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(54) **PARTICIPANT GROUPING FOR ENHANCED INTERACTIVE EXPERIENCE**

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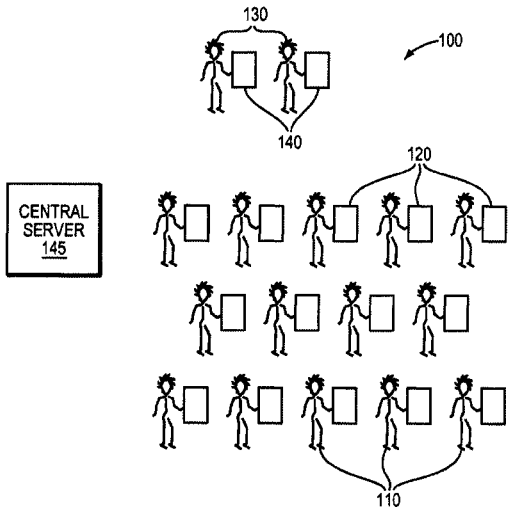
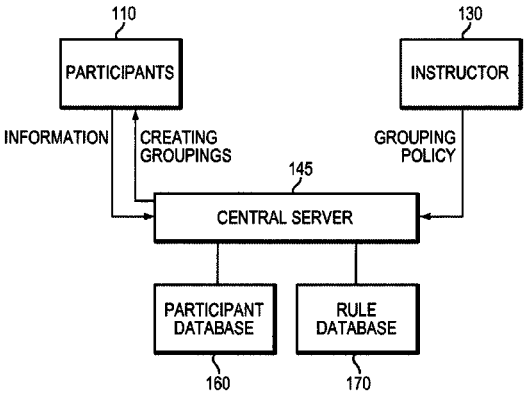
(57) **ABSTRACT**

Representative embodiments of a method for grouping participants in an activity include the steps of: (i) defining a grouping policy; (ii) storing, in a database, participant records that include a participant identifier, a characteristic associated with the participant, and/or an identifier for a participant's handheld device; (iii) defining groupings based on the policy and characteristics of the participants relating to the policy and to the activity; and (iv) communicating the groupings to the handheld devices to establish the groups.

20 Claims, 5 Drawing Sheets





Related U.S. Application Data

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(60) Provisional application No. 61/480,565, filed on Apr. 29, 2011.

(51) **Int. Cl.**

G06Q 10/06	(2012.01)
H04W 4/02	(2018.01)
H04W 4/08	(2009.01)

(52) **U.S. Cl.**

CPC ***G06F 17/30896*** (2013.01); ***G06F 21/41*** (2013.01); ***G06Q 10/06311*** (2013.01); ***H04W 4/02*** (2013.01); ***H04W 4/023*** (2013.01); ***H04W 4/08*** (2013.01)

(58) **Field of Classification Search**

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See application file for complete search history.

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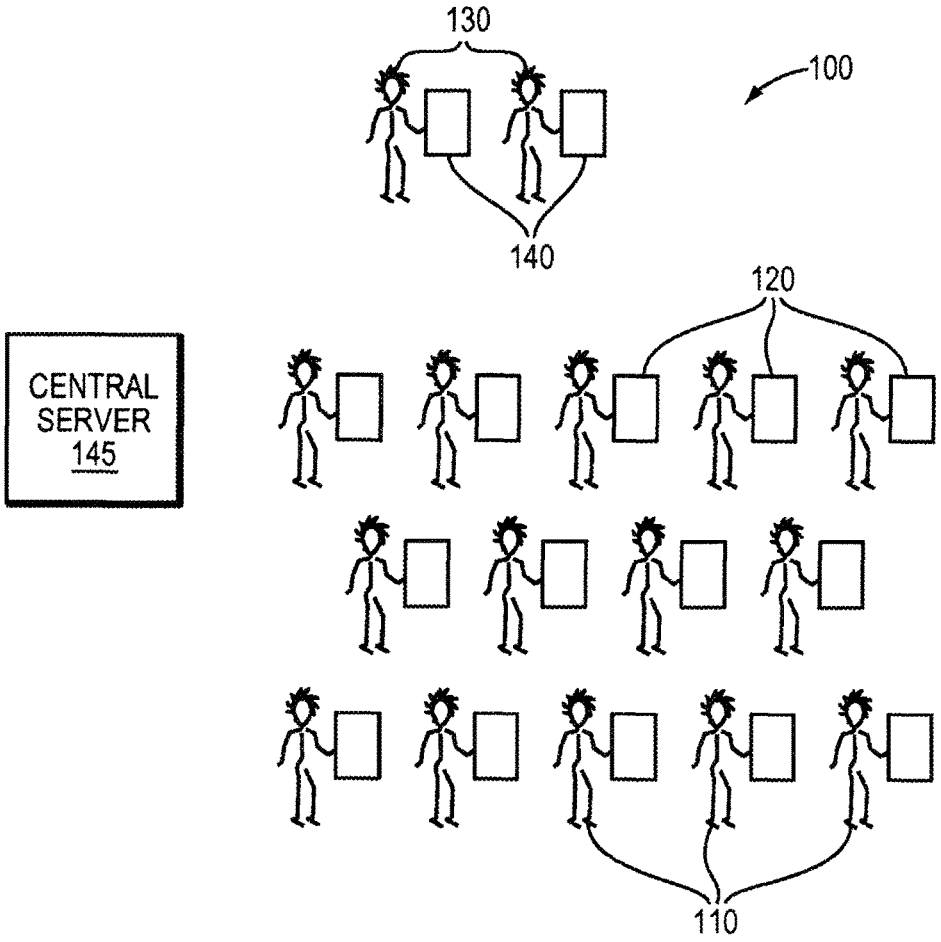

FIG. 1A

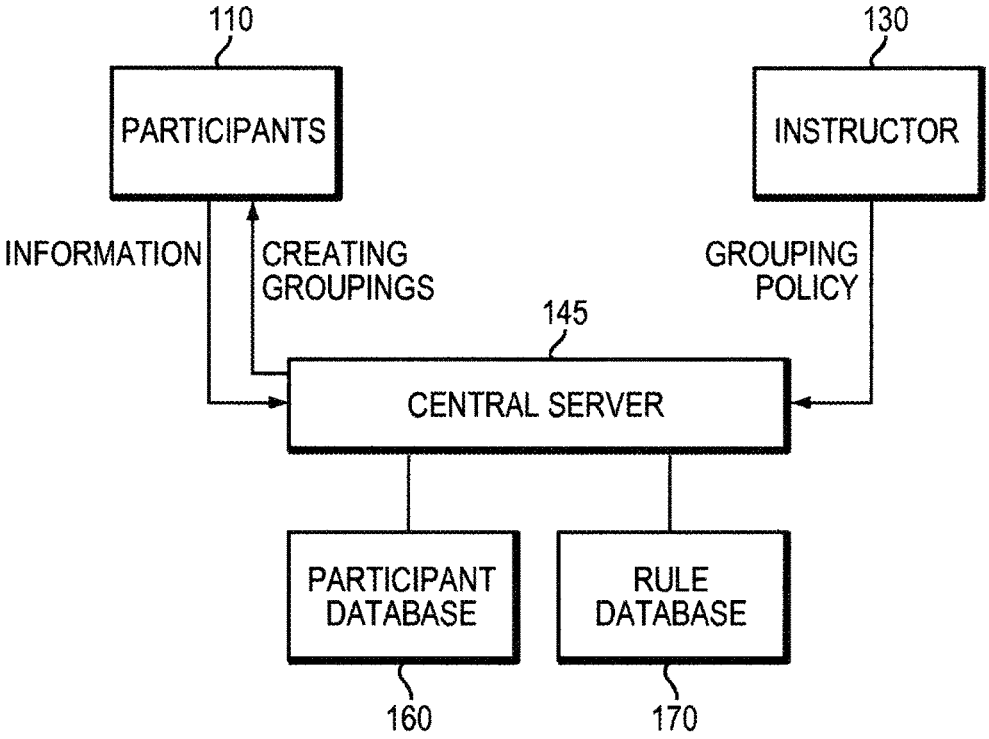
110
PARTICIPANTS
130
INSTRUCTOR
INFORMATION
CREATING GROUPINGS
GROUPING POLICY
145
CENTRAL SERVER
PARTICIPANT DATABASE
RULE DATABASE
160
170

FIG. 1B

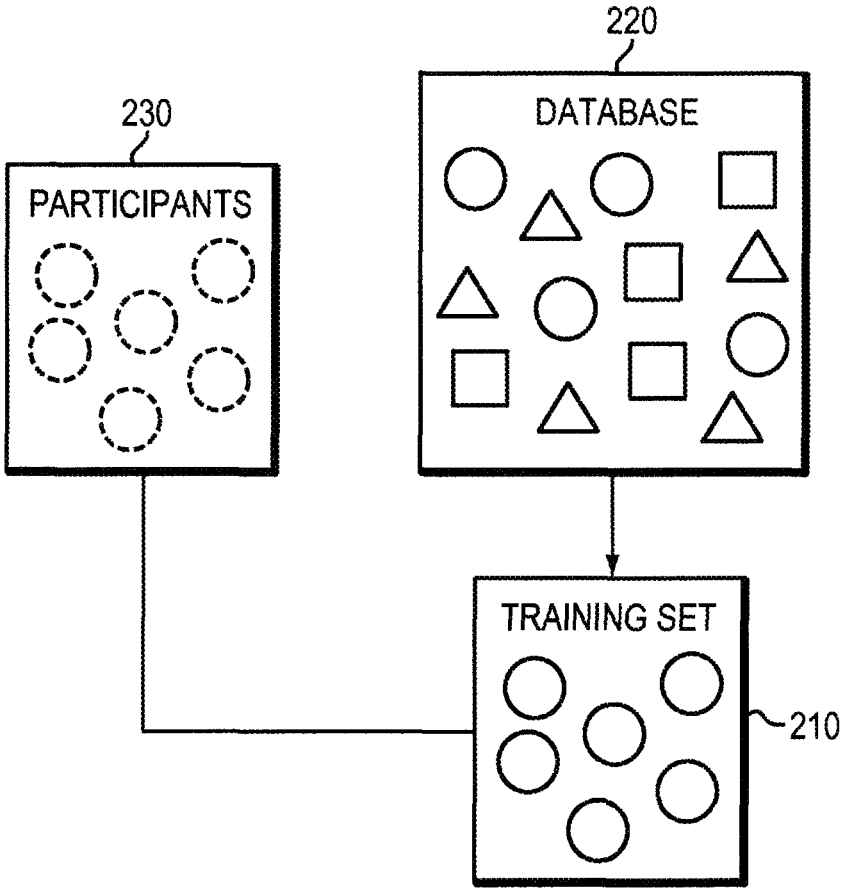

FIG. 2

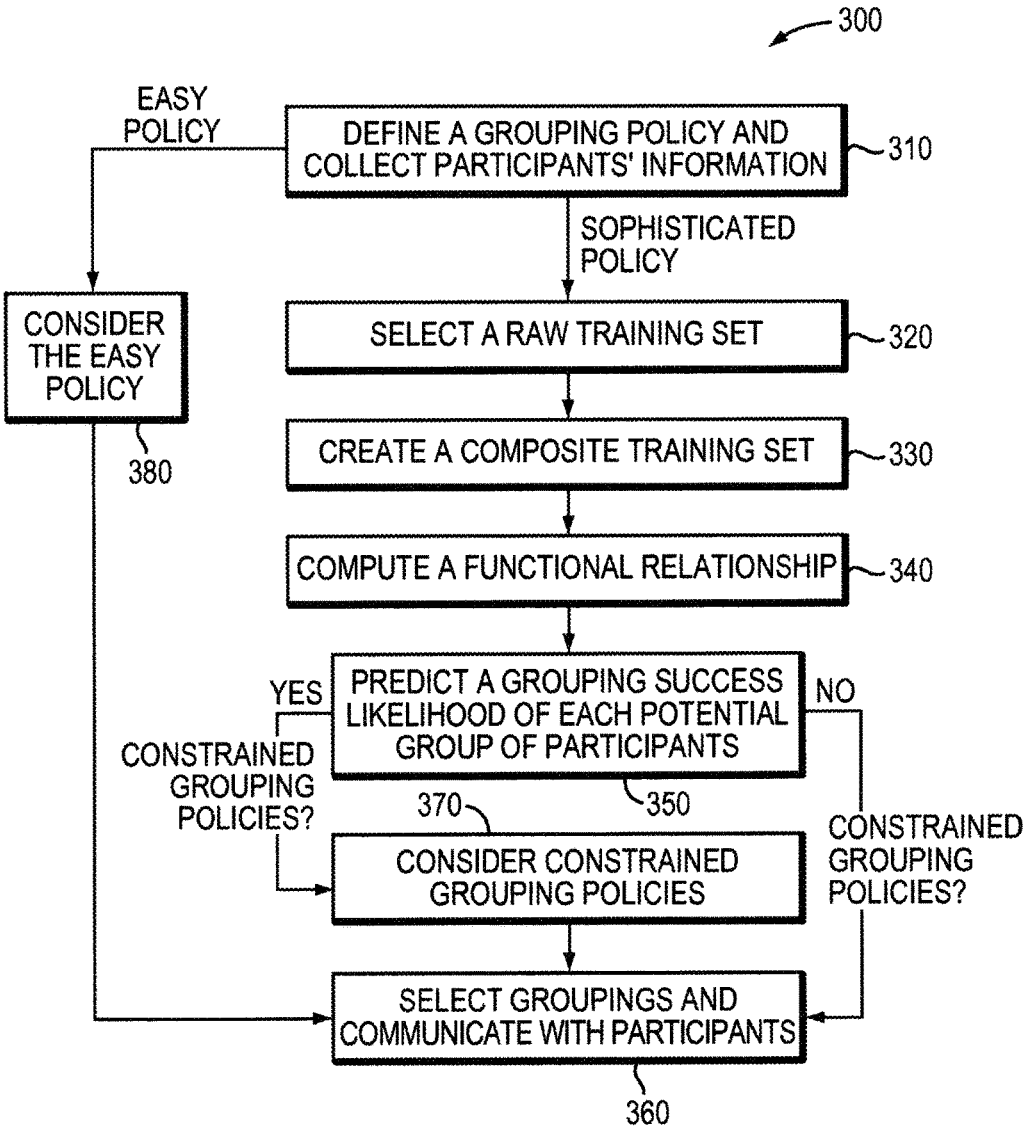
300
EASY POLICY
DEFINE A GROUPING POLICY AND COLLECT PARTICIPANTS' INFORMATION
310
SOPHISTICATED POLICY
CONSIDER THE EASY POLICY
SELECT A RAW TRAINING SET
320
380
CREATE A COMPOSITE TRAINING SET
330
COMPUTE A FUNCTIONAL RELATIONSHIP
340
YES
PREDICT A GROUPING SUCCESS LIKELIHOOD OF EACH POTENTIAL GROUP OF PARTICIPANTS
NO
CONSTRAINED GROUPING POLICIES?
350
370
CONSIDER CONSTRAINED GROUPING POLICIES
CONSTRAINED GROUPING POLICIES?
SELECT GROUPINGS AND COMMUNICATE WITH PARTICIPANTS
360

FIG. 3

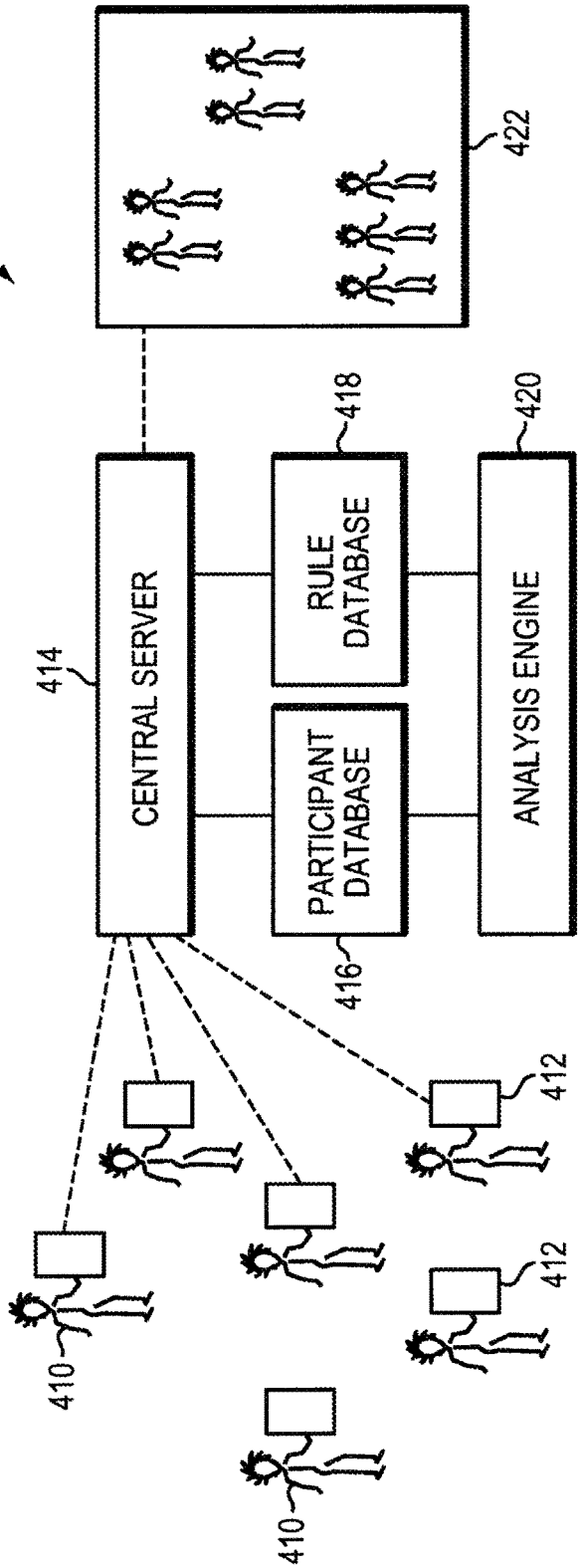
400
422
CENTRAL SERVER
414
RULE DATABASE
418
PARTICIPANT DATABASE
416
ANALYSIS ENGINE
420
410
412
410
412

FIG. 4

PARTICIPANT GROUPING FOR ENHANCED INTERACTIVE EXPERIENCE

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/537,790, filed on Nov. 10, 2014, and issued as U.S. Pat. No. 9,219,998 on Dec. 22, 2015, which is a continuation of U.S. patent application Ser. No. 13/458,040, filed on Apr. 27, 2012, and issued as U.S. Pat. No. 8,914,373 on Dec. 16, 2014, which claims priority to and the benefit of U.S. patent application Ser. No. 61/480,565, filed on Apr. 29, 2011, both of which are incorporated herein by reference in their entireties.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

This invention was made with government support under National Science Foundation award IIS-0835338. The government has certain rights in the invention.

FIELD OF THE INVENTION

In various embodiments, the present invention relates generally to grouping participants in an activity for enhancing interactive experience.

BACKGROUND OF THE INVENTION

Learning new skills or knowledge traditionally involves lectures, where an instructor spends a majority of time presenting materials to the participants in an activity. The instructor is primarily responsible for pacing the activity and setting the level of rigor. Participant involvement, unfortunately, tends to be limited to asking questions when confusion arises. Such one-way communication discourages critical thinking and has been shown to do little in improving the participants' understanding of the concepts presented.

Various teaching methods in which participants actively discuss new material among themselves encourage engagement and allow the participants to cooperatively reach consensus on correct answers, which results in a deeper understanding of new material. Such cooperative learning methods including, for example, "peer instruction" and "think-pair-share," generally require appropriately grouping the participants so as to foster a positive and meaningful discussion in each group. See, e.g., Crouch & Mazur, "Peer Instruction: Ten years of experience and results," *American Journal of Physics,* 69(9), 970 (2001); E. Mazur, *Peer Instruction: A User's Manual* (1997); *Cooper & Robinson, "Getting Started: Informal Small-Group Strategies in Large Classes" New directions for teaching and learning,* 81, 17-24 (2000).

Conventionally, the instructor or organizer allows participants to self-select into groups; this is especially common in large activities or when groups are arranged based on the spatial locations of the participants. As a result, some participants are grouped with others who have comparable knowledge, the same misconception, or the same correct understanding; this reduces learning opportunities through productive conversations within the group. A "productive conversation" as used herein means one in which each participant in the group gains from the discussion experience, such as switching from the wrong answer to the correct answer, improving his or her understanding of the correct answer, or developing a greater understanding of why the wrong answers are in fact wrong. Grouping the participants randomly or with an unplanned approach may produce productive conversations only by chance, thereby greatly hampering the potential and effectiveness of the cooperative learning approaches.

Consequently, there is a need for an approach that groups participants in an activity with a substantially high likelihood of producing productive conversations in each group.

BRIEF SUMMARY OF THE INVENTION

Embodiments of the present invention facilitate automatic grouping of participants in an activity such that each group is likely to produce productive conversations. In various embodiments, the participants' identifiers and/or characteristics are first transmitted via electronic devices to a central server and stored in a database. Individuals in the database who have similar characteristics and/or criteria relevant to the activity are selected as a training set. A functional relationship between the characteristics of the selected individuals in the training set and the likelihood of having productive conversations is computationally estimated. Based on the estimated functional relationship, the characteristics of participants in the activity, and/or a grouping policy, a probability of having productive conversations in each potential group of participants is obtained. Groupings having a high or maximum predicted likelihood of achieving productive conversations in each group are selected; the participants are then instructed to form groups based thereon via the electronic devices. As the information of more participants is stored in the database and more successful groupings (i.e., groups having productive conversations) are formed and analyzed, the likelihood of making an accurate prediction increases; this provides improvements in the grouping predictions over time without changing the underlying approach.

Accordingly, in one aspect, the invention pertains to a method of grouping participants in an activity, the participants each having a handheld device. In various embodiments, the method includes the steps of defining a grouping policy; storing, in a database, participant records each including a participant identifier, an identifier for the participant's handheld device, and at least one characteristic associated with the participant; defining groupings based on the policy and characteristics of the participants relating to the policy and to the activity; and communicating the groupings to the handheld devices to establish the groups.

The grouping policy may include or consist of deterministic rules and/or may be created adaptively based on one or more statistical models relating participant characteristics to conversational productivity. In some embodiments, the deterministic rules include requiring two or more different associated values for one or more participant characteristics in each group. The participant characteristic may include a behavioral characteristic, a performance characteristic, and/or a demographic characteristic. In various embodiments, the statistical model is a coarsened exact matching model. The conversational productivity may include switching from a wrong answer to a correct answer, improving the participants' understanding of the correct answer, and/or improved understanding of why a wrong answer is wrong. Additionally, the grouping policy may be based at least in part on geographic proximities among potential group members. For example, the participants may be co-located within a single defined space and the grouping policy requires a

defined proximity between members of a group based on geographic locations of the handheld devices.

The characteristics of the participants may be weighted by selecting a training set of individuals and computationally estimating a functional relationship between the characteristics and a grouping success likelihood based on the training set. The training set is larger than or equal to the number of the participants to be grouped and the individuals in the training set are related to the participants based on criteria relevant to the activity. In some embodiments, each participant has an associated value for each characteristic, and groupings are defined by (i) defining a set of candidate participant groupings consistent with the grouping policy and, for each candidate grouping, estimating a grouping success likelihood based on the functional relationship as applied to the values of the characteristics associated with each participant within the candidate grouping; and (ii) selecting optimized groupings based on the estimated grouping success likelihoods. The training set may be established based on nonparametric matching of candidate individuals to the participants using inputs that are specific to each individual and incorporate the criteria. In one embodiment, the inputs include demographic characteristics, behavioral characteristics, and/or performance characteristics. The demographic characteristics include participants' backgrounds, an organizer's background, and/or a geographic location of the activity. The performance characteristics include participants' performances in other activities and/or in the same activity previously. The grouping success of the selected optimized groupings may be analyzed and the functional relationship may be updated based thereon.

In a second aspect, the invention relates to a system for grouping participants in an activity, the participants each having a handheld device. In various embodiments, the system includes a memory for storing a participant database having a record for each of the participants and a processor in operative communication with the memory. Each record stored in the participant database may specify a participant identifier, an identifier for the participant's handheld device, and one or more characteristics associated with the participant. For example, the database record for each participant includes fields for a behavioral characteristic, a performance characteristic, and/or a demographic characteristic. The processor may be configured to: (i) define groupings of participants based on a grouping policy and characteristics of the participants, stored in the database, relating to the policy and to the activity; and (ii) communicate the groupings to the handheld devices to establish the groups. Additionally, the processor may be configured to create the grouping policy adaptively based on one or more statistical models stored in the memory and relating participant characteristics to conversational productivity. In one embodiment, the statistical model is a coarsened exact matching model.

The memory may include a rules database for storing rules defining the grouping policy. The deterministic rules, for example, may require two or more different associated values for one or more participant characteristics in each group. The memory may further include a training database having records corresponding to individuals collectively defining a training pool. Additionally, the processor may be configured to weigh the characteristics of the participants by: selecting, from the training database, a training set of records, and computationally estimating a functional relationship between the characteristics and a grouping success likelihood based on the training set. In one embodiment, the training set is larger than or equal to a number of the participants to be grouped and the individuals in the training set are related to the participants based on criteria relevant to the activity.

The database record for each participant may include an associated value for each characteristic, and the processor is configured to define groupings by (i) defining a set of candidate participant groupings consistent with the grouping policy and, for each candidate grouping, estimating a grouping success likelihood based on the functional relationship as applied to the values of the characteristics associated with each participant within the candidate grouping; and (ii) selecting optimized groupings based on the estimated grouping success likelihoods.

Reference throughout this specification to "one example," "an example," "one embodiment," or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the example is included in at least one example of the present technology. Thus, the occurrences of the phrases "in one example," "in an example," "one embodiment," or "an embodiment" in various places throughout this specification are not necessarily all referring to the same example. Furthermore, the particular features, structures, routines, steps, or characteristics may be combined in any suitable manner in one or more examples of the technology. The headings provided herein are for convenience only and are not intended to limit or interpret the scope or meaning of the claimed technology.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, with an emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the present invention are described with reference to the following drawings, in which:

FIG. **1**A schematically illustrates an activity having a gathering of participants and instructors;

FIG. **1**B depicts participants' information and a grouping policy set by instructors are transmitted to a central server and stored in a participant database and a rule database, respectively;

FIG. **2** depicts a selected training set of individuals who are related to the participants based on criteria relevant to the activity;

FIG. **3** depicts a method for grouping participants in an activity in accordance with embodiments of the current invention; and

FIG. **4** illustrates a system for grouping participants in an activity in accordance with embodiments of the current invention.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the term "event" refers to a gathering of "participants" led by one or more "instructors" in which the instructors desire to use handheld devices to measure participants' attitudes, opinions, knowledge, or understanding about the relevant subject matter. The most common case consists of students attending a class led by a professor or graduate student who wants to gauge student understanding of the content. However, participants need not be in the same room as each other or the instructor, so events encompass distance learning situations. In addition, participants need not be students; they might be employees participating in a

corporate training event, or workshop participants attending a workshop where the session leader wishes to gauge the opinions of the participants. An "item" is a question that an instructor poses to participants during an event and that participants respond to by using handheld devices. Items may or may not have a correct answer and may have any response format (i.e., they need not be multiple-choice). Items may attempt to assess factual information, tease out conceptual difficulties, or measure participants' opinions.

The present discussion focuses in part on students in a college classroom environment, it should be understood that the approach described herein is applicable to participants in any group pedagogical or intellectual endeavor, and the terms "student" and "participant" are used herein interchangeably. In addition, the term "instructor" used herein is not limited to a teacher or a professor in the classroom; the "instructor" may be a facilitator in a corporate event or in any group pursuing a pedagogical or intellectual endeavor.

FIG. **1**A depicts an exemplary event or activity **100** where a gathering of participants **110**, each having a handheld device **120**, are led by one or more instructors or organizers **130**, who may each have a handheld device **140**. Again, the nature of the activity is not material to the invention, nor are the specific roles of instructor and participant; instructor(s) **130** may, for example, be chosen from the participants **110** or may be a different group of people. What is important is for the activity to involve the transmission of unfamiliar information whose assimilation and understanding is facilitated or enhanced by productive conversations.

The participants **110** and the instructor(s) **130** may directly communicate via the handheld devices **120**, **140** or indirectly via a central server **145**. The handheld devices **120**, **140** may be, for example, computers, cell phones or other electronic devices that transmit participants' responses, attitudes, opinions, knowledge, characteristics, and/or understanding of relevant subject matter or items to one another, to the instructor(s) **130** and/or to the central server **145**. The subject matter or an item may be a question or a discussion topic that the instructor(s) 130 pose(s) to participants **110** during the activity. In one embodiment, participants **110** are students, the activity **100** is a class and the instructor **130** is a professor or teacher who wishes to gauge student understanding of the content. The students may be co-located or geographically dispersed (e.g., distance learning classes). In another embodiment, the activity is a corporate training event attended by employees or a workshop attended by workshop participants where the session leader wishes to gauge the opinions of the participants. A person of ordinary skill in the art will appreciate that the invention described herein may be applicable to any group of participants pursuing pedagogical or intellectual endeavors.

Referring to FIG. **1**B, in the beginning of the activity, the participants **110** may wirelessly or otherwise (e.g., by a wired connection) transmit their identifiers, locations, characteristics (e.g., behavioral characteristics, performance characteristics, or demographic characteristics) and/or the handheld devices' identifiers to a central server **145**; the central server **145** stores the received information in a participant database **160**. The central server **145** may be implemented in the instructor's handheld device or in a separate, independent system in wireless (or wired) communication therewith. The instructor **130** sets up a grouping policy and transmits the policy to (or enters it into) the central server **145**; the policy is stored in a rule database **170**. The central server **145** creates groupings based on characteristics of the participants, the likelihood of having productive conversations in each group and/or the grouping policy-typically based on all three factors. Group assignments based on the generated groupings are automatically communicated to the participants **110** via the handheld devices to establish the groups.

The grouping policy may consider the relationships among participants with groups consisting of related participants—such as participants sitting near each other—being formed. In one embodiment, simple policies based on deterministic rules are utilized to establish groups. The deterministic rules define each group as having, for example, two or more different associated values for one or more participant characteristics (e.g., behavioral characteristics, performance characteristics, and/or demographic characteristics); these rules maximize participant diversity based on factors that may be different (or weighted differently) depending on the subject matter. For example, the deterministic rules may create (i) "groups of two where participants have different responses to a preliminary question"; (ii) "groups of three where there are 0, 1, 2, or 3 women"; (iii) "groups composed of members, each having different levels of knowledge of the discussion problem," or (iv) "groups of participants from different countries." Rules creating groups (ii) and (iv) utilize demographic data only, while rules creating groups (i) and (iii) focus on subject-matter knowledge. With the criteria upon which the rules themselves are based stored in the participant database **160**, the rules themselves are straightforwardly implemented and combined according to pedagogical and group-dynamics criteria. For example, grouping rules (i) through (iv) may all be applied sequentially based on a desired order of priority, so that, for example, subject-matter knowledge may take primacy over demographics but the latter is not ignored altogether. In this way, all criteria deemed relevant are considered in formulating groups, and sparse participant data for a particular grouping rule or rule set is not fatal to operation.

In another embodiment, groups are adaptively created by more sophisticated policies that are based on statistical models—i.e., different groupings are selected based on statistical analysis of the characteristics of the participants being grouped. The statistical models predict the probability of having productive conversations in each potential group and then establish groups by maximizing the productive-conversation probabilities of all potential groups. Conversational productivity may be defined based on a desired pedagogical objective; for example, in teaching problem-based, difficult-to-grasp subject matter such as physics or engineering, a productive conversation may be one in which participants are likely to switch from a wrong answer to a correct answer to a problem posed by the instructor, to improve their understanding of the correct answer, and/or to understand why one of the wrong answers is in fact wrong.

Referring to FIG. **2**, in a second step of the embodiment under discussion, the sophisticated policies are implemented by selecting a raw training set **210** of individuals from a training database **220**, which contains records specifying individuals at least some of whom are not participants in the current activity for which grouping is to take place. However, at least some proportion of individuals in the database **220** are related to the participants to be grouped **230** based on criteria relevant to the activity. For example, the individuals from the training database **220** who will form the training set are typically selected to maximize similarities of selected grouping "inputs" between individuals in the training set and the participants in the current activity. These "inputs" may include characteristics such as:

1. Demographic characteristics of the participants and/or the instructor (e.g., age, sex, family income, educational background, origin, ethnicity, etc.). For a classroom-based current activity, the training database will have records specifying demographic characteristics of a class in which various of the listed individuals participated (e.g., class size, class composition based on the participants' demographic characteristics and/or experience, etc.), facilitating identification of training-set members who participated in a class demographically similar to the current class. For college-based activities, the training database will have records specifying demographic characteristics of the college (e.g., the ranking, specialties, catchment area for student population, etc.) attended by various of the listed individuals, and the geographic location of the college, facilitating identification of training-set members who attend a college demographically and/or geographically similar to the college where the current activity takes place.

2. Behavioral characteristics of the participants (e.g., the reaction time to conceptual questions, the number of completed homework assignments, the percentage of positive feedback from other participants, etc.). The training database will have records specifying behavioral characteristics of at least some listed individuals, facilitating identification of training-set members who have behavioral characteristics similar to those of individuals participating in the current activity.

3. Performance characteristics, including performance of the participants (e.g., scores on previous exams, correct answers to conceptual questions, completion of homework assignments, and positive peer instruction) and past performance on and contribution to in-class peer instruction or conversations (e.g., whether the participants have acquired new knowledge or improved their understanding from peer instruction, with which type of partners the participants have learned the most, etc.). The training database will have records specifying performance characteristics of at least some listed individuals, facilitating identification of training-set members who have performance characteristics similar to those of individuals participating in the current activity.

The training set may include the same participants who have attended the same activity (e.g., the same class from previous weeks) or a different activity (e.g., prerequisite classes) previously, or different participants who have attended the same or similar activities in the same or similar institutions. For example, the training set can be selected from the same class from an earlier semester in the same institution, the same or a similar class at another similar institution, or a similar class at the same institution. In one embodiment, the training set is selected from as many sources as are available and from which information may be obtained.

The number of individuals selected in the raw training set as described above may be larger than or equal to the number of participants in the current activity. In a third step of the embodiment under discussion, a nonparametric matching approach, for example, "Coarsened Exact Matching" (CEM) CEM (see, e.g., Iacus, King & Porro, "Causal Inference Without Balance Checking: Coarsened Exact Matching"; and Stefano, King & Porro, "Multivariate Matching Methods That are Monotonic Imbalance Bounding," the disclosures of which are hereby incorporated by reference) is used to remove from the raw training set individuals who are unlike any of the participants in the activity (i.e., whose inputs or characteristics are significantly different from the current participants). This step creates a composite training set composed of individuals who have maximally similar inputs or characteristics compared with the participants to be grouped in the present activity. Because a CEM approach requires no assumptions about generating the composite individuals, CEM advantageously reduces model dependence and statistical bias in the creation of the composite individuals and improves efficiency of the matching approach. Additionally, a CEM approach allows the determination of a threshold level of similarity and the importance of each input variable ex ante. Other matching approaches utilized in causal inference may be suitable for creating composite individuals and are thus within the scope of the current invention; many of these are detailed in Ho, Imai, King, & Stuart, "Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference," *Political Analysis* 15 (2007): 199-236 (the entire disclosure of which is hereby incorporated by reference). The selected matching approaches may be related or unrelated to the current tasks (i.e., grouping); if an unrelated matching approach (e.g., estimating causal inferences, record linkage in unconnected databases, and/or missing data imputation) is chosen, modifications of the selected approach for use herein may be necessary.

In a fourth step of the embodiment under discussion, an ensemble classifier based on statistical models and/or machine learning approaches is used to compute a functional relationship between the inputs or characteristics of the composite individuals and the likelihood of having a productive conversation in the groups of the composite training set. Based on the computed functional relationship and the inputs of the current participants to be grouped, a likelihood of having productive conversations for each potential group of the participants (i.e., grouping success likelihood) is predicted.

A standard stability (assured by how the composite training set is selected and matched) is assumed in the prediction of the occurrence of a productive conversation in a dyad, triad, or other-sized groupings. Optimized groupings are then selected based on maximizing the likelihood of having productive conversations in all potential groups. This grouping information is automatically transmitted to the participants wirelessly or otherwise (e.g. a wired connection) via the handheld devices. The ensemble classifier may be defined and used straightfowardly; much literature exists in statistics, machine learning, and applied statistics relating to improving classifiers and applying them to different areas. See, e.g., Hastie, Trevor; Jerome Friedman; and Robert Tibshirani, *Elements of Statistical Learning: Data Mining, Inference, and Prediction* (2009), which is incorporated herein by reference.

The results from the groupings (i.e., whether each group produces productive conversations) are analyzed after the activity and stored in the training database **220**. In a subsequent activity, the functional relationship between the inputs and the grouping success likelihood (based on success actually achieved in the groups utilized) may be newly computed or updated partially based on the newly stored results. Because the ensemble classifier is based upon statistical models and/or machine learning approaches, the functional relationship becomes more accurate as more individuals' information is stored in the training database **220**; this is due to an increasing likelihood of selecting a good match set of composite individuals for the training set. As a result, the accuracy of the success-likelihood prediction in each potential group increases over time. The grouping

approach in the current invention thereby improves over time as the database grows while maintaining the underlying structure.

In some embodiments, the groupings are formed at least partially based on a constrained grouping policy. For example, suppose the grouping policy involves the geographical locations of the participants where group members must be seated in proximity to one another. The participants' locations are first identified by, for example, a global positioning system, seat numbers assigned by the instructor, or an identified location of one or more other participants. The location information is then transmitted to the central server **145** via the participants' handheld devices and stored in a database. Groupings of the participants are then selected based on maximizing the likelihood of having productive conversations in potential groups (i.e., grouping success likelihood) while also satisfying the physical constraints on the participants' geographical locations.

A representative method **300** for grouping participants in an activity in accordance with embodiments of the current invention is shown in FIG. **3**. In a first step **310**, a grouping policy is defined by the instructor(s) and the participants' identifiers (and/or the identifiers of the participants' handheld devices), along with characteristics of the participants relevant to grouping for the current activity, are transmitted to a central server and stored in a rule database and a participant database, respectively. If the grouping policy is a sophisticated policy, in a second step **320**, a raw training set containing individuals is chosen; the individuals relate to the participants based on criteria relevant to the activity. In a third step **330**, a nonparametric matching approach is utilized to create a composite training set where the similarities of the composite individuals' inputs and the participants' inputs are maximized. In a fourth step **340**, a functional relationship between the composite individuals' inputs and a grouping success likelihood in the composite training set is computed. In a fifth step **350**, a grouping success likelihood of each potential group of participants is predicted based on the computed functional relationship and the inputs of the participants. In a sixth step **360**, optimal groupings are selected and the grouping information is communicated to the participants via their handheld devices. If a constrained grouping policy is set by the instructor, the optimal groupings may include this constraint (step **370**). Alternatively, if the grouping policy is a simple policy having deterministic rules, the groupings can be easily established based thereupon. Again, this grouping information is then transmitted to the participants via the handheld devices (step **380**).

A system **400** for grouping participants in an activity in accordance with embodiments of the current invention is shown in FIG. **4**. An ungrouped set of participants **410** each has a handheld device **412**; as noted above, the participants may be co-located or may be geographically dispersed. A central server **414** includes (or is in communication with) a participant database **416**, which contains records for the participants **410** as well as for other individuals who may be used in a training set. Each record identifies the participant **410**, his or her handheld device **412**, and participant-specific values for characteristics relevant to the activity (and, therefore, to optimal groupings). A rules database **418** contains rules associated with the grouping policy. An analysis engine **420** accesses databases **416**, **418** and defines groupings based on the grouping policy and characteristics of the participants as described above. If necessary, the central server **414** communicates with participants **410** to obtain data necessary to the analysis. Based on the analysis, the participants are grouped as described above, and the central server **414** communicates the groupings to the handheld devices **412** of the participants **410** to establish the groups, as indicated at **422**. Typically, communication with the handheld devices **412** occurs wirelessly, e.g., by SMS, an automated telephone call, e-mail or other suitable form of communication.

Analysis engine **420** may be implemented by computer-executable instructions, such as program modules, that are executed by a conventional computer. Generally, program modules include routines, programs, objects, components, data structures, etc. that performs particular tasks or implement particular abstract data types. Those skilled in the art will appreciate that the invention may be practiced with various computer system configurations, including multiprocessor systems, microprocessor-based or programmable consumer electronics, minicomputers, mainframe computers, and the like. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote computer-storage media including memory storage devices.

Any suitable programming language may be used to implement without undue experimentation the analytical functions described above. Illustratively, the programming language used may include assembly language, Ada, APL, Basic, C, C++, C*, COBOL, dBase, Forth, FORTRAN, Java, Modula-2, Pascal, Prolog, Python, RUM and/or JavaScript for example. Further, it is not necessary that a single type of instruction or programming language be utilized in conjunction with the operation of the system and method of the invention. Rather, any number of different programming languages may be utilized as is necessary or desirable.

The servers described herein may each be one or more server-class computers, such as a PC having a CPU board containing one or more processors such as the Pentium or Celeron family of processors manufactured by Intel Corporation of Santa Clara, Calif., the 680x0 and POWER PC family of processors manufactured by Motorola Corporation of Schaumburg, Ill., and/or the ATHLON line of processors manufactured by Advanced Micro Devices, Inc., of Sunnyvale, Calif. The computing environment may also include other removable/nonremovable, volatile/nonvolatile computer storage media. For example, a hard disk drive may read or write to nonremovable, nonvolatile magnetic media. A magnetic disk drive may read from or writes to a removable, nonvolatile magnetic disk, and an optical disk drive may read from or write to a removable, nonvolatile optical disk such as a CD-ROM or other optical media.

The processor that executes commands and instructions may be a general-purpose processor, but may utilize any of a wide variety of other technologies including special-purpose hardware, a microcomputer, mini-computer, mainframe computer, programmed micro-processor, micro-controller, peripheral integrated circuit element, a CSIC (Customer Specific Integrated Circuit), ASIC (Application Specific Integrated Circuit), a logic circuit, a digital signal processor, a programmable logic device such as an FPGA (Field Programmable Gate Array), PLD (Programmable Logic Device), PLA (Programmable Logic Array), RFID processor, smart chip, or any other device or arrangement of devices that is capable of implementing the steps of the processes of the invention.

As noted, the handheld devices **412** typically communicate with the central server **404** via a wireless link, but

communication may take place in any convenient manner, e.g., via a wired or wireless local area network (LAN) and a wide area network (WAN), wireless personal area network (PAN) and/or other types of networks. When used in a LAN networking environment, computers may be connected to the LAN through a network interface or adapter. When used in a WAN networking environment, computers typically include a modem or other communication mechanism. Modems may be internal or external, and may be connected to the system bus via the user-input interface, or other appropriate mechanism. Computers may be connected over the Internet, an Intranet, Extranet, Ethernet, or any other system that provides communications. Some suitable communications protocols may include TCP/IP, UDP, or OSI for example. For wireless communications, communications protocols may include Bluetooth, Zigbee, IrDa or other suitable protocol. Furthermore, components of the system may communicate through a combination of wired or wireless paths.

The terms and expressions employed herein are used as terms and expressions of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof. In addition, having described certain embodiments of the invention, it will be apparent to those of ordinary skill in the art that other embodiments incorporating the concepts disclosed herein may be used without departing from the spirit and scope of the invention. Accordingly, the described embodiments are to be considered in all respects as only illustrative and not restrictive.

What is claimed is:

1. A method of grouping participants in an activity, the participants each having a handheld device, the method comprising:

determining a value associated with one or more behavioral characteristics associated with the participants, the value of the one or more behavioral characteristics determined from a reaction time to a conceptual question or a percentage of positive feedback from other participants;

receiving one or more statistical models defining a relationship between the value of the one or more behavioral characteristics and conversational productivity between participants in a group of participants associated with a same behavioral characteristic for a different participant in the group of participants;

determining the group of participants, wherein the determined group will generate a productive conversation between the participants based in part on the one or more statistical models; and

transmitting a communication to the handheld device of at least one of the participants in the determined group, wherein the communication includes an identification of another participant in the determined group.

2. The method of claim **1**, wherein the conversational productivity comprises at least one of (i) switching from a wrong answer to a correct answer, (ii) improving the participants' understanding of the correct answer, or (iii) improved understanding of why a wrong answer is wrong.

3. The method of claim **1**, wherein at least one of the one or more statistical models is a coarsened exact matching model.

4. The method of claim **1**, wherein the one or more statistical models define the relationship also based on a performance characteristic or a demographic characteristic.

5. The method of claim **4**, wherein the demographic characteristic comprises a global positioning system, seat numbers assigned by an instructor, or an identified location of one or more participants.

6. The method of claim **1**, wherein the determined group includes potential participants based in part on geographic proximities between the potential participants.

7. The method of claim **1**, wherein the determining the group of participants further comprises computationally estimating a functional relationship of the participants.

8. The method of claim **1**, further comprising:

before transmitting the communication, receiving an identifier for the handheld device and a location of the handheld device from the handheld device.

9. A system for grouping participants in an activity, the participants each having a handheld device, the system comprising:

a memory for storing a participant database of the participants, wherein the participant database includes one or more behavioral characteristics and a value associated with the one or more behavioral characteristics; and

a processor in operative communication with the memory, the processor being configured to:

determine the value associated with the one or more behavioral characteristics associated with the participants, the value of the one or more behavioral characteristics determined from a reaction time to a conceptual question or a percentage of positive feedback from other participants;

receive one or more statistical models defining a relationship between the value of the one or more behavioral characteristics and conversational productivity between participants in a group of participants associated with a same behavioral characteristic for a different participant in the group of participants;

determine a group of participants, wherein the determined group will generate a productive conversation between the participants based in part on the one or more statistical models; and

transmit a communication to the handheld device of at least one of the participants in the determined group, wherein the communication includes an identification of another participant in the determined group.

10. The system of claim **9**, wherein the conversational productivity comprises at least one of (i) switching from a wrong answer to a correct answer, (ii) improving the participants' understanding of the correct answer, or (iii) improved understanding of why a wrong answer is wrong.

11. The system of claim **9**, wherein at least one of the one or more statistical models is a coarsened exact matching model.

12. The system of claim **9**, wherein the one or more statistical models define the relationship also based on a performance characteristic or a demographic characteristic.

13. The system of claim **12**, wherein the demographic characteristic comprises a global positioning system, seat numbers assigned by an instructor, or an identified location of one or more participants.

14. The system of claim **9**, wherein the determined group includes potential participants based in part on geographic proximities between the potential participants.

15. The system of claim **9**, wherein the determining the group of participants further comprises computationally estimating a functional relationship of the participants.

16. The system of claim 9, the processor further being configured to:

before transmitting the communication, receive an identifier for the handheld device and a location of the handheld device from the handheld device.

17. A non-transitory computer-readable medium embodying information indicative of instructions for causing one or more machines to perform a method comprising:

determining a value associated with one or more behavioral characteristics associated with participants, the value of the one or more behavioral characteristics determined from a reaction time to a conceptual question or a percentage of positive feedback from other participants;

receiving one or more statistical models defining a relationship between the value of the one or more behavioral characteristics and conversational productivity between participants in a group of participants associated with a same behavioral characteristic for a different participant in the group of participants;

determining a group of participants, wherein the determined group will generate a productive conversation between the participants based in part on the one or more statistical models; and

transmitting a communication to a handheld device of at least one of the participants in the determined group, wherein the communication includes an identification of another participant in the determined group.

18. The non-transitory computer-readable medium of claim 17, wherein the conversational productivity comprises at least one of (i) switching from a wrong answer to a correct answer, (ii) improving the participants' understanding of the correct answer, or (iii) improved understanding of why a wrong answer is wrong.

19. The non-transitory computer-readable medium of claim 17, wherein at least one of the one or more statistical models is a coarsened exact matching model.

20. The non-transitory computer-readable medium of claim 17, wherein the one or more statistical models define the relationship also based on a performance characteristic or a demographic characteristic.

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