick list module.

[0069] Both selections may be checked to determine if there is any constraint violation or conflict. In this embodiment, there are two overlapping seats preference at seats 600b and 600c, therefore a conflict of seats 600b and 600c is detected. In an embodiment, selection recommendation and possible selections/actions may be determined for user A and user B. For example, as user A comes first and 5 minutes time constraint is not violated, the system may generate options for user B to wait for additional 1 minutes to check if the overlapping seats would be released by user A and become available, or an option to user B to change screen time to 20:00. User B may indicate that he accepts the selection recommendation to wait for 1 minute. An increased priority for seat allocation may be given to User B should they be made available next.

[0070] User A may receive a notification indicating a conflict is detected in his/her preferred seat combinations. The notification may include a reminder reminding user A to commit their seat request within the next 1 minute or consider alternative seats at 20:00. Subsequently, user A make a further selection to select change screen time to 20:00, taking seats 602a, 602b, 602c. User B may then receive a notification of the availability of his/her preferred seats. Subsequently, the pick list of user A and user B may be updated with respective selection of seats as depicted in Fig. 6B. User A and user B can then commit their selection and purchase by making necessary payment.

[0071] Alternatively, in another embodiment, such selection recommendation and possible selection/action may be presented differently depending on which event type is given higher importance to by the movie operator. For example, the selection recommendation can be presented to user A asking user A to wait for additional 1 minute despite user A coming first. This may be because user B is a privileged user of the movie operator. Similarly, the selection recommendation of the seats at 20:00 may be presented to user B because user B had accepted or committed a similar selection/reallocation of seats in the past.

[0072] It is appreciable that such resource optimization process is not limited to above embodiments, and can be applied to other services such as shuttle bus booking service.

[0073] Figs. 7A and 7B depict a schematic diagram illustrating a process for adaptively optimizing a limited resource according to another embodiment. In this embodiment, five hot desks are available in a co-working space. Members A, B and C may respectively make a reservation for a desk in the co-working space. Suitable desks may be recommended to members A, B and C according to their membership privilege and preferences. Members A, B and C may select their respective preferred desks, as illustrated in Fig. 7A, and the selections are staged in pick list module. All selections may be checked to determine if there is any constraint violation or conflict. In this example, no conflict among all three selections is detected. A five minutes allowance period may be given to each member to secure the reservation with payment. A minute later, member D indicate that they also would like to receive a bigger hot desk space to work with a colleague. Based on the members, A, B, C and D pick list, a conflict is detected in staged desk request.

[0074] In an embodiment, because members A, B, C come first, and 5 minutes time constraints is not violated. Possible selections/actions may be determined and presented to member D asking member D to consider two separate desk with lower price or to wait 4 minutes to see if new space will be available. However, member D may have constraints from working separately therefore choose to wait). At the same time, members A, B and C may be presented with incentivized options to relocate to alternative desk with lower price so as to maximise potential revenue and optimize resource utilization. Due to attractive lower price, members B and C may willing to relocate, and select the alternative desk such as seats 700b, and 700c, respectively. A reply message may be sent notifying the updated selection of members B and C, and member D may be then notified about availability of a bigger hot desk space and subsequently pick seats 700d and 700e. The pick list of member A, B, C and D may be updated accordingly as those depicted in Fig. 7B. Members A. B, C and D can then commit their selection and purchase by making necessary payment.

[0075] In another embodiment, upon receiving selection of members A, B, C and prior to receiving selection of member D, a forecast bid, such as a forecast demand of two consecutive desks, may be determined as the service provider may expect or wish the remaining desk arrangement can be catered for a next member such as member D who may

request for a bigger hot desk space. Such forecast bid may be determined based on historical transaction of the desk (e.g. the desks around the same time last month). A selection recommendation may be determined and optimized based on the forecast bid and profile information of members A, B and C. In this example, an option to relocate to alternative desk may be presented to members A, B and C, and members B and C may willing to relocate and create a bigger hot desk space such as a next member such as member D can be presented with availability of two consecutive desk immediately upon request. This may advantageously improve user satisfaction and more efficient resource utilization operation.

[0076] Fig. 8 depicts a schematic diagram of a computer system suitable for use to implement the systems shown in Fig. 3. As shown in Fig. 10, the example computing device 800 includes a processor 804 for executing software routines. Although a single processor is shown for the sake of clarity, the computing device 800 may also include a multi-processor system. The processor 804 is connected to a communication infrastructure 806 for communication with other components of the computing device 800. The communication infrastructure 806 may include, for example, a communications bus, cross-bar, or network.

[0077] The computing device 800 further includes a main memory 808, such as a random access memory (RAM), and a secondary memory 810. The secondary memory 810 may include, for example, a storage drive 812, which may be a hard disk drive, a solid state drive or a hybrid drive and/or a removable storage drive 814, which may include a magnetic tape drive, an optical disk drive, a solid state storage drive (such as a USB flash drive, a flash memory device, a solid state drive or a memory card), or the like. The removable storage drive 814 reads from and/or writes to a removable storage medium 818 in a well-known order. The removable storage medium 818 may include magnetic tape, optical disk, non-volatile memory storage medium, or the like, which is read by and written to by removable storage drive 814. As will be appreciated by persons skilled in the relevant art(s), the removable storage medium 818 includes a computer readable storage medium having stored therein computer executable program code instructions and/or data.

[0078] In an alternative implementation, the secondary memory 810 may additionally or alternatively include other similar means for allowing computer programs or other instructions to be loaded into the computing device 800. Such means can include, for example, a removable storage unit 822 and an interface 820. Examples of a removable

storage unit 822 and interface 820 include a program cartridge and cartridge interface (such as that found in video game console devices), a removable memory chip (such as an EPROM or PROM) and associated socket, a removable solid state storage drive (such as a USB flash drive, a flash memory device, a solid state drive or a memory card), and other removable storage units 822 and interfaces 820 which allow software and data to be transferred from the removable storage unit 822 to the computer system 800.

[0079] The computing device 800 also includes at least one communication interface 824. The communication interface 824 allows software and data to be transferred between computing device 800 and external devices via a communication path 824. In various embodiments of the inventions, the communication interface 824 permits data to be transferred between the computing device 800 and a data communication network, such as a public data or private data communication network. The communication interface 824 may be used to exchange data between different computing devices 800 which such computing devices 800 form part an interconnected computer network. Examples of a communication interface 824 can include a modem, a network interface (such as an Ethernet card), a communication port (such as a serial, parallel, printer, GPIB, IEEE 1394, RJ45, USB), an antenna with associated circuitry and the like. The communication interface 824 may be wired or may be wireless. Software and data transferred via the communication interface 824 are in the form of signals which can be electronic, electromagnetic, optical or other signals capable of being received by communication interface 824. These signals are provided to the communication interface via the communication path 824.

[0080] As shown in Fig. 10, the computing device 800 further includes a display interface 802 which performs operations for rendering images to an associated display 830 and an audio interface 832 for performing operations for playing audio content via associated speaker(s) 834.

[0081] As used herein, the term "computer program product" may refer, in part, to removable storage medium 818, removable storage unit 822, a hard disk installed in storage drive 812, or a carrier wave carrying software over communication path 826 (wireless link or cable) to communication interface 824. Computer readable storage media refers to any non-transitory, non-volatile tangible storage medium that provides recorded instructions and/or data to the computing device 800 for execution and/or processing. Examples of such storage media

include magnetic tape, CD-ROM, DVD, Blu-ray™ Disc, a hard disk drive, a ROM or integrated circuit, a solid state storage drive (such as a USB flash drive, a flash memory device, a solid state drive or a memory card), a hybrid drive, a magneto-optical disk, or a computer readable card such as a PCMCIA card and the like, whether or not such devices are internal or external of the computing device 800. Examples of transitory or non-tangible computer readable transmission media that may also participate in the provision of software, application programs, instructions and/or data to the computing device 800 include radio or infra-red transmission channels as well as a network connection to another computer or networked device, and the Internet or Intranets including e-mail transmissions and information recorded on Websites and the like.

[0082] The computer programs (also called computer program code) are stored in main memory 808 and/or secondary memory 810. Computer programs can also be received via the communication interface 824. Such computer programs, when executed, enable the computing device 800 to perform one or more features of embodiments discussed herein. In various embodiments, the computer programs, when executed, enable the processor 804 to perform features of the above-described embodiments. Accordingly, such computer programs represent controllers of the computer system 800.

[0083] Software may be stored in a computer program product and loaded into the computing device 800 using the removable storage drive 814, the storage drive 812, or the interface 820. The computer program product may be a non-transitory computer readable medium. Alternatively, the computer program product may be downloaded to the computer system 800 over the communications path 1027. The software, when executed by the processor 804, causes the computing device 800 to perform the necessary operations to execute the method as shown in Fig. 3.

[0084] It is to be understood that the embodiment of Fig. 8 is presented merely by way of example to explain the operation and structure of the system 300. Therefore, in some embodiments one or more features of the computing device 800 may be omitted. Also, in some embodiments, one or more features of the computing device 800 may be combined together. Additionally, in some embodiments, one or more features of the computing device 800 may be split into one or more component parts.

[0085] It will be appreciated that the elements illustrated in Fig. 8 function to provide means for performing the various functions and operations of the servers as described in the above embodiments.

[0086] When the computing device 800 is configured to optimize efficiency of a transport provider, the computing system 800 will have a non-transitory computer readable medium having stored thereon an application which when executed causes the computing system 800 to perform steps comprising: receive a first departure time of a vehicle which is administered by the transport provider at a first location; receive a second departure time of the vehicle at a second location which is located after the first location; determine a difference between the first departure time and the second departure time; and update a current schedule to provide an updated schedule in response to the determination of the difference, the updated schedule indicating an updated estimated arrival time of the vehicle at a location after the second location.

[0087] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

Claims

1. A method for adaptively optimizing a limited resource for a plurality of users including a first user and a second user, the method comprising:

receiving a first selection of the limited resource from the first user, the first selection indicating how the first user would like to use the limited resource;

comparing the first selection and a second selection from the second user, the second selection indicating how the second user would like to use the limited resource; and

determining a selection recommendation of the limited resource based on the comparison of the first selection and the second selection, the selection recommendation indicating how the limited resource is best utilised.

2. The method according to claim 1, wherein the step of determining the selection recommendation of the limited resource comprises:

retrieving at least one parameter relevant to utilising the limited resource, the at least one parameter comprises quantity of the limited resource, time information and location information; and

determining the selected resource based on the at least one parameter.

3. The method according to claim 1 or 2, wherein the step of determining the selection recommendation of the limited resource further comprises:

receive a further selection relating to the limited resource, the further selection being one that is made by one of the plurality of users; and

comparing the further selection and the selection recommendation to determine if there is a conflict.

4. The method according to any one of claims 1- 3, further comprising:

determining a list of possible selections in response to receiving the first selection, each of the possible selections having a corresponding incentive and trade-off; and

presenting the list of possible selections to the first user, wherein the first selection is included in the list of possible selections.

5. The method according to any one of the preceding claims, further comprising:

retrieving an event type relating to the selection recommendation, the event type indicating how important an event in which the selection recommendation will be utilised.

6. The method according to any one of the preceding claims, further comprising:

retrieving profile information relating to each of the first user and the second user, the profile information including one of the historical transaction information.

7. The method according to any one of claims 2- 6, wherein the step of determining the selection recommendation of the limited resource further comprises optimizing the selection recommendation based on at least one of the at least one parameter, the event type, the profile information and a forecast bid that is likely to be received from at least one of the plurality of users.

8. The method according to claim 7, further comprising:

presenting the selection recommendation to at least one of the first user and the second user; and

receiving a reply message from the at least one of the first user and the second user in response to the presentation of the selection recommendation.

9. The method according to claim 8, wherein the step of determining the selection recommendation of the limited resource comprises updating the selection recommendation based on the reply message.

10. The method according to any one of the preceding claims, further comprising:

updating a database on an availability of the limited resource in response to a utilisation of the limited resource.

11. An apparatus for adaptively optimizing a limited resource for a plurality of users including a first user and a second user, the apparatus comprising:

at least one processor; and

at least one memory including computer program code;

the at least one memory and the computer program code configured to, with at least one processor, cause the apparatus at least to:

receive a first selection of the limited resource from the first user, the first selection indicating how the first user would like to use the limited resource;

compare the first selection and a second selection from the second user, the second selection indicating how the second user would like to use the limited resource; and

determine a selection recommendation of the limited resource based on the comparison of the first selection and the second selection, the selection recommendation indicating how the limited resource is best utilised.

12. The apparatus according to claim 11, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

retrieve at least one parameter relevant to utilising the limited resource, the at least one parameter comprises quantity of the limited resource, time information and location information; and

determine the selected resource based on the at least one parameter.

13. The apparatus according to claim 11 or 12, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

receive a further selection relating to the limited resource, the further selection being one that is made by one of the plurality of users; and

compare the further selection and the selection recommendation to determine if there is a conflict.

14. The apparatus according to any one of claims 11-13, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

determine a list of possible selections in response to receiving the first selection, each of the possible selections having a corresponding incentive and trade-off; and

present the list of possible selections to the first user, wherein the first selection is included in the list of possible selections.

15. The apparatus according to any one of claims 11-14, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

retrieve an event type relating to the selection recommendation, the event type indicating how important an event in which the selection recommendation will be utilised.

16. The apparatus according to any one of claims 11-15, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

retrieve profile information relating to each of the first user and the second user, the profile information including one of the historical transaction information.

17.The apparatus according to any one of claims 12-16 , wherein the at least one memory and the computer program code is further configured with the at least one processor to:

optimize the selection recommendation based on at least one of the at least one parameter, the event type, the profile information and a forecast bid that is likely to be received from at least one of the plurality of users.

18. The apparatus according to claim 17, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

present the selection recommendation to at least one of the first user and the second user; and

receive a reply message from the at least one of the first user and the second user in response to the presentation of the selection recommendation.

19. The apparatus according to claim 18, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

update the selection recommendation based on the reply message.

20. The apparatus according to any one of claims 11-19, wherein the at least one memory and the computer program code is further configured with the at least one processor to:

update a database on an availability of the limited resource in response to a utilisation of the limited resource.