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Electronic Preference-Based Measurement with Reduced Communication Overhead

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Electronic Preference-Based Measurement with Reduced Communication Overhead

TECHNICAL FIELD

[0001] Aspects of the disclosure relate generally to exchanging information between networked devices.

BACKGROUND

[0002] With the advance of modern medicine, health care evolved from physician-centered to patients-centered. Improving how medical providers, among other service providers, obtain information from their patients is a long-felt need in the medical field. Medical providers often obtain a majority of their information regarding a patient's condition directly from the patient. While a discussion of the patient's condition with the patient would appear to be removed from bias, patients are prone to adapting their responses to new questions based on their previous responses. Similarly, patients often employ various coping strategies to alleviate feelings of discomfort or stress while discussing their medical condition. Those adaptive responses and coping strategies often hamper the medical professional's task of obtaining a reliable and valid assessment of the patient's condition.

Patient-Reported Outcome Measure (PROM)

[0003] A patient-reported outcome (PRO) or patient-reported outcome measure (PROM) is any assessment coming directly from patients, without interpretation by physicians or others, about how they function or feel in relation to their health condition. The term PROM encompasses a broad spectrum of outcomes that include the symptoms of a disease or the side effects of a treatment (e.g., fatigue, pain, or low mood), functions (e.g., social activities, cognitive functioning, or physical abilities), and even multidimensional constructs, including health-related quality of life (HRQoL) or perceived health status. Evidence shows that the use of information from PROMs contributes to better communication, decision making between doctors and patients and improves patient satisfaction with health outcome and care.

[0004] One tool medical professionals have started using to reduce the effects of adaptions and coping-related issues is to use machine-based questionnaires to obtain an assessment of the patient's condition independent of an actual interview with the patient. These machine-based questionnaires – also known as electronic Patient-

Reported Outcome Measures (ePROMs) – provide additional benefits including, but not limited to, the following: monitoring patients with medium to chronic diseases from a distance; improving treatment to patients; permitting patients to become more actively involved in their treatments; and reducing costs by limiting in-person, telephone, and telepresence visits).

[0005] PROM and ePROMs can be developed within various measurement frameworks. One dominant framework is questionnaire-based, with these instruments measuring the intensity or level of specific health aspects through a bundle of items. However, when comparing health outcomes across different populations, conducting disease modeling studies, or performing economic evaluations of various health-care interventions, preference-based PROMs are more useful. Preference-based PROMs express outcomes in a single metric number ("value"). They do this by incorporating weights that reflect the relative importance attached to health items. Based on these weights, an overall "value" for a health state can be generated.

[0006] Existing advanced measurement methods in the social sciences (e.g., psychology, economics, marketing) and health sciences (e.g., health economics, clinimetrics) are all preference-based and all based on one of the three fundamental measurement models for subjective phenomena: item response theory (IRT), discrete choice experiments (DCEs), and valuation techniques. Such measurement models are used to quantify phenomena such as attitudes, perceived health, intelligence, and consumer preferences. Preference values (variously called utilities, strengths of preferences, indices, or weights) that these methods generate are preferably assumed to be unidimensional on a linear scale, so that differences between values of assessment of respondent states can be assumed to correspond to increments of difference in quality of these states, which implies that the values should be interval-level or cardinal data. Thus, the differences between values indicate true differences (e.g., if a patient's value of his/her health status increases from 40 to 60, this increase is the same as an increase from 70 to 90). Preference-based measurement can be very convenient because it produces one overall numerical score, which makes analyzing and interpreting results a straightforward procedure.

[0007] The methods of these models are all based on prespecified complex experimental research designs or complex mathematical computations controlled by a central server/computer. During the assessment tasks performed by individual respondents, connection to a central server/computer is required to transmit data (items, responses) in consecutive steps. Based on each answer from a respondent, a central computer running a complex algorithm processes a received answer and determines which next question to ask. In short, individual responses are sent in real time to the central server. The individual then waits until the central computer has determined a new question and waits until that question is received on the individual's device. This process continues until the end of the survey is reached. To prevent user frustration waiting for a next question to appear, a robust network connection (often an Internet connection) is required to interact with the central server/computer with no delay. In short, for a conventional survey to be effective, it must be supported by a system with low network latency. An issue with the conventional surveys is that the demanding bi-directional communications required to implement those surveys results in more communications to be handled by networks. In the aggregate, the quantity of bi-directional communications for widespread questionnaires/instruments may result in increased network latency for the implementation of those questionnaires/instruments. Aspects of the disclosure are directed to improving how surveys are generated and processed to reduce reliance on computer networks, thereby reducing network requirements for an immediate survey as well as reducing latency for other network communications occurring at the same time a given survey is being conducted.

[0008] Surveys exist to obtain information from respondents. In a fully networked, high-bandwidth environment, processing for the surveys may be consolidated to one or more servers. However, in environments with little connectivity or in high network traffic environments, expecting fast and consistent communications with the servers is not possible. In some situations, a user may be unable to start a survey based on the inability to obtain survey information from the one or more servers. In other situations, a user may be unable to complete the survey based on the lack of to communicate with the servers at any given moment. In yet further situations, the user's results may not be readily accessible at the completion of the survey based on the lack of connectivity or exceedingly heavy network traffic.

SUMMARY

[0009] The following presents a simplified summary of various aspects described herein. This summary is not an extensive overview, and is not intended to identify key or critical elements or to delineate the scope of the claims. The following summary merely presents some concepts in a simplified form as an introductory prelude to the more detailed description provided below.

[0010] Aspects described herein may address these and other problems, and generally improve how data may be provided to users and information from users provided to computing systems.

[0011] A system, method, and computer-readable medium storing instructions for conducting and analyzing results from a survey are disclosed. The survey permits respondents to take the survey and to view results with little to no communication with a remote server. This ability to obtain survey results is relevant to environments with little to no bandwidth connecting a user's device to a remote server. To take the survey, a respondent identifies his heath state by modifying severity levels of a predetermined quantity of fields. Next, the respondent orders the severity levels by comparing the levels to the levels to the remaining levels of the other fields. Using the combination of the original health state and the order in which the respondent quantified the levels against other levels, additional health states are postulated and a clearer identification of the state of health of the individual may be obtained.

[0012] In additional aspects, providing the analysis to the patient, without requiring additional processing by a remote server, improves the overall experience for the patient in as much as the patient will be able to see how his answers.

BRIEF DESCRIPTION OF DRAWINGS

[0013] The present disclosure is illustrated by way of example and not limited in the accompanying figures in which like reference numerals indicate similar elements and in which:

[0014] Figure 1 depicts an example of a computing device and system architecture that may be used in implementing one or more aspects of the disclosure in accordance with one or more illustrative aspects discussed herein;

[0015] Figure 2 depicts a block diagram of an environment in which systems and/or methods described herein may be implemented;

[0016] Figure 3 shows an example user interface for a first task of a survey process;

[0017] Figure 4 shows an example user interface for a second task of a survey process;

[0018] Figure 5 shows a comparison between user interfaces between the first survey process and the second survey process;

[0019] Figure 6A shows a sample order of interactions with a user interface of the first survey process. Figure 6B shows an example of how a user's interactions with the first survey process are postulated;

[0020] Figure 7 shows an example of how a user's interactions with the first survey process are postulated in a sample order;

[0021] Figure 8 shows network communications associated with a first survey process;

[0022] Figure 9 shows network communications associated with a second survey process;

[0023] Figure 10 shows network communications associated with a third survey process;

[0024] Figure 11 shows network communication delays and other processing delays associated with the first survey process, the second survey process, and the third survey process;

[0025] Figure 12 shows sample network communication data size comparisons between the first survey process, the second survey process, and the third survey process;

[0026] Figure 13 shows a graph displaying coefficients of the described survey processes;

[0027] Figure 14 shows a bar chart for the described survey process;

[0028] Figures 15A, 15B, 15C, and 15D show various user interfaces;

[0029] Figures 16A, 16B, and 16C show various user interfaces; and

[0030] Figure 17 shows a user interface.

DETAILED DESCRIPTION

[0031] In the following description of the various embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration various embodiments in which aspects of the disclosure may be practiced. It is to be understood that other embodiments may be utilized and structural and functional modifications may be made without departing from the scope of the present disclosure. Aspects of the disclosure are capable of other embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. Rather, the phrases and terms used herein are to be given their broadest interpretation and meaning. The use of “including” and “comprising” and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof. Any sequence of computer-implementable instructions described in this disclosure may be considered to be an "algorithm" as those instructions are intended to solve one or more classes of problems or to perform one or more computations. While various directional arrows are shown in the figures of this disclosure, the directional arrows are not intended to be limiting to the extent that bi-directional communications are excluded. Rather, the directional arrows are to show a general flow of steps and not the unidirectional movement of information. In the entire specification, when an element is referred to as "comprising" or "including" another element, the element should not be understood as excluding other elements so long as there is no special conflicting description, and the element may include at least one other element. In addition, the terms "unit" and "module", for example, may refer to a component that exerts at least one function or operation, and may be realized in hardware or software, or may be realized by combination of hardware and software. In addition, terms such as "... unit", "... module" described in the specification mean a unit for performing at least one function or operation, which may be implemented as hardware or software, or as a combination of hardware and software. Throughout the specification, expression "at least one of a, b, and c" may include 'a only', 'b only', 'c only', 'a and b', 'a and c', 'b and c', and/or 'all of a, b, and c'.

[0032] By way of introduction, aspects discussed herein may relate to methods and techniques for collecting information from a user and analyzing the information to identify responses of higher significance than others. Further, the collection process reduces the quantity of information requested from the user, thereby making the collection process significantly easier to implement in a low bandwidth environment.

[0033] In general, a user is provided with two tasks: the first task is to identify the user's current state; and the second task is to order the selections of the first task in an order of prominence (e.g., severity). The system may use the results of these two tasks to postulate which of the selections of the first task are of higher importance than others.

[0034] Before discussing these concepts in greater detail, however, several examples of a computing device that may be used in implementing and/or otherwise providing various aspects of the disclosure will first be discussed with respect to Figure 1. Figure 1 illustrates one example of a computing device 101 that may be used to implement one or more illustrative aspects discussed herein. For example, the computing device 101 may, in some embodiments, implement one or more aspects of the disclosure by reading and/or executing instructions and performing one or more actions based on the instructions. In some embodiments, the computing device 101 may represent, be incorporated in, and/or include various devices such as a desktop computer, a computer server, a mobile device (e.g., a laptop computer, a tablet computer, a smart phone, any other types of mobile computing devices, and the like), and/or any other type of data processing device.

[0035] The computing device 101 may, in some embodiments, operate in a standalone environment. In others, the computing device 101 may operate in a networked environment. As shown in Figure 1, various network nodes 101, 105, 107, and 109 may be interconnected via a network 103, such as the Internet. Other networks may also or alternatively be used, including private intranets, corporate networks, LANs, wireless networks, personal networks (PAN), and the like. Network 103 is for illustration purposes and may be replaced with fewer or additional computer networks. A local area network (LAN) may have one or more of any known LAN topologies and may use one or more of a variety of different protocols, such as Ethernet. Devices 101, 105, 107, 109, and other devices (not shown) may be connected to one or more of the networks via twisted pair wires, coaxial cable, fiber optics, radio waves, or other communication media. Additionally or alternatively, the computing device 101 and/or the network nodes 105, 107, and 109 may be a server hosting one or more databases.

[0036] As seen in Figure 1, the computing device 101 may include a processor 111, RAM 113, ROM 115, network interface 117, input/output interfaces 119 (e.g., keyboard, mouse, display, printer, etc.), and memory 121. Processor 111 may include one or more computer processing units (CPUs), graphical processing units (GPUs), and/or other processing units such as a processor adapted to perform computations associated with database operations. Input/output 119 may include a variety of interface units and drives for reading, writing, displaying, and/or printing data or files. Input/output 119 may be coupled with a display such as display 120. Memory 121 may store software for configuring computing device 101 into a special purpose computing device in order to perform one or more of the various functions discussed herein. Memory 121 may store operating system software 123 for controlling overall operation of the computing device 101, control logic 125 for instructing the computing device 101 to perform aspects discussed herein, database creation and manipulation software 127 and other applications 129. Control logic 125 may be incorporated in and may be a part of database creation and manipulation software 127. An integrated display is provided as display 130 as part of computing device 101. In other embodiments, the computing device 101 may include two or more of any and/or all of these components (e.g., two or more processors, two or more memories, etc.) and/or other components and/or subsystems not illustrated here.

[0037] Devices 105, 107, 109 may have similar or different architecture as described with respect to the computing device 101. Those of skill in the art will appreciate that the functionality of the computing device 101 (or device 105, 107, 109) as described herein may be spread across multiple data processing devices, for example, to distribute processing load across multiple computers, to segregate transactions based on geographic location, user access level, quality of service (QoS), etc. For example, devices 101, 105, 107, 109, and others may operate in concert to provide parallel computing features in support of the operation of control logic 125 and/or software 127.

[0038] One or more aspects discussed herein may be embodied in computer-usable or readable data and/or computer-executable instructions, such as in one or more program modules, executed by one or more computers or other devices as described herein. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types when executed by a processor in a computer or other device. The modules may be written in a source code programming language that is subsequently compiled for execution, or may be written in a scripting language such as (but not limited to) Python or JavaScript. The computer executable instructions may be stored on a computer readable medium such as a hard disk, optical disk, removable storage media, solid-state memory, RAM, etc. As will be appreciated by one of skill in the art, the functionality of the program modules may be combined or distributed as desired in various embodiments. In addition, the functionality may be embodied in whole or in part in firmware or hardware equivalents such as integrated circuits, field programmable gate arrays (FPGA), and the like. Particular data structures may be used to more effectively implement one or more aspects discussed herein, and such data structures are contemplated within the scope of computer executable instructions and computer-usable data described herein. Various aspects discussed herein may be embodied as a method, a computing device, a data processing system, or a computer program product.

Having discussed several examples of computing devices which may be used to implement some aspects as discussed further below, discussion will now turn to a method for conducting a survey with limited communications with a remote server.

[0039] Figure 2 is a block diagram of an environment in which systems and/or methods described herein may be implemented. As shown in Figure 2, the environment may include servers 201 and 202 and a computing device 203 connected by a network 204. The devices, servers, and network may be interconnected via wired connections, wireless connections, or a combination of wired and wireless connections. The server 201 may be directed toward receiving files relating to activities from computing device 203 and then sending the files to server 202 for processing. The server 201 may further include a processor 205 and storage 206. The server 202 may further include a processor 207 and storage 208. The computing device 203 may further include a processor 209 and storage 210.

[0040] The network 204 may include one or more wired and/or wireless networks. For example, network 204 may include a cellular network (e.g., a long-term evolution (LTE) network, a code division multiple access (CDMA) network, a 3G network, a 4G network, a 5G network, another type of next generation network, etc.), a public land mobile network (PLMN), a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), a telephone network (e.g., the Public Switched Telephone Network (PSTN)), a private network, an ad hoc network, an intranet, the Internet, a fiber optic-based network, a cloud computing network, or the like, and/or a combination of these or other types of networks.

[0041] The number and arrangement of devices and networks shown in Figure 2 are provided as an example. In practice, there may be additional devices and/or networks, fewer devices and/or networks, different devices and/or networks, or differently arranged devices and/or networks than those shown in Figure 2. Furthermore, two or more servers shown in Figure 2 may be implemented within a single server, or a single server shown in Figure 2 may be implemented as multiple, distributed servers or in a cloud-based computing environment. Additionally, or alternatively, a set of devices (e.g., one or more devices) of the environment 203 may perform one or more functions described as being performed by another set of devices of the environment. Network 204 may be represented as a single network but may comprise combinations of other networks or subnetworks. In one or more examples, a data stream (not shown) may be received by server 201, where server

201 is a data store for received survey information. The data stream may also be received by server 202. Server 202 may also store the new survey information as well. The servers 201 and 202 may extract information from the data stream or streams, create survey items, and store one or more survey templates in their respective storages. The application on computer device 203 may request information survey information from one or more of the servers 201 and/or 202 and the survey started.

Mobile Application

[0042] One or more aspects described herein relate to an electronic patient-reported outcome measure (ePROM) that uses software to run a mobile application to obtain user responses to a survey. The mobile application may provide immediate analyses of the user's results. As part of the measurement model (multi-attribute preference response: MAPR), users perform two distinct tasks in the mobile application. The first produces a description (health state) of the patient's current health condition (health status), and the second elicits the patient's preference responses in regard to his/her own health status.

[0043] The MAPR model is a generic statistical model that, based on the input from many respondents estimating their relative positions in relationship to states in which other respondents are or may be. Preference responses (whether respondents consider their own situation/condition better or worse than alternative situations/conditions) are collected in interaction with a user interface controlled by the computer program product being executed and sent to the central server. On the central server, a computer program processes the received data in accordance with the MAPR model structure.

[0044] Preference values (variously called utilities, strengths of preferences, indices, or weights) that these methods generate are preferably assumed to be unidimensional on a linear scale, so that differences between values of assessment of respondent states can be assumed to correspond to increments of difference in quality of these states, which implies that the values should be interval-level or cardinal data. Thus, the differences between values indicate true differences (e.g., if a patient's value of his/her health status increases from 40 to 60, this increase is the same as an increase from 70 to 90). Preference-based measurement can be very convenient because it produces one overall numerical score, which makes analyzing and interpreting results a straightforward procedure.

MAPR Measurement Model: Response Tasks

Task 1: Base State

[0045] A user operates a user interface (e.g., referred to herein as "CS-Base User Interface" or just "CS-Base") to establish an initial base state. For simplicity of explanation and for example, the base state being obtained is a health state. One of ordinary skill in the art would readily appreciate the base state may be directed to any base state and not specifically related to a patient's health. Alternatively, depending on the type of PROM and its content, a particular base health states may be obtained. The CS-Base User Interface is one of a plurality of ePROMs that may be used. For instance, other ePROMs may be directed specifically to particular health areas including cardiovascular, pulmonary, transplantation, prosthetics, and the like. Where the CS-Base user interface is used for establishing a base health state and for each health item in the CS-Base user interface, the mobile application depicts an interactive box all together on the same screen. When the patient clicks on the box for a specific health item, it rotates, displaying the response options. For example, a user may start with an initial state 301 as shown in Figure 3. The user may modify five of the options in step 302 (e.g., "some problems with mobility", "good vision", "poor hearing", "not anxious", and "a little pain"). The completed set of selections is shown, for instance in the modified user interface of step 303.

[0046] More particularly, Figure 3 shows an example user interface for task 1 of the survey process. A first displayed page 301 includes a plurality of regions identifying items for which a user will be requested to specify a particular level of severity. As used herein, the severity level may also be expressed as a priority level, an intensity level, a burden, and/or items that hinder or disturb the patient the most. Examples of the regions may include items relating to mobility, vision, hearing, cognition, mood, anxiety, pain, fatigue, social functioning, daily activities, self-esteem, and independence. 12 regions are provided for selection in the user interface 301. Regions may be added or subtracted as desired. The user interacts with one or more of the regions of user interface 301 to specify a level of severity (e.g., in the case of CS-Base, four levels of intensity may be used. A different quantity of levels may be made available as desired). In the example of Figure 3, page 302 of the user interface shows the user having modified the following regions: mobility (selecting "some problems with mobility"); vision (selecting "good vision"); hearing (selecting "poor hearing"); cognition (selecting "no cognitive problems"); and mood (selecting "good mood"). Here, "hearing" has been modified to a second level of severity (e.g., "poor hearing"). In one more examples, the various selected level may be identified as an intensity bar (e.g., in length, position, and/or color) associated with each of the selectable regions. In page 303, all regions have been interacted with at least once. If at least some fields are interacted with, the user may be presented with the option to proceed to task 2 of the survey.

[0047] The actual interactions with the user interface may be visual emphasized to improve how the information displayed on the screen. For instance, when a patient selected the "Hearing" box of user interface 301 of Figure 3, the displayed options may shift (e.g., rotate) to offer the response option "Some hearing problems" (Level 1). After selecting the box again, the display shifted to "Poor hearing" (Level 2). Other options may also be provided. For instance, for "Fatigue", the option may include "Not tired" (Level 1), "Little tired" (Level 2), "Quite tired" (Level 3), and "Very tired" (Level 4). Patients rate their current health status by rotating the boxes to show the best-fit descriptions in all boxes 303 of Figure 3. The CS-Base user interface may permit the local application generate a description of a patient's overall state of health expressed as 12 digits (e.g., 213111212221, or even worse 214111212331). Patients can also click information points beside the health items to access explanations.

Task 2: Preferences

[0048] After Task 1, patients performed a second task (Task 2), based on their descriptions of their own health states (Task 1) according to the same CS-Base. Task 2 requires them to make trade-offs and to provide selections regarding which of the displayed intensity levels causes the greatest burden to the patient. Two different methods for establishing preference are described herein: Better/Worse (BW) and Drop-Down (DD). For the Better/Worse method, a full description is provided in US Patent No. 11,631,476 to Dr. Paul F. M. Krabbe.

Drop-Down (DD) Method

[0049] For the Drop-Down method, Figure 4 shows an example user interface for task 2 of a survey process. Upon selecting "next" from displayed page 401 (showing the result from task 1), the user is presented with pages 402 and 403 (and others as relevant). The user is requested to select, of the identified items in the user interface, which health-related aspect hinders the patient the most. In page 402, the user selected "poor hearing". That region is replaced with a next lower level of that aspect and displayed, in page 403, as "impaired hearing". The user continues identifying, of the remaining displayed aspects, which is the most hindering. To aid the user, the relevant selectable fields may be identified while the fields with no lower level aspects may be grayed out (e.g., not selectable). As shown on page 404, the first region "some problems with mobility" was deprecated to "no problems with mobility", the third region "poor hearing" was deprecated to "impaired hearing" (from page 403) and left at "impaired hearing" on page 404. The seventh region "a little pain" was deprecated to "no pain" on page 404. The ninth region "some problems with social functioning" was deprecated to "no problems with social functioning" on page 404. The tenth region "some problems with daily activities" was deprecated to "no problems with daily activities" on page 404. The "good self-esteem" was not modified between pages 403 and 404.

[0050] For the DD method (Figure 5, steps 503), the patient's own health state from Task 1 501 was presented on the screen. The patient was asked to select the item (with a suboptimal level: 2, 3, or 4) that hindered or disturbed them the most. By clicking or swiping (dropping down via the user interface) this item is shifting one level lower (better). Each drop-down produced a health state ranked better than the initial health state from Task 1 501 (There had to be at least two items with levels > 1, otherwise the choice was predetermined. Items at Level 3 or higher could be dropped down more than once).

[0051] In the DD method, patients make trade-offs between the levels of multiple items (i.e., "is Level *i* of an item *x* worse than any level of another item?"). In contrast to the Better/Worse method, patients do not have to make trade-offs between their own and an alternative health state. Patients used the drop-down option up to a maximum of quantity of levels, with each drop-down producing a different (better) ranked health state. In the example of Figures 4 and 5, five levels were useable. However, greater or fewer quantities of levels may be made available. For each patient, therefore, the ranking for the states could range from 1, 2, 3 (with at least 2 items having suboptimal levels: 2 drop downs) and 1, 2, 3, 4, 5, 6 (in case of 5 drop-downs). The lowest or worst ranking was coded as 1, representing the patient's actual health state. With the new task 2, the instrument is able to determine, for an individual patient, which health aspects are most important for an individual patient (and correspondingly relevant information for medical doctors).

Better/Worse (BW) Method

[0052] For the Better/Worse method as shown in steps 502 of Figure 5, patients compared their own health states (Task 1, step 501) to a computer generated, slightly different alternative health state (502A, 502B, 502C). The alternative states differed from their own health states by a predetermined and limited number of items (for example, two) that had been altered. Patients could thus regard these alternative states as hypothetical states. One of the items represented an improvement of one level compared to the patient's actual health state (one level lower, depicted as a green box). The other item represented a reduction of one level compared to the patient's actual health state (one level higher, depicted as a red box). For example, on Task 1 (1001), a patient reported being "Not tired" for the "Fatigue" condition and having "Some problems with daily activities" for the "Daily activities" condition. These two health items were altered into "A little tired" and "No problems with daily activities" to construct an alternative health state in the subsequent Task 2 (See Figure 5, 502A, Better/Worse).

[0053] The assumption is that a one-level improvement on one item is not necessarily the same difference as a one-level decline on another item. For example, patients may have appraised differences between the levels of distinct items in different ways. The patients may have been asked "Please indicate whether your health is better or worse than the health description below." The generation of these alternative health states may have been based on a flexible randomization algorithm (number of alternative states, number of items to vary, colors) that was built into the software. The task essentially called for the patients to internally make a trade-off between their own health state and other alternative states in a paired comparison, and then to select either their own health state or the alternative health state as better (i.e., 1 if preferred and 0 if not).

[0054] In one example, patients compared five alternative health states with their own health state. For each patient, therefore, there were five sets of the most basic ranking, namely of two health states: 1,2 (coded as 1,0 for the statistical software)..

MAPR Measurement Model: Statistical Models

[0055] Like all probabilistic measurement models, the MAPR measurement model use an indirect form of measurement. The data generated by the preference methods are not measures. Ordinal response data (ranks) obtained from the preference methods are aggregated to estimate coefficients based on a mathematical (measurement) model. Subsequently, the coefficients are used to compute values for the health states. These values are the measures. As used herein, the terms "coefficient" and "weight" may be used in place of each other or, as described in a particular section, refer to values that are applied as weighting factors to adjust outcomes.

[0056] The mathematical model consists of a latent (hidden) variable (the metric scale) and a set of manifest (observable) variables (i.e., the items of the CS-Base). Such models have a long history, commencing with the model developed by Louis Thurstone in 1927. Other researchers have introduced extensions to the basic Thurstonian model.

[0057] For all probabilistic measurement models, respondents must perform assessments (preliminary phase of information processing prior to making a judgment) and judgments (choice in favor of something) in particular ways to endorse specific responses. This then generates data for an analysis in accordance with the measurement model. Within these probabilistic measurement frameworks, the assessment consists of comparing at least two objects (i.e., health states or set of health items), with the aim of expressing which object is preferred (i.e., better). Therefore, the Better/Worse and DD methods are developed in such a way that both will produce preference data that fits the measurement model described below.

[0058] The data generated when patients select one health state over another (Better/Worse method) are discrete choice data. The data generated when patients rank health states from most favorite to least favorite (DD) are rank-ordered data. To process the data generated by the Better/Worse and DD methods, two different but related statistical models are adequate: conditional logit and rank-ordered logit. These models differ in terms of the expected data structure of health-state preferences and estimation procedures. The distinction is that the dependent variable (preference: choice or rank) in the conditional logit records only the best state by a value not equal to zero ("1" if best state and "0" for the other state)). In contrast, the ranked-ordered logit model marks the rankings of the states.

Mathematics

[0059] The preference data of the Better/Worse and Drop-Down methods are processed in similar ways. The Drop-Down methods process preferences in the following way. The value of a health state *j* for an individual *i* is denoted by *Vij*. A respondent will rank state *j* higher than state *k* if *Vij* > *Vik*. The probability of choosing state *j* as the most preferred of the set of *J* states (Better/Worse: *J* = 2; Drop-Down: *J* > 2) can be written as follows:

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{ik}}} \qquad (1)$$

[0060] The probability of observing a specific ranking among three or more health states (Drop-Down) can be written as the product of such terms, representing a sequential interpretation. In this sequence, the respondent first chooses the most preferred health state, followed by the most preferred of the remaining health states, and so forth. It was assumed that *Vij* is a linear combination of the levels of the health-state items plus an error term εij for the individual. The model is specified as follows:

$$V_{ij} = \beta x_j + \varepsilon_{ij} \qquad (2)$$

where β represents a vector of regression coefficients. Further, ***xj*** is a vector of binary dummy explanatory variables ($x^{\delta\lambda}$), with λ indicating the levels of each of the items for a given health state. For example, in an example involving the CS-Base, x^{72} represents the second level (“A little pain”) of the seventh item (Pain). Because a given health state has the same expected value across all respondents, *x* is indexed only by *j*. Although the estimation procedures for the two models differ, they will produce the same results if the rank-ordered logit model is used for data consisting exclusively of sets of two states.

[0061] The Drop-Down method provides an improvement in how the data is gathered as the Drop-Down method forces the patients to order their health states such that no two items (e.g., poor hearing/poor mobility each with the same intensity level) can have the same latent/internal weight . For instance, where a patient's hearing was designated as Level 3: Poor Hearing and the patient's mobility was designated as Level 3: Poor Mobility, the Drop-Down method forces the patient to drop down each item (hearing or mobility) separately, e.g., forcing one to be dropped down before the other.

[0062]

Postulated States

[0063] For the Drop-Down method, additional health states may be created, for instance, on a server, according to the patients' responses. The postulated states may be based on the ranked health states produced in the preference task (in which patients dropped down item levels to improve their actual health states), as the information derived from the Drop-Down task 1 is limited and may not be sufficient. For example, although the case of five drop-downs (Figure 5, 503) generated six ranked health states, all the levels for these states are lower (i.e., better) than the patient's actual health state. Moreover, for each of these ranked states, only one of the 12 items has a level that is lower.

[0064] The regression routine of the MAPR measurement model to estimate the weights for the levels of the items requires variation (i.e., more than one item must vary for each health state, and to both lower and higher levels) to determine a stable estimation (i.e., achieve convergence). For this reason, postulated states can be imputed based on information (Figure 6A) derived from the actual states (Figure 5, 501). This extend the ranking in the analyses to a maximum of 9 ranked states (Figure 6B). The additional postulated states may be created locally on the user's device and/or later on a remote server.

[0065] As shown in Figure 6A, five states were modified (e.g., hearing 601, pain 602, daily activities 603, mobility 604, and social functioning 605). The order of the drop downs is shown as order 606. The levels of intensity (including baseline) are shown in as group 607.

[0066] Figure 6B shows an example of creating postulated states. The postulated states are logical derivations from the combination of the patient's original health state and the order of the drop down tasks performed on the original health state. In this example, the first drop-down (the health aspect considered as most disturbing) is item 3 (drop from level 3 to level 2). Increasing the actual health state for this item one level higher is producing a health state that is by definition worse than the actual health state. Moreover, even if we reduce a particular item level from which it is know that this is considered less disturbing than the item from the first drop-down, we might assume that overall such a postulated state is still worse than the actual state. Here in this example, to increase the contrast (the right square bracket in Figure 6B) the third drop-down was selected as the item to decrease the level. The original order from Task 1 is shown as row 0 608 and represents the patients' own health state. The Drop-Down health states are shown in the Drop-Down ordered levels of the items as rows 1-5. The original health state and the dropped down intensity levels are shown in the matrix 614 as row 0 (the original health state) and rows 1-5 as heath states corresponding to the modifications from each drop down step.

[0067] Next, as shown in matrix 615, the patient's own health state (from row 0 of matrix 614) is replicated and modified based on the drop down information. In this example, the patient's own health state is replicated three times. The patient's own health state may be replicated a greater number of times or a fewer number of times as desired. For instance, the user's health state may be replicated a number of times where the number of times is scaled to the quantity of drop down steps. Where the quantity of drop down steps is five (as shown in Figures 6A and 6B), the quantity of replicated original health states may be three (= quantity of drop down steps – 2). Using this approach, where the quantity of drop down steps is eight, the quantity of replicated original health states may be six (= 8 - 2). Other approaches may be available as well for quantify health states (e.g., sliding scales on user interfaces and the like).

[0068] As a result, the quantity of health states is increased from the single health state provided by the patient to six health states (the original health state plus the five health states identified by dropping down one intensity level from the identified health items), and subsequently to nine health states (the previous six health states plus the three replicated and modified from the patient's actual health state). These additional health states, all centered about the patient, help to increase the precision of the estimated weights (regression coefficients) of the levels of the items. Consequently, these additional health states allow a survey to be conducted across fewer individuals to achieve analyzable results between individuals.

[0069] In this example, the first three items dropped down have one level added to each. The last three items dropped down have one level subtracted from each. Other examples exist including only adding level intensities to the levels of the items in the original health state, only subtracting level intensities from the levels of the items in the original health state, and/or a different combination of additions and subtractions.

[0070] In the current example, item 3 609 was dropped down first, item 7 610 was dropped down second, item 10 611 was dropped down third, item 1 612 was dropped down fourth, and item 9 613 was dropped down fifth. The first postulated state (row 1 of matrix 615) reflects modifications of the original health state (608 from matrix 614) as modified by the first drop down. The first drop down (609) is raised by one level (from 3 to 4). The second postulated state (row 2 of matrix 615) reflects modifications of the original health state as modified by the second drop down. The second drop down (610) is raised by one level (from 2 to 3). The third postulated state (row 3 of matrix 615) reflects modifications of the original health state as modified by the third drop down. The third drop down (611) is raised by one level (from 2 to 3).

[0071] Next, the third postulated state (row 3 of matrix 615) is further modified by the drop downs. The fifth drop down (613) is lowered by one level (from 2 to 1). The second postulated state (row 2 of matrix 615) is further modified by the drop downs. The fourth drop down (612) is lowered by one level (from 2 to 1). The first postulated state (row 1 of matrix 615) is further modified by the drop downs. The third drop down (611) is lowered by one level (from 2 to 1).

[0072] As shown in Figure 7, the ranks of drop downs are shown in matrix 701. The third item is raised in intensity as shown by arrow 702. The seventh item is raised in intensity as shown by arrow 703. The tenth item is raised in intensity as shown by arrow 704. The ninth item is lowered in intensity as shown by arrow 706. The first item is lowered in intensity as shown by arrow 705, and the tenth item (previously raised) is now lowered in intensity as shown by arrow 707. Alternatively, the number of additional rows added may be closer to the quantity of drop down steps.

In the example of Figure 7, the number of additional rows is three but the quantity of drop down steps is five. Here, the level for item 10 is raised for one additional level (e.g., row 3) and dropped in another additional level (e.g., row 1). In another example, the number of additional rows may be three as well but the quantity of increased levels and decreased levels may be reduced to one change per row. In other words, for an even quantity of drop down steps, the quantity of increased levels may be equal to the quantity of decreased levels. For an odd quantity of drop down steps, the quantity of increased levels may be one greater (or one less than, as desired) than the quantity of decreased levels.

[0073] Further, in the example of Figure 7, the postulated states are modified to include the increase in levels per the first three drop down steps. The first new row (row 1) reflects the increase in the item related to the first drop down step (e.g., the previous level 3 being changed to a level 4). The second new row (row 2) reflects the increase in the item relating to the second drop down step (e.g. the previous level 2 for item seven being changed to level 3). The third new row (row 3) reflects the increase in the item relating to the third drop down step (e.g., the previous level 2 of the tenth item being changed to level 3).

[0074] Next, for row 3, the level of the last selected drop down item (item 9) is decreased from level 2 to level 1. For row 2, the level of the second to last drop down item (item 1) is decreased from level 2 to level 1. Finally, for row 1, the level of the third to last drop down item (item 10) is decreased from level 2 to level 1. The result is three postulated health states now found in rows 1-3 of the matrix of Figure 7 where each of the new rows is different from the original health state (now row 4) and the related drop down health states (rows 5-9).

Differences in Communication with Remote Servers

[0075] Figure 8 shows an example of generation of alternative states by a server (for a survey using the Better/Worse method). server-based generation of the alternative states. A server 802 generates a selection set 803 and sends it to a local device 801. The user input's his health state in step 804. The results are sent to the server in step 805, an alternative state generated in step 806, and the alternative state sent to the local device in step 807. The user selects his preference in step 808. The process is repeated through steps 809-821. In step 822, the complete survey results are exchanged between the local device 801 and the server 802.

[0076] Figure 9 shows an example of generation of alternative states by a local device (for a survey using the Better/Worse method). A local device 901 receive a selection set 903 from a server. The user's state is determined in step 904. Alternative states are generated, provided to the user, and the user's responses received in steps 904-911. The survey may be reset in step 913 for the next user. In step 914, the completed survey or surveys may be provided to the server for analysis.

[0077] Figure 10 shows an example of sequential level comparison by a local device (for a survey using the Drop-Down method). A local device 1001 receiving user selections is shown in relation to a server 1002. A selection set of options 1003 may be received from the server. A user may receive and designate his own health state (e.g., a user state) as a first task in step 1004. In steps 1005-1011, the user may identify an order in which the previous selections comprising the first task have priority. In step 1012, the survey may be completed and, in step 1013, prepared for the next user. Additionally or alternatively, the system may provide the result of the analysis to the user in step 1014. Additionally or alternatively, the process may send the completed survey results to the server in step 1015. Based on the completed survey results being sent the server 1002 in step 1015, the server may generate (step 1017) postulated states. The postulated states may be sent (in step 1018) to a physician and/or to the user. On the server, weights for the levels of the items may be estimated.

[0078] Figure 11 shows relative bandwidth and processing comparisons between the server generated alternative states (steps 1104-1109), the local device generating the alternative states (steps 1110-1112), and the local device using the Drop-Down method comparison (steps 1113-1115). In short, the server-based generation of the alternative states is subject to the greatest quantity of network-based and processing-based delays. The local device-generated alternative states is better as fewer communications over a burdened network are present. However, the Drop-Down method faces the fewest amount of network delays as no alternative states are generated and subsequently stored. Figure 12 provides an explanation of why the different transmission volumes can be significant in low-bandwidth environments.

[0079] A conventional approach to generating and receiving survey results may generate questions and ask the user to generate responses to each question. U.S. Patent 8340982 to Bjorner et al. is an example of the item response theory (IRT) method of conducting a survey. US 7552104 to Hansen is an example of a discrete choice model (DCE) method of conducting a survey.

[0080] The MAPR model using Better/Worse alternatives is an improvement to the IRT and DCE examples of surveys. In general, the Drop-Down method is an improvement to the MAPR model, where both the Drop-Down method and the Better/Worse method are applicable. However, specific situations may exist where the Drop-Down method is not a feasible option. While the MAPR model may be used with a specific set of steps to significantly reduce network latency, the Drop-Down method further improves on reducing network latency. A goal of the Drop-Down method is to make the measurement of perceived health by individual patients possible and easy while minimizing load on a computer network. In short, the use of the Drop-Down method model simplifies the quantity of survey questions while ensuring adequate sampling of user responses.

[0081] This is possible because the initial response of the patient (describing his/her own health condition by selecting the levels of specific items) is obtained and the levels of intensity of the specific items ordered by the user based on the user's subjective view of the intensity of each. So, patients can use the application without internet connection. Responses are stored in app and send to the central server when internet connection is available. In short, the user is being asked to rank each of his items that make up his health state with other items within his own health state, not comparing those results to alternative heath states or answer another round of questions (i.e., generated by a remote server). One of ordinary skill in the art would appreciate that the application's ability to reduce reliance on a possibly intermittent network solves the technical issue of reducing reliance on an active network connection to complete a survey.

[0082] With respect to reduced data transmissions, both the number of transmissions and the quantity of data that is part of each transmission may be reduced. In existing software to measure subjective phenomena, such as health, the number of transmission occasions as well as the amount of transmitted data is higher per user. Respondents (patients or non-patients) are presented item by item (IRT) or pairs of health states (DCE). Each assessment requires data to be transmitted back and forth to the central server/computer. In the approach of the present application, the assessment is different and simpler. Therefore, less data transmission is needed: 1) After a patient has described his/her own health state, no further data transmission is needed to depict the alternate states in the assessment; and 2) as the patient ranks the levels of his items in his health state against the levels of other items in his health state, thus reducing the need to generate alternative health states.

[0083] In contrast, the conventional approach (IRT) or (DCE) requires repeated queries to the central computer for each of the items (e.g., sending, by the central computer, five options for each of each of five items equals 25 sent separate items and five returned items from the local device). As the present application compares the patients' own health state with alternate states, less data transmission is needed compared to the existing measurement methods.

[0084] One of ordinary skill in the art would have appreciate that the application's teachings of sending a respondent's state and the ordered level of user's subjective comparisons between the items comprising the respondent's state solves the technical issue of reducing data transmissions not possible with the conventional question-based survey generating and data gathering techniques.

[0085] The improvement to the device administering the survey to the user is a technical improvement shown by how the device operates in low bandwidth environments. As described below, three devices operating in a low bandwidth environment are compared in how long each takes to complete a survey described in the application (e.g., where the user indicates a preference for remotely generated alternatives; where the user indicates a preference for locally generated alternatives; and where a user describes the user state and internally ranks items in the state against each other).

[0086] The first device, shown in Figure 3, represents the remote generation, e.g., by a server, of additional queries or comparison states for the user. In the example of the first device, the additional queries are alternative states of the MAPR model. However, the additional queries may also be the next set of questions using a conventional survey (e.g., the next set of questions using the survey method of US 20020035486 to Huyn et al.). The second device, shown in Figure 4, represents the local generation of the alternative states of the MAPR model. The third device, shown in Figure 4, represents the user's selection of a state and then internally compares the items and their respective levels of the user's state against each other. The operations within the dotted rectangles in each of Figures 3, 4, and 5 (e.g., 323, 415, and 516) are compared. As described below, the faster operation of the device of Figure 5 shows how the improvement of the application provides a technical improvement to related computing systems. In the examples below, an initial user state is identified as 354 bytes (B), an alternative state is identified as 354 B, and the combination of the alternative state and the user preference (the preference associated with the MAPR model) is identified as 354~355 B. For the purposes of the calculations shown below, the size of 355 B is used to differentiate from the size of the initial state and alternative states by themselves.

[0087] Figure 3 shows a local device and a server. The local device presents options to a user and the user, by selecting various ones of the presented options, identifies the initial user state. The local device transmits the user state of 354 B to the server. In response, the server generates a first alternative state (e.g., alternative state 1) and transmits it (at 354 B) to the local device. The local device displays the alternative state 1 to the user and receives the user's preference. The alternative state 1 and the user's preference are sent to the server (at 355 B) where the server generates the next alternative state 2. This process continues for as many alternative states to complete the survey. Shown outside the dotted rectangle, the survey is completed. At this point the local device may be provisioned to begin another survey, for instance, for another user.

[0088] Figure 4 shows an example of a local device generating the initial states by itself instead of relying on the server to generate the alternative states. In Figure 4, the local device presents options to the user and the user, by selecting various ones of the presented options, identifies the initial user state. A processor of the local device generates, based on the initial user state, alternate state 1. Alternate state 1 is displayed to the user and the user identifies a preference for the initial user state or alternative state 1. Based on the user's preference, the processor of the local device generates alternative state 2. Alternative state 2 is displayed to the user and the user identifies a preference for the initial user state or alternative state 2. This process continues for the quantity of alternative states needed to complete the survey. While shown outside the dotted rectangle in Figure 4, the local device may be used to complete another survey by another individual before eventually uploading the survey or surveys to the server.

[0089] In Figure 5, the Drop-Down method uses the ordering of the intensity levels previously assigned to each item in the user's heath state to better quantify the relationships between the severities of the items. Based on the comparison between intensity levels, the tasks of generating alternative health states and the associated recordkeeping of those alternative health states with the user's Better/Worse preferences are not required.

[0090] For each of the examples of Figures 3 and 4, the initial set of total selectable options is shown as 4.8 kilobytes (KB). As that data may be downloaded or already resident on the local device, it is excluded from the following analysis.

[0091] High-speed wireless communication is not ubiquitous. Sometimes, wireless communications are restricted or the infrastructure supporting high-speed wireless communication (e.g., access points and wired networks and/or mesh networks) does not exist. Wireless communications are often prohibited in cardiac monitoring wards of hospitals. Rural environments may lack the infrastructure to guarantee high-speed wireless connections. Where communication with a server does not exist (e.g., in a cardiac monitoring ward or in rural environment without connectivity), the local device of Figure 3 may never be able to complete the survey as the local device of Figure 3 relies on the server to generate the alternative states. Where some connectivity does exist, that connectivity may be slow. To show how the local device of Figure 4, representing the technical approach of the application, is a technical improvement to the operation of the local device of Figure 3, the following compares the operation of the local devices in an environment with a communication bandwidth of 100 kbits/second, e.g., the communication bandwidth specified in IEEE 802.15.4 "Low-rate wireless personal area network". The 100 kbits/second bandwidth described below is only an example as greater bandwidths may be used in practice. This bandwidth is used to explain where delays occur and how those delays differentiate the operates of the local devices of Figures 4 and 5.

[0092] Figure 6 shows a comparison between the local device relying on the server to generate the alternative states (e.g., Figure 3 above) and the local device generating the alternative states by itself (e.g., Figure 4 above and relating to a technical improvement over that of Figure 3 in the processing time to complete the survey). Figure 6 also shows the improvement of Figure 5 over each of the processes of Figures 3 and 4.

[0093] Figure 6 represents the processes for receiving a user state, generating an alternative state, obtaining a user preference between the user state and the alternative state, and getting ready to generate the next alternative state. Three types of delays are present in the operation of the server-side calculated alternative states (left side of Figure 6 pertaining to the process of Figure 3) that are not present in the operation of the locally generated alternative states (middle of Figure 6 pertaining to the process of Figure 4). The first delay is the transmission delay between the sending of the user state from the local device and when the user state is received at the server. The second delay is the transmission delay between the sending of the alternative state of the server to the local device. The third delay is the transmission delay between the sending of the alternative state and user preference from the local device to the server. These three types of delays are not present in the process (of Figure 4 and shown at the middle in Figure 6) where the local device generates the alternative states. The combined delay is shown in the curly bracket at the bottom center of Figure 6.

[0094] To compare the differences between the times to complete a survey using the server generated alternatives approach of the left side of Figure 6 and the locally generated alternatives approach of the middle side of Figure 6, the transmission delays are determined using a 100 kbits/second bandwidth with five alternative states. As used herein, a given transmission delay is determined as the transmission size divided by the available bandwidth. The total transmission delay may be determined as the {initial send delay} plus the per alternative delay (each alternative delay represented as the sum of the {alternative receive delay} + {alternative send delay}).

Total delay = initial send delay + X(alternative receive delay + alternative send delay),

where X = quantity of alternative states compared to initial user state

Where bandwidth = 100 kbits/s (IEEE 802.15.4 Low-rate wireless personal area network) = 12.5 kB/s,

For 5 alternative states, X =5,

$$\begin{aligned}\text{Total delay} &= 354/12500 + 5((354/12500) + (355/12500))\\ &= 0.0283 + 5(0.0283 + 0.0284)\\ &= 0.0283 + 5(0.0567)\\ &= 0.0283+0.2835\\ &= 0.3118\ \text{s}\end{aligned}$$

For 10 alternative states, X =10,

Total delay	=	354/12500 + 5((354/12500) + (355/12500))
	=	0.0283 + 5(0.0283 + 0.0284)
	=	0.0283 + 5(0.0567)
	=	0.0283+0.567
	=	0.5953 s

[0095] Where the five alternative state survey takes an estimated 60 seconds (depending on the length of the survey) for a user to complete using a device locally generating alternative states, an equivalent survey using a device relying on the server to generate the alternative states and in the low bandwidth environment described above would take an estimated 60.3118 seconds, an increase of approximately 1% (=60.3118/60). Using a device that locally generates the alternatives, the local device may complete the survey faster and without reliance on communications with the remote server.

[0096] These examples show how, for limited bandwidth environments, the device that locally generates the alternative states requires less time to complete the survey. Where a device relies on the server to generate the alternative states, its processor continues to run (and consume power, drain battery, etc.) that is not required by the device that locally generates the alternative states. This reduction in processing time of the device that locally generates the alternative states is a technical improvement to the operation of a device used to conduct a survey of an individual.

[0097] The right side of Figure 6 (pertaining to the process of Figure 5) shows the further improvement in that no generation of alternative states is needed but instead the user internally ranks the levels that comprise his health state against each other. The process of Figure 5 and as shown on the right side of Figure 6 shows the computational savings of the processor and the subsequent data transmissions with the server. As such, the process of Figure 5 does not face the processing delays of the process of Figure 4 to generate the alternative states. Further, because the results of the process of Figure 5 are computable based on the postulated states described herein, the survey results may be locally analyzed by the computing device 616 instead of requiring that the analysis be performed on the server 602.

[0098] Figure 7 shows examples of data transmissions for a native application (e.g., running on a local device) and a web-based application communicating with a server (e.g., a server-based application). A user device 701 is shown obtaining an initial user state (Task 1). For Task 2, in step 702 the user interacts with a user interface using the Drop-Down method to identify and order the most significant selections of Task 1. For Task 1, 12 selections were received. For Task 2, 5 selections were received. The result is 17 total selections are pushed to the server. For each of the native app 703 and the web-based app 704, the 17 total selections are the same. At a transmission size of 354 kB per transmission of a selection, the resulting data transmitted is approximately 6 kB (= 17 * 354 B = 6018 B).

[0099] For the locally generated states (using the Better/Worse method) of method 705, Task 1 results in 12 initial selections. Task 2 results in 77 selections (=(12 alternatives + 1 selection (Better/Worse)) x 5 alternatives). By comparison, other selections using a server-based alternatives generation (the IRT method 710) results in 120 selections and individual server-based/ per-item selections (the DCE method 708) results in 125 selections. For the IRT method 710 with an estimated 354 B per selection, the resulting data transmitted is approximately 42 kB (= 120 * 354 B = 42480 B). For the DCE method 708 with an estimated 354 B per selection, the resulting data transmitted is approximately 44 kB (= 125 * 354 B = 44250 B).

[0100] Where each transmission is estimated as 354-355 B per selection, the locally generated Better/Worse process 705 results in approximately 27 kB as follows: Total subsequent transmissions equals 77 = (quantity of users = 1)(initial state (12)+ 5(alternative state (12)+ preference(1))). At a transmission size of 354 B per transmission, the resulting data transmitted is approximately 27 kB (= 77 * 354 B = 27280 B).

[0101] For a server-side generation of alternative states, the server-side-generated Better/Worse process 710 is a combination of the total sent to the server and the total received from the server during the comparison window. The result is (12 initial responses x 5 alternatives) + (12 alternates x 5 preferences) = 120 transmissions.

Additional Patient-Centered Features

[0102] It is helpful to include items that are relevant to target populations' subjective health evaluation. In the development of PROMs, it's increasingly recognized that the items selection should be based on patient's input. However, many of the existing PROMs are not patient-centered in their development, but the health professionals' views are prioritized. This could result in either omitting health items that have a high relevance to patients or accentuate irrelevant ones. Even for the widely used EQ-5D-5L, its content (5 items) was not selected by patients but by health researchers. The questions arise if its content really reflects what's important to patients and if the five items are enough to assess the overall health of patients well. Despite that the EQ-5D-5L owns the great advantage of short and simple using. A new generic health outcome measurement CS-Base has been developed. The CS-Base is an electronic patient-reported outcome measure (ePROM) that may run in a mobile app. The mobile app may comprise 12 health items, each specified on four levels. All the 12 items in the CS-Base were selected by patients.

[0103] Besides health items selection, another crucial part of preference-based PROMs is the health valuation or preference method. This is used to generate weights for levels of items and can further provides a quantitative measure (value) of the overall health. The value allows comparison between many different diseases groups and can be used for many areas such as calculating quality-adjusted life years, assessing cost-effectiveness of interventions, monitoring health conditions of the population, supporting clinical decision making.

[0104] Preference-based methods are frequently used in valuation techniques. Conventional preference-based methods (e.g., Standard Gamble, Time Trade-Off) applied in the health setting were developed by health economists and mainly based on (pairs of) hypothetic health states assessed by a sample of the general population instead of patients. However, it is reasonable to assume that in many situations, a sample of unaffected respondents from the general population may be inadequately informed or lack good imagination to make an appropriate assessment about the impact of (severe) health states.

[0105] Besides, such conventional preference-based methods are, to some extent, too complicated to be easily understood by respondents. As such, well-trained interviewers are often needed to help respondents to complete the tasks. Preference-based methods used by health-economists often use an iterative process to offer respondents different lengths of life. This may introduce anchoring bias, which means people tend to rely too heavily on the very first piece of information encountered. As Tversky and Kahneman explained, people make estimates by starting from an initial value that is adjusted to yield the final answer. One example given by Tversky and Kahneman is participants spun a wheel to select a number between 0 and 100. The volunteers were then asked to adjust that number up or down to indicate how many African countries were in the U.N. Those who spun a high number gave higher estimates while those who spun a low number gave lower estimates. In each case, the participants were using that initial number as their anchor point to base their decision. In general, these conventional preference-based tasks are complex and cognitively demanding, as a result, these tasks are likely to produce results that are less precise or that may even be biased.

[0106] It is beneficial to make the preference tasks as simple as possible. A novel preference-based measurement framework has been recently introduced. This framework is known as the multi-attribute preference response (MAPR) model described above. In its general form, it is a probabilistic choice model that combines the Rasch model (item response theory) and the discrete choice model (i.e., discrete choice experiments). These type of choice models have a long history, commencing with Louis Thurstone's model, which was developed in 1927. Other researchers have introduced extensions of the basic Thurstonian model. There are two assessment tasks within the MAPR model, the first is a descriptive task, patients (hence, not respondents from the general population) describe the health states of themselves in this task based on a set of health items. This health items are all selected by patients themselves. The second is a preference-based task, which generates ranked preference data that is used to estimate the overall weights of the levels of the items.

[0107] The Drop-Down method, described above, was used as the preference-based task in MAPR model. In the Drop-Down method, respondents do not need to be confronted with hypothetic health states or make trade-offs between their own health and alternative, hypothetical health states. They only focus on their own health state and select health items that hinders them most. The Drop-Down method provides good results as described herein. An additional benefit of the MAPR measurement framework is that the assessment tasks (Task 1: descriptive task, Task 2: preference-based task) can be performed on smartphone screens which makes the PROM user-friendly, and attractive to the users (patients) and to researchers. In addition, all responses are automatically stored and processed.

CS-Base

[0108] CS-Base is a generic health-outcome instrument. Specifically, this instrument is an electronic patient-reported outcome measure (ePROM) that uses special software. The CS-Base was developed for measuring HRQoL and comprises 12 health items, each specified on four levels: mobility, vision, hearing, cognition, mood, anxiety, pain, fatigue, social functioning, daily activities, self-esteem, and independence.

MAPR measurement model

[0109] The MAPR measurement model (belongs to the probabilistic choice models) was used for the CS-Base. These probabilistic choice models can establish the relative merit (value) of a subjective phenomenon. These models are indirect, producing measures using the metric scale (analogous to a yardstick). For all probabilistic choice models, respondents must perform preference-based tasks in a particular way to endorse a specific response. This then generates data for an analysis in accordance with the measurement model. The core of a preference-based task in these probabilistic measurement frameworks consists of a response task that compares at least two objects with the aim of expressing which object is most preferred (is better). From a technical perspective, these models group ordinal data obtained from respondents. The grouped data are then aggregated to infer an interval scale (metric measure: value) that is based on a mathematical (measurement) model.

[0110] The probability of observing a specific ranking can be written as the product of such terms, representing a sequential decision interpretation, in which the respondent first chooses the most preferred alternative, and then the most preferred alternative among the rest, etc.

Mobile app

[0111] PROMs may be executed in a mobile app (e.g., in the HealthSnApp from Château Santé of the Netherlands). This is a flexible tool, with interactive routines. It runs on various electronic devices (e.g., smartphone, tablet, laptop) and is highly configurable from a web-based console.

Coefficients

[0112] An empirical study using the CS-Base has been conducted in which the Drop-Down was used. The coefficients estimation of the CS-Base was based on outcomes of

2,534 respondents who did the Drop-Down tasks. For CS-Base, all coefficients revealed a logical order (all the coefficients are negative numbers). The more negative a coefficient is, the lower the coefficient is (indicating a higher impact) (See the Table below). All coefficients showed statistically significant differences (P<0.001). Clear differences of coefficients were observed between levels for all items (Figures 13,).

Table

Coefficients of CS-Base (N=2534)

Item levels	Coefficient	SE	Z
Mobility (2)	-3.22	0.13	-25.49
Mobility (3)	-8.95	0.19	-46.29
Mobility (4)	-15.40	0.35	-44.57
Vision (2)	-3.25	0.12	-26.06
Vision (3)	-8.24	0.19	-43.54
Vision (4)	-14.55	0.39	-37.67
Hearing (2)	-3.45	0.10	-35.59
Hearing (3)	-8.66	0.16	-53.91
Hearing (4)	-14.76	0.32	-46.31
Cognition (2)	-3.28	0.14	-23.43
Cognition (3)	-8.19	0.21	-37.77
Cognition (4)	-12.87	0.54	-23.81
Mood (2)	-3.30	0.10	-33.49
Mood (3)	-7.89	0.16	-50.51
Mood (4)	-13.19	0.27	-48.34
Anxiety (2)	-3.13	0.09	-34.28
Anxiety (3)	-7.44	0.14	-51.67
Anxiety (4)	-12.94	0.22	-57.65
Pain (2)	-3.23	0.09	-35.93
Pain (3)	-7.54	0.14	-53.28
Pain (4)	-13.14	0.22	-58.81
Fatigue (2)	-3.40	0.09	-39.08
Fatigue (3)	-7.65	0.14	-53.25
Fatigue (4)	-12.55	0.23	-55.68
Social function (2)	-3.44	0.10	-33.63
Social function (3)	-7.56	0.17	-45.59
Social function (4)	-12.71	0.29	-43.50

Daily activity (2)	-3.46	0.10	-34.14
Daily activity (3)	-7.65	0.17	-45.76
Daily activity (4)	-11.72	0.35	-33.20
Self-esteem (2)	-3.81	0.11	-35.80
Self-esteem (3)	-7.54	0.17	-45.19
Self-esteem (4)	-12.45	0.25	-50.58
Independence (2)	-3.83	0.13	-28.63
Independence (3)	-8.15	0.22	-36.41
Independence (4)	-12.50	0.42	-29.83

All the p values <0.001

Health States and Values

[0113] There were 1,988 respondents that assessed their health states. The number of different health states assessed in the CS-Base, were 1,472. Mean values of the health states reported in the CS-Base was -30.05. No respondent reported the worst health state in the CS-Base. The worst health state among the 1,988 respondents reported in the CS-Base is 342444443344 (value=-131.80).

[0114] Figures 13 and 14 show distributions of values (without perfect health) for the CS-Base. The values for perfect health state in the CS-Base are 0. The perfect health state was excluded from Figures 13 and 14, so there are no values (Figure 13) or bars (Figure 14) above value “0”. The number of respondents (without those reported perfect health) in the CS-Base PROM is identified in the top-left.

[0115] Compared to conventional preference-based methods, the most outstanding advantage of the Drop-Down method is that it is easy to perform. No alternative or hypothetic health states are included in this method, the patients only have to assess their own health conditions. They just need to select and swipe away the items that hinders them most. Thus, the Drop-Down method is directed more accurately at the patients’ own experience and easier to perform. Meanwhile, the Drop-Down method can also be administered on smartphones or other electronic devices, which makes the tasks more convenient and attractive to users.

[0116] Figure 15A shows an example bar chart of how results may be provided to a physician. Scores on each item for individual patients may be identified in item 1 as the narrower bars. Scores on each item for a group may be identified as item 2 as the wider bars. Health items with the highest burden to an individual patient may be identified as item 3 – the orange narrow bar. In Figure 15B, the total values based on scores on items (e.g., based on an estimation at a server) are represented as values for individual patients as item 5. Item 6 pertains to values on a group level for a selected group of patients. Figure 15C compares subgroups of patients as item 7. Figure 15D shows how scores may change (as item 9) for patients over time.

[0117] Figure 16A shows, as item 4, the ordered top number of items 1601 that are considered as giving the largest burden to an individual patient. Figure 16B shows bubble charts for males 1602 and females 1603 with different medians. Figure 16C shows a warning level graphic 1604 with an explanation 1605. Figure 17 shows an alternative version of Figure 16B where the results of the individual 1702 are highlighted in an overall plot of all similarly situated individuals 1701. With respect to Figures 15A, 15B, 15C, 15D, 16A, 16B, 16C, and 17, items 3-4 are only available using the Drop-Down method for the survey and not for the Better/Worse method for the survey.

[0118] Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0119] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

CLAIMS

We claim:

1. A computer-implemented process comprising:

receiving, from a remote server and by a user computing device, fields with selectable levels;

generating, based on the received fields, a first user interface comprising a plurality of regions, each with two or more selectable levels;

displaying, on a display of the user computing device, the first user interface;

receiving, based on first user interactions with the first user interface, selected levels for at least two of the plurality of regions;

storing, based on the first user interactions, the selected levels for the at least two of the plurality of regions;

generating, without communicating with the remote server and based on the selected levels, a second user interface;

displaying, on the display, the second user interface;

receiving, based on second user interactions with the second user interface, an order of severity of the selected levels;

calculating, without communicating with the remote server and based on the order of severity of the selected levels, additional levels;

generating, without communicating with the remote server and based on the selected levels from the first user interface and the calculated additional levels, a third user interface comprising results of the selected levels and the calculated additional levels; and

storing the results.

2. The computer-implemented method of claim 1, further comprising:

displaying, based on the generated results, the third user interface on the display of the user computing device.

3. An apparatus comprising:

a display;

one or more processors; and

a memory storing instructions that, when executed by the one or more processors, controls the apparatus to:

receive, from a remote server, fields with selectable levels;

generate, based on the received fields, a first user interface comprising a plurality of regions, each with two or more selectable levels;

display, on the display, the first user interface;

receive, based on first user interactions with the first user interface, selected levels for at least two of the plurality of regions;

storing, based on the first user interactions, the selected levels for the at least two of the plurality of regions;

generate, without communicating with the remote server and based on the selected levels, a second user interface;

display, on the display, the second user interface;

receive, based on second user interactions with the second user interface, an order of severity of the selected levels;

calculate, without communicating with the remote server and based on the order of severity of the selected levels, additional levels;

generate, without communicating with the remote server and based on the selected levels from the first user interface and the calculated additional levels, a third user interface comprising results of the selected levels and the calculated additional levels; and

store the results.

4. The apparatus of claim 3, wherein the instructions, when executed by the one or more processors, are further configured to:

display, based on the generated results, the third user interface on the display of the user computing device.

5. One or more computer-readable media comprising instructions configured, when executed by one or more processors, to perform steps comprising:

receiving, from a remote server and by a user computing device, fields with selectable levels;

generating, based on the received fields, a first user interface comprising a plurality of regions, each with two or more selectable levels;

displaying, on a display of the user computing device, the first user interface;

receiving, based on first user interactions with the first user interface, selected levels for at least two of the plurality of regions;

storing, based on the first user interactions, the selected levels for the at least two of the plurality of regions;

generating, without communicating with the remote server and based on the selected levels, a second user interface;

displaying, on the display, the second user interface;

receiving, based on second user interactions with the second user interface, an order of severity of the selected levels;

calculating, without communicating with the remote server and based on the order of severity of the selected levels, additional levels;

generating, without communicating with the remote server and based on the selected levels from the first user interface and the calculated additional levels, a third user interface comprising results of the selected levels and the calculated additional levels; and

storing the results.

6. The one or more computer-readable media comprising instructions configured, when executed by one or more processors, to perform further steps comprising:

displaying, based on the generated results, the third user interface on the display of the user computing device.

ABSTRACT

A system, method, and computer-readable medium storing instructions for conducting and analyzing results from a survey are disclosed. The survey permits respondents to take the survey and to view results with little to no communication with a remote server. This ability to obtain survey results is relevant to environments with little to no bandwidth connecting a user's device to a remote server. To take the survey, a respondent identifies his heath state by modifying severity levels of a predetermined quantity of fields. Next, the respondent orders the severity levels by comparing the levels to the levels to the remaining levels of the other fields. Using the combination of the original health state and the order in which the respondent quantified the levels against other levels, additional health states are postulated and a clearer identification of the state of health of the individual may be obtained.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	

Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 [Remove]

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
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All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. [Add]

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	22910
Email Address	[Add Email] [Remove Email]

Application Information:

Title of the Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead		
Attorney Docket Number	005032.00438\US	**Small Entity Status Claimed**	☒
Application Type	Provisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	17	**Suggested Figure for Publication (if any)**	

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	
Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
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Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
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This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
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Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	

Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Remove Access Code[i] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	
Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

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The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	
Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee ○ Legal Representative under 35 U.S.C. 117 ○ Joint Inventor

◉ Person to whom the inventor is obligated to assign. ○ Person who shows sufficient proprietary interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

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Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	

Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead

Applicant 2 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee ○ Legal Representative under 35 U.S.C. 117 ○ Joint Inventor

◉ Person to whom the inventor is obligated to assign. ○ Person who shows sufficient proprietary interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

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Email Address			

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	005032.00438\US
	Application Number	

Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
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See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Christopher R. Glembocki/			Date (YYYY-MM-DD)	2023-08-22
First Name	Christopher R.	Last Name	Glembocki	Registration Number	38800

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The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

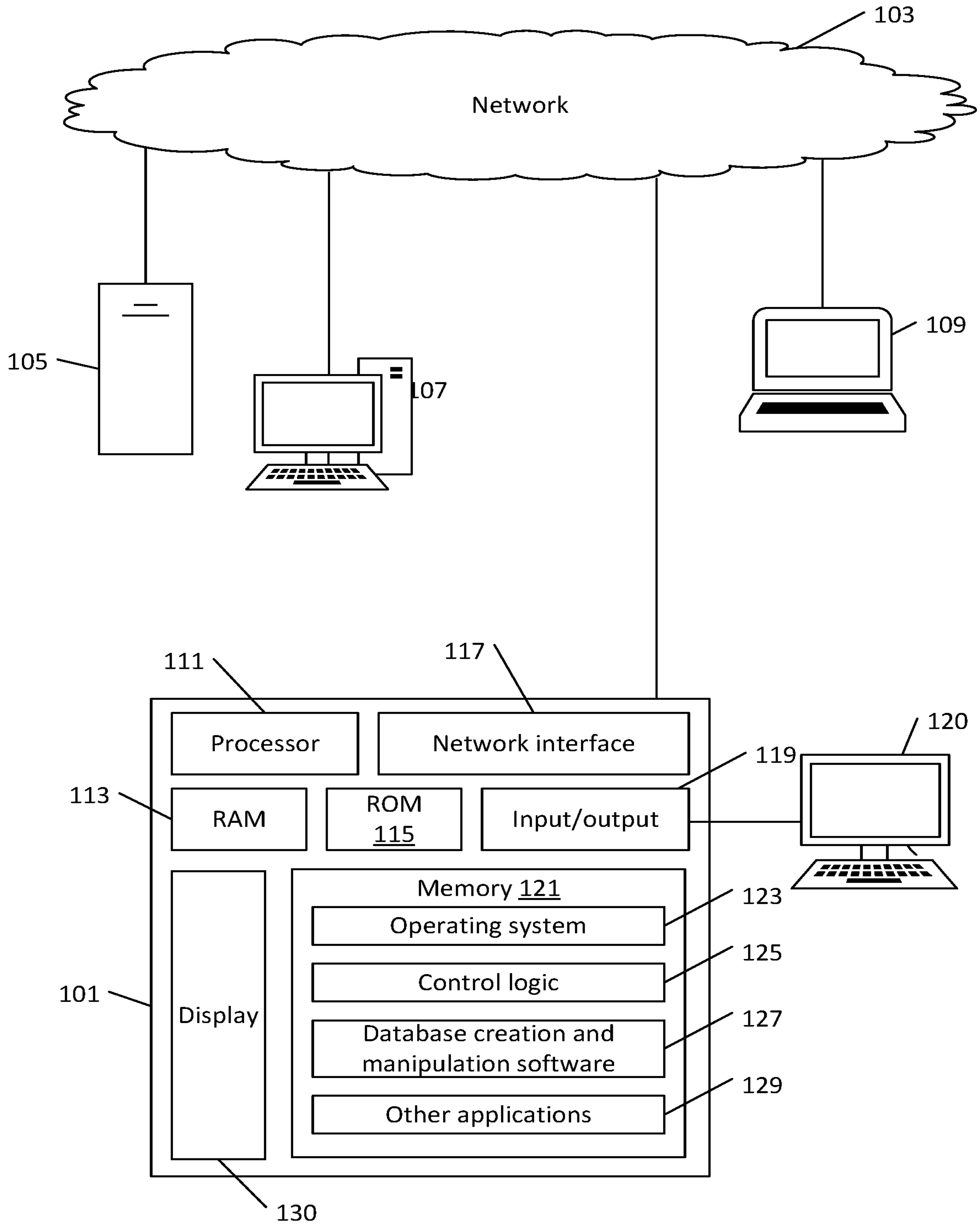

103
Network
105
107
109
111
117
Processor
Network interface
120
119
113
RAM
ROM
115
Input/output
Memory 121
123
Operating system
125
Control logic
101
Display
127
Database creation and
manipulation software
129
Other applications
130

Figure 1

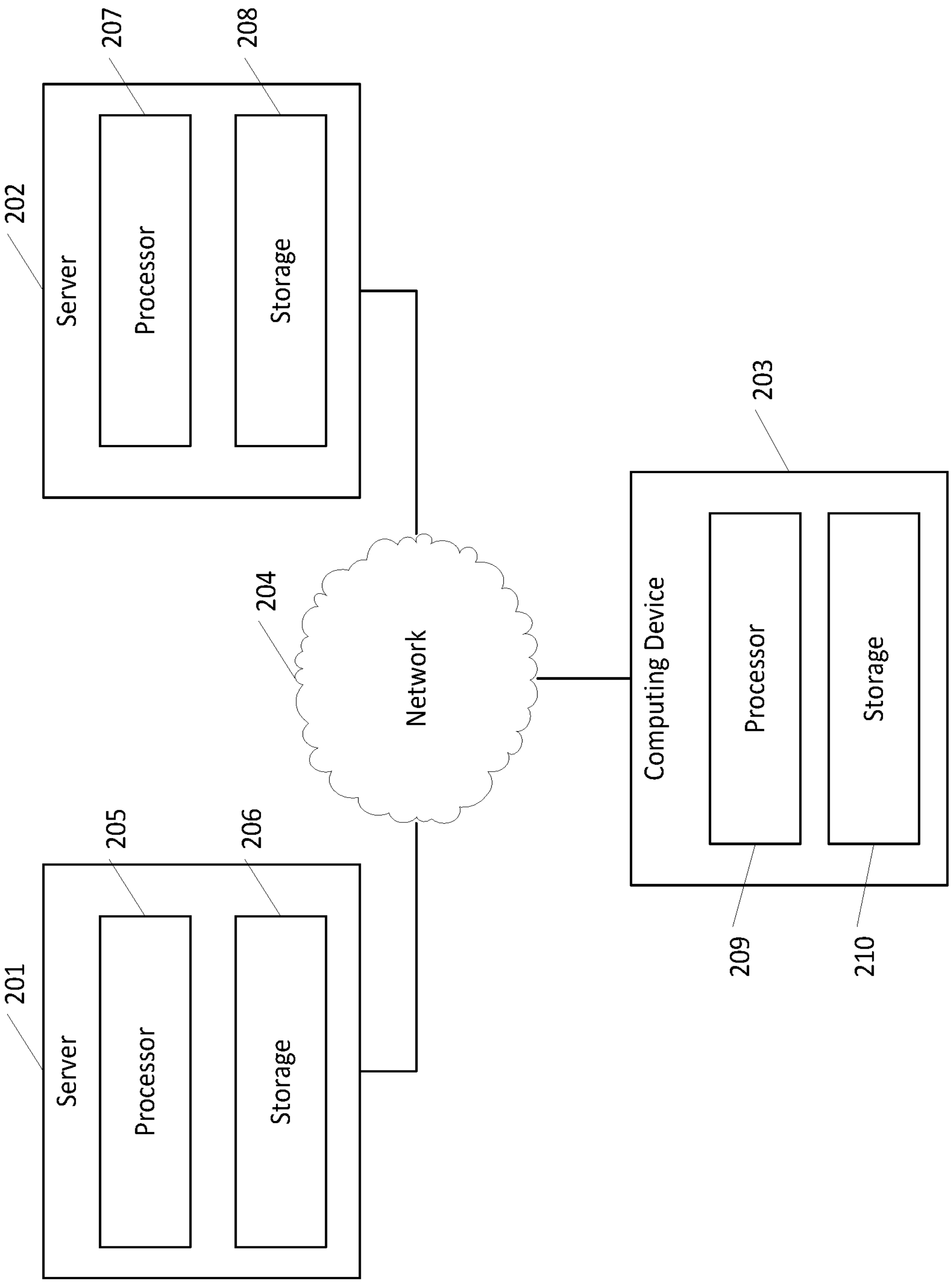

201
Server
Processor
Storage
205
206
202
Server
Processor
Storage
207
208
204
Network
203
Computing Device
Processor
Storage
209
210

Figure 2

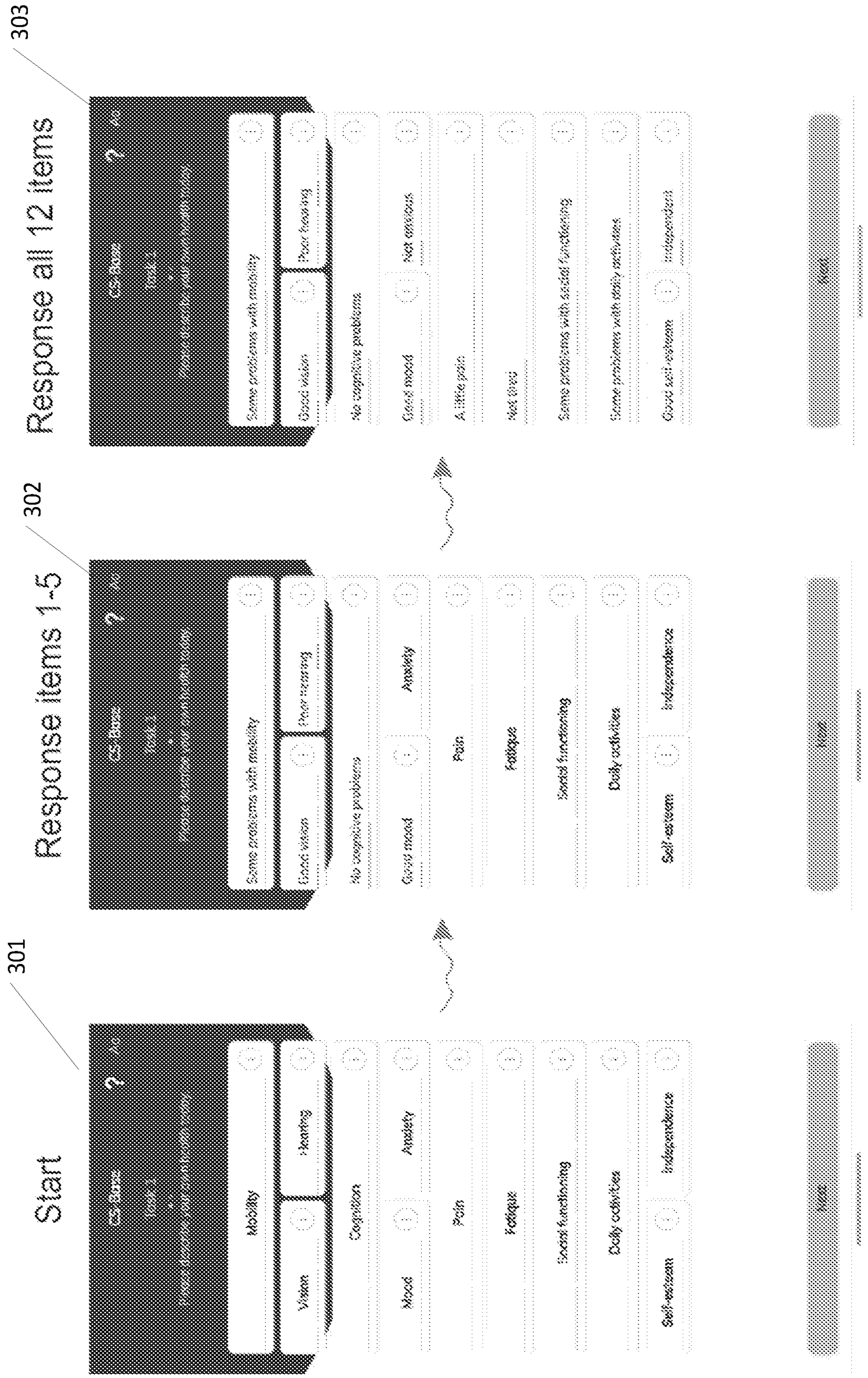

301
302
303
Start
Response items 1-5
Response all 12 items
CS-Base
Task 1
Mobility
Vision
Hearing
Cognition
Mood
Anxiety
Pain
Fatigue
Social functioning
Daily activities
Self-esteem
Independence
Next
Some problems with mobility
Good vision
Poor hearing
No cognitive problems
Good mood
Not anxious
A little pain
Not tired
Some problems with social functioning
Some problems with daily activities
Good self-esteem
Independent

Figure 3

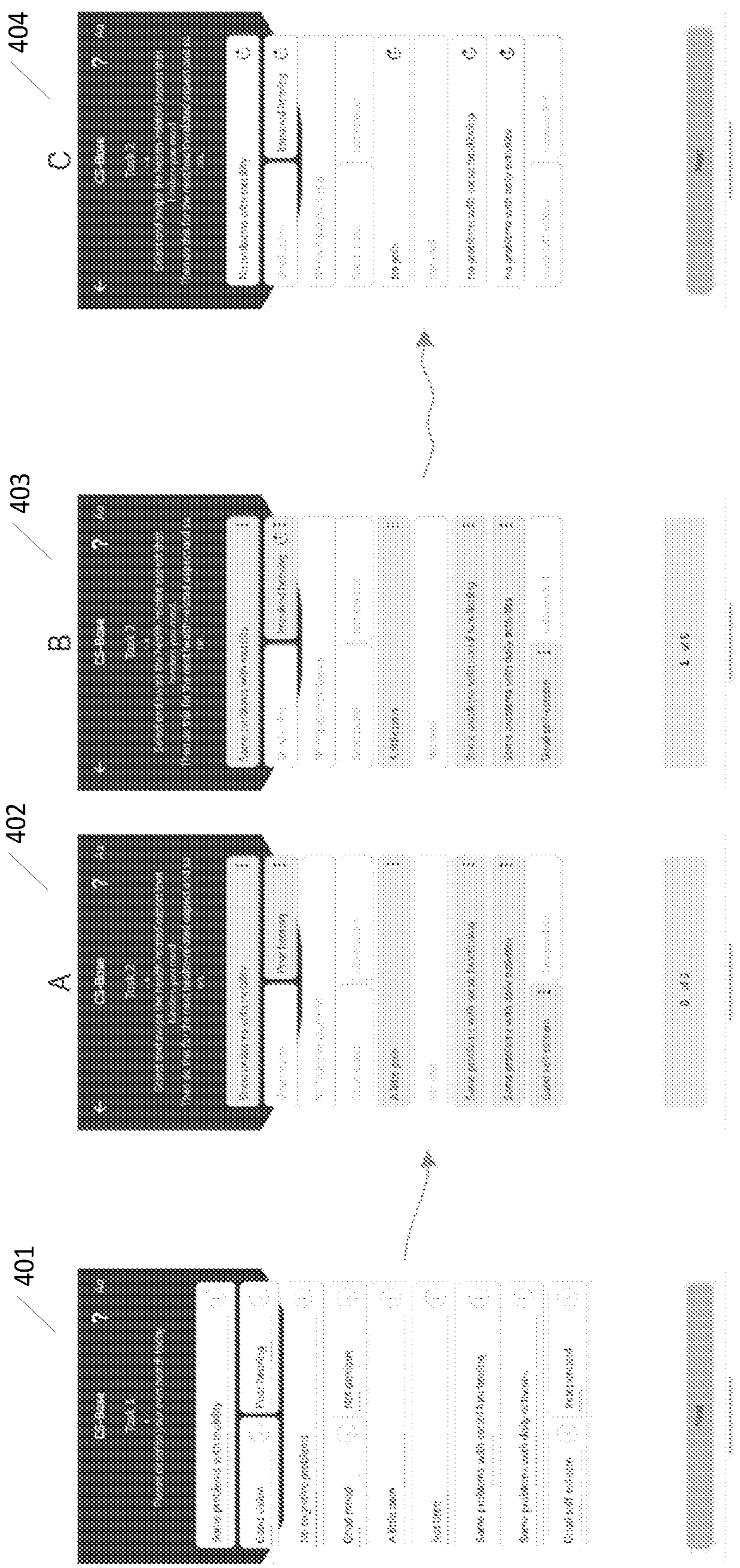


Figure 4

Figure 5

Figure 6A

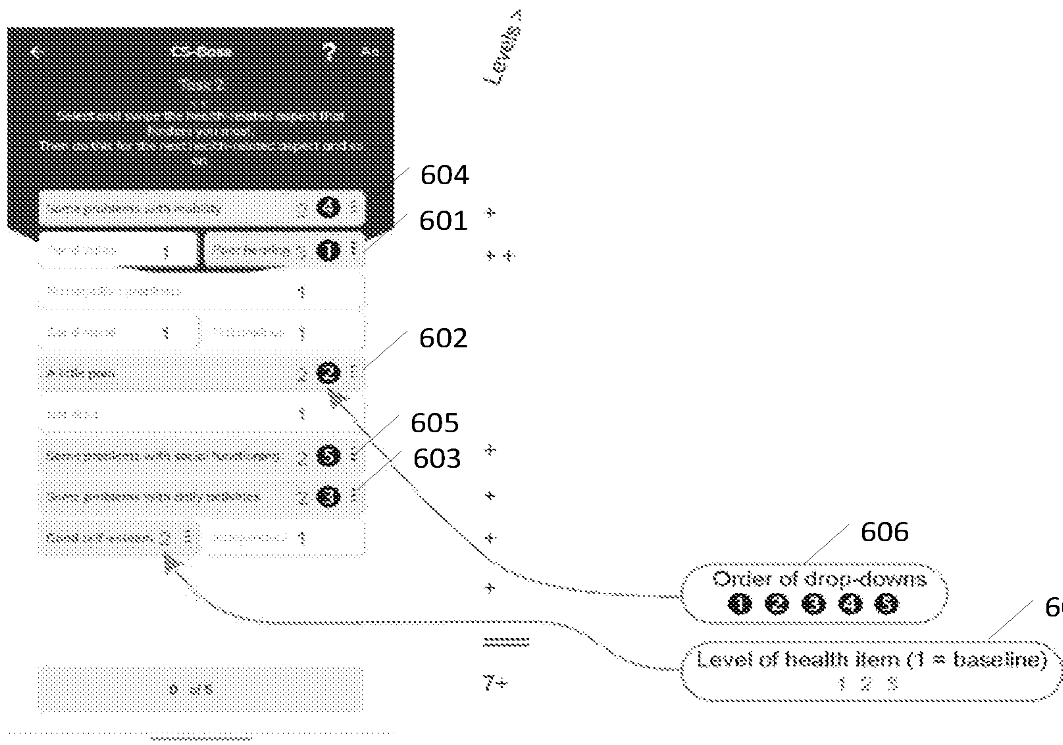
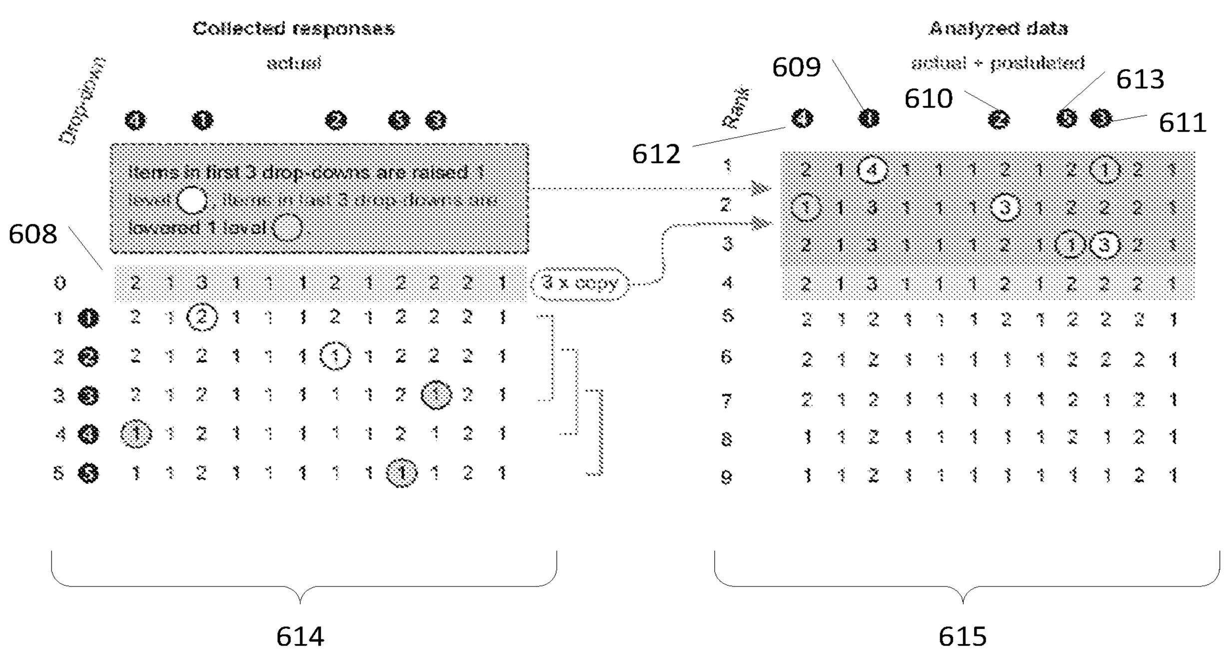


Figure 6B



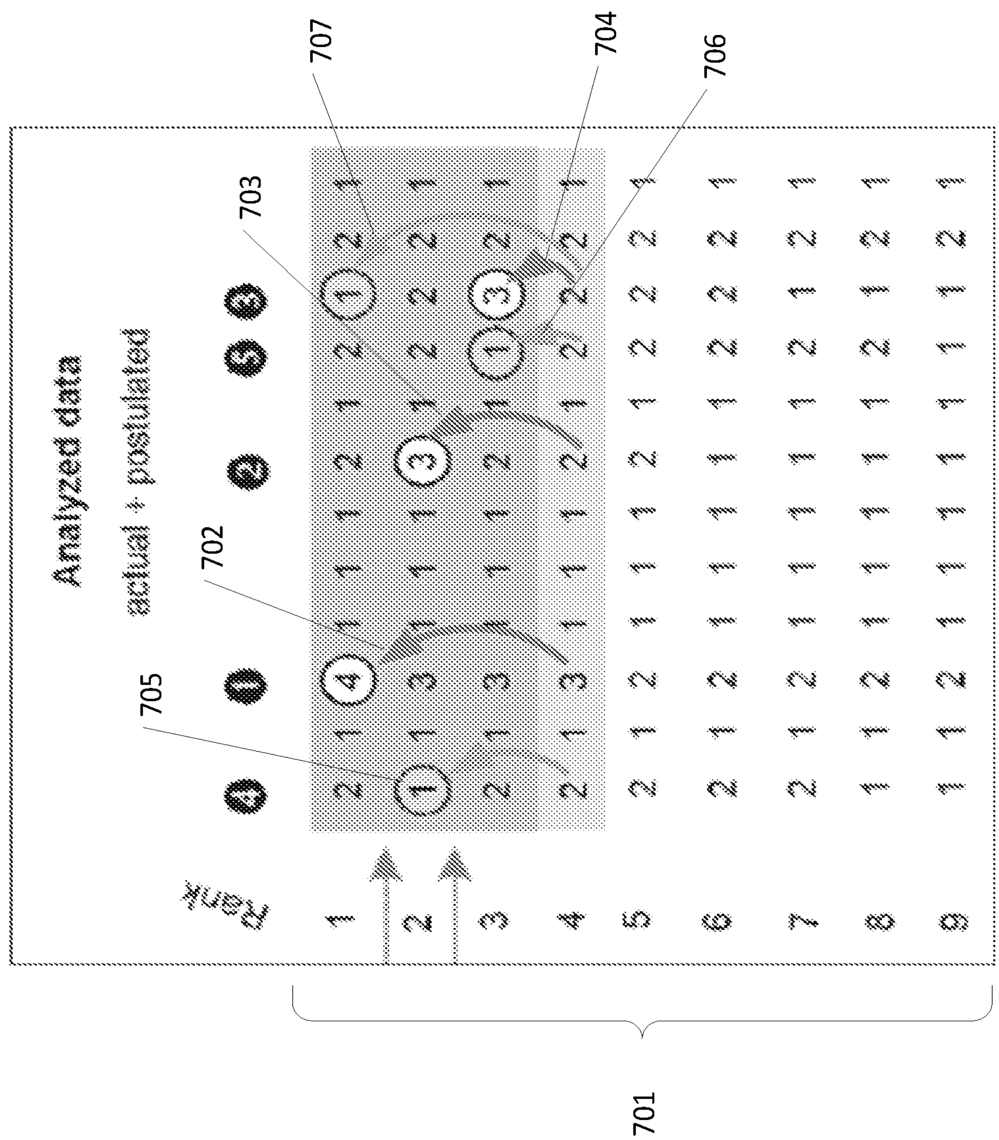

Analyzed data
actual + postulated
Rank
701
702
703
704
705
706
707

Figure 7

**Generation of Alternative States by Server
(Better/Worse Method)**

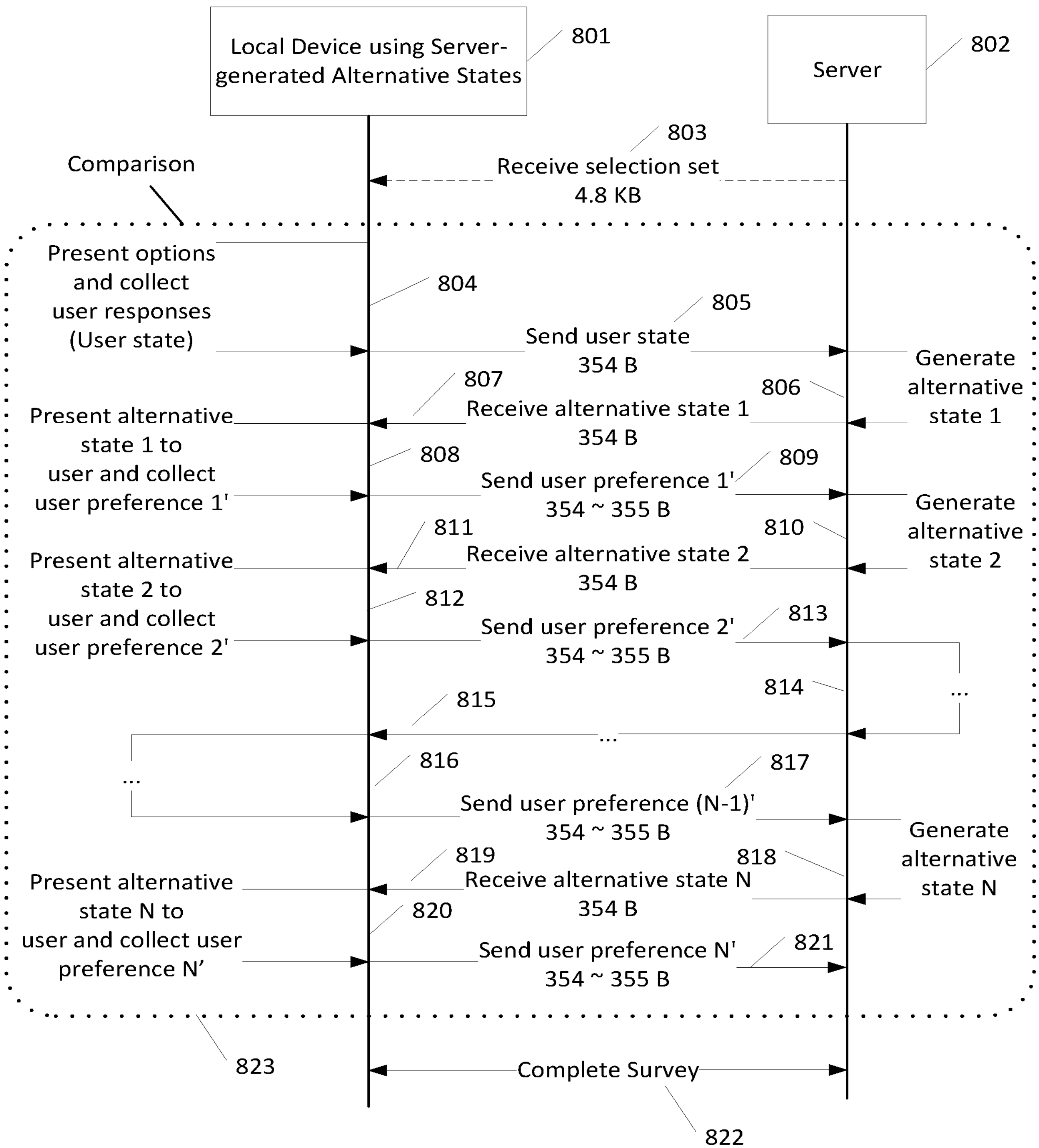


Figure 8

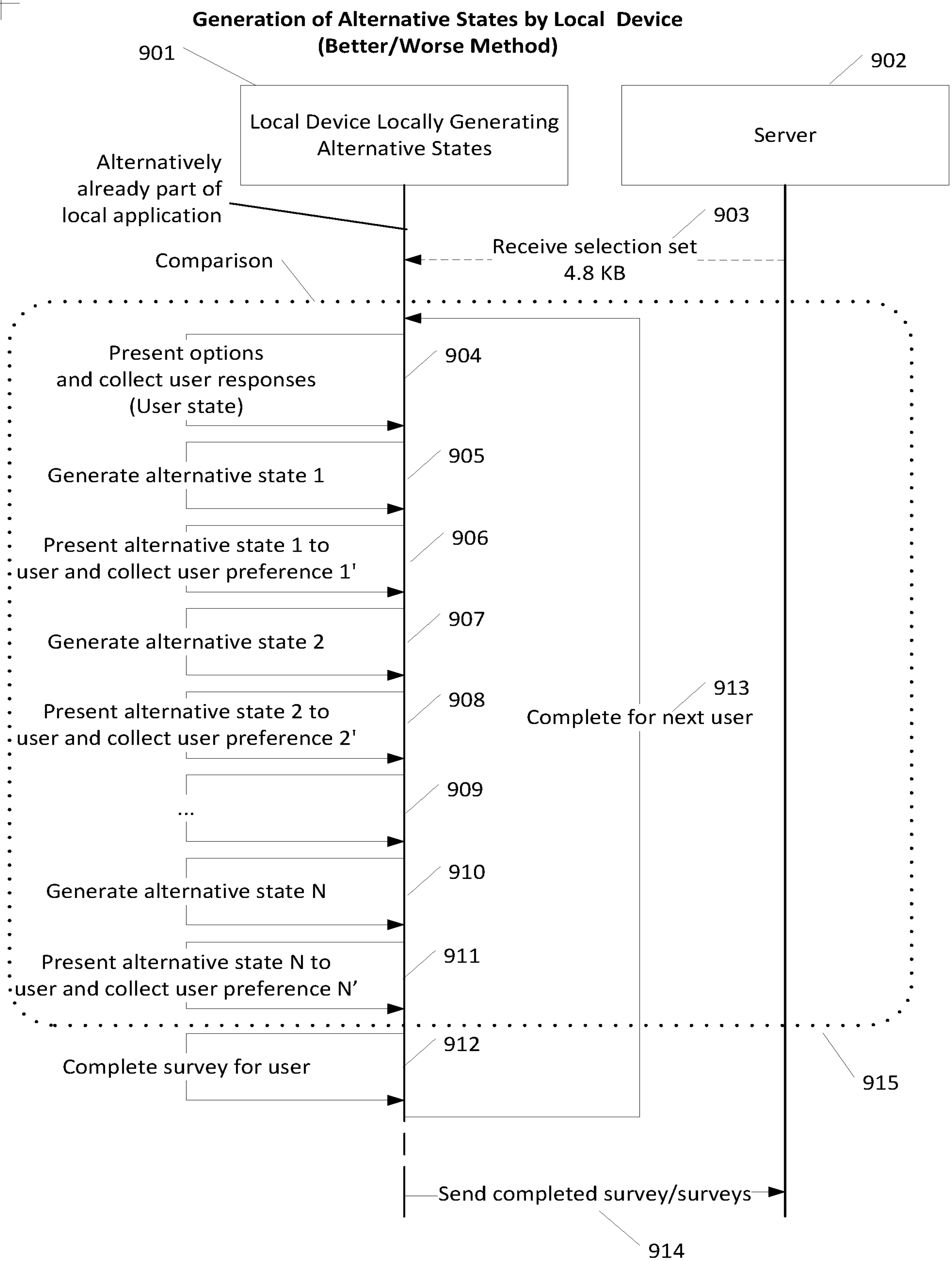

Generation of Alternative States by Local Device
(Better/Worse Method)
901
902
Local Device Locally Generating Alternative States
Server
Alternatively already part of local application
903
Receive selection set
4.8 KB
Comparison
Present options and collect user responses (User state)
904
Generate alternative state 1
905
Present alternative state 1 to user and collect user preference 1'
906
Generate alternative state 2
907
Present alternative state 2 to user and collect user preference 2'
908
913
Complete for next user
...
909
Generate alternative state N
910
Present alternative state N to user and collect user preference N'
911
Complete survey for user
912
915
Send completed survey/surveys
914

Figure 9

Sequential Level Comparison by Local Device (Drop Down Method)

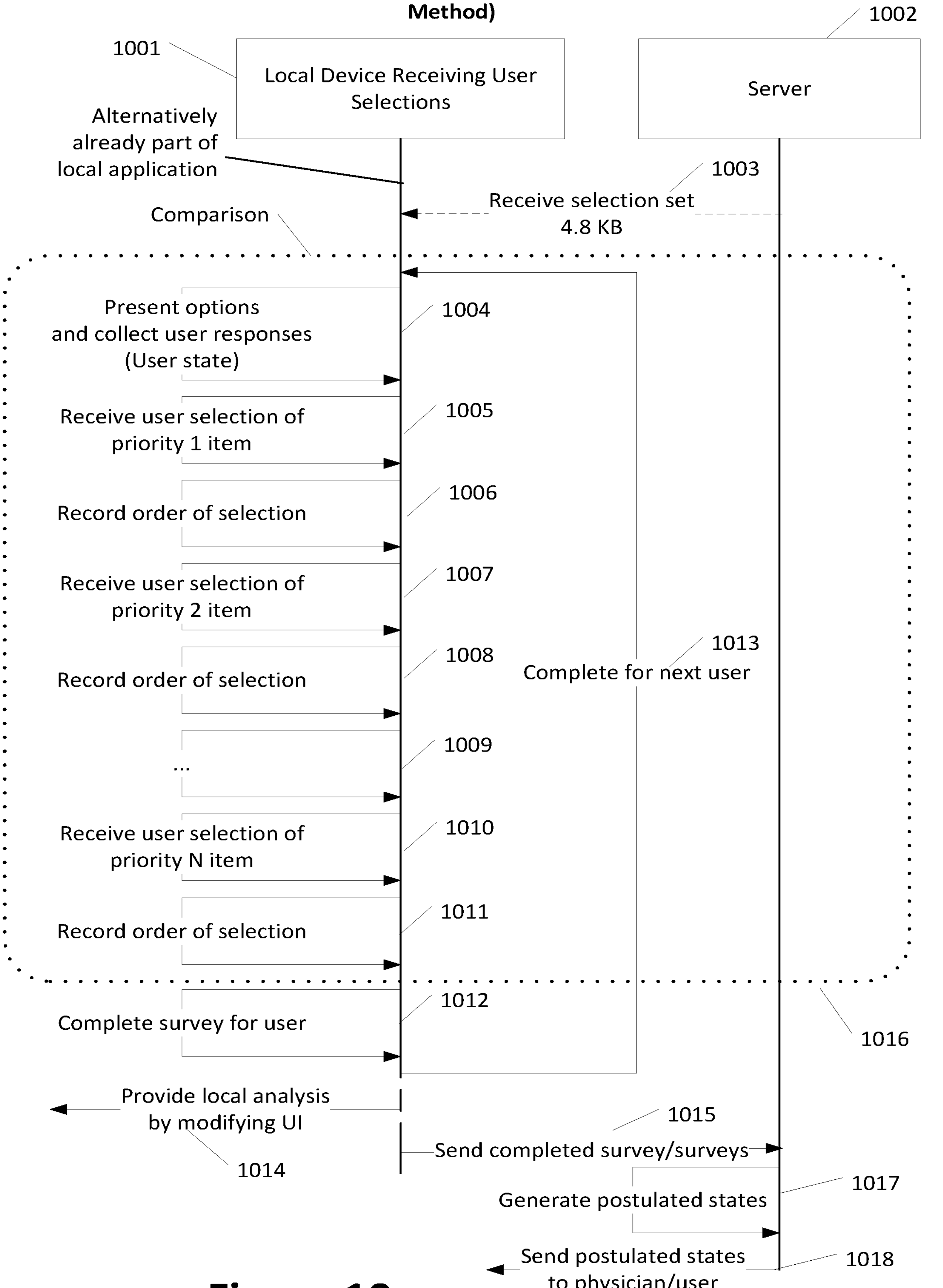


Figure 10

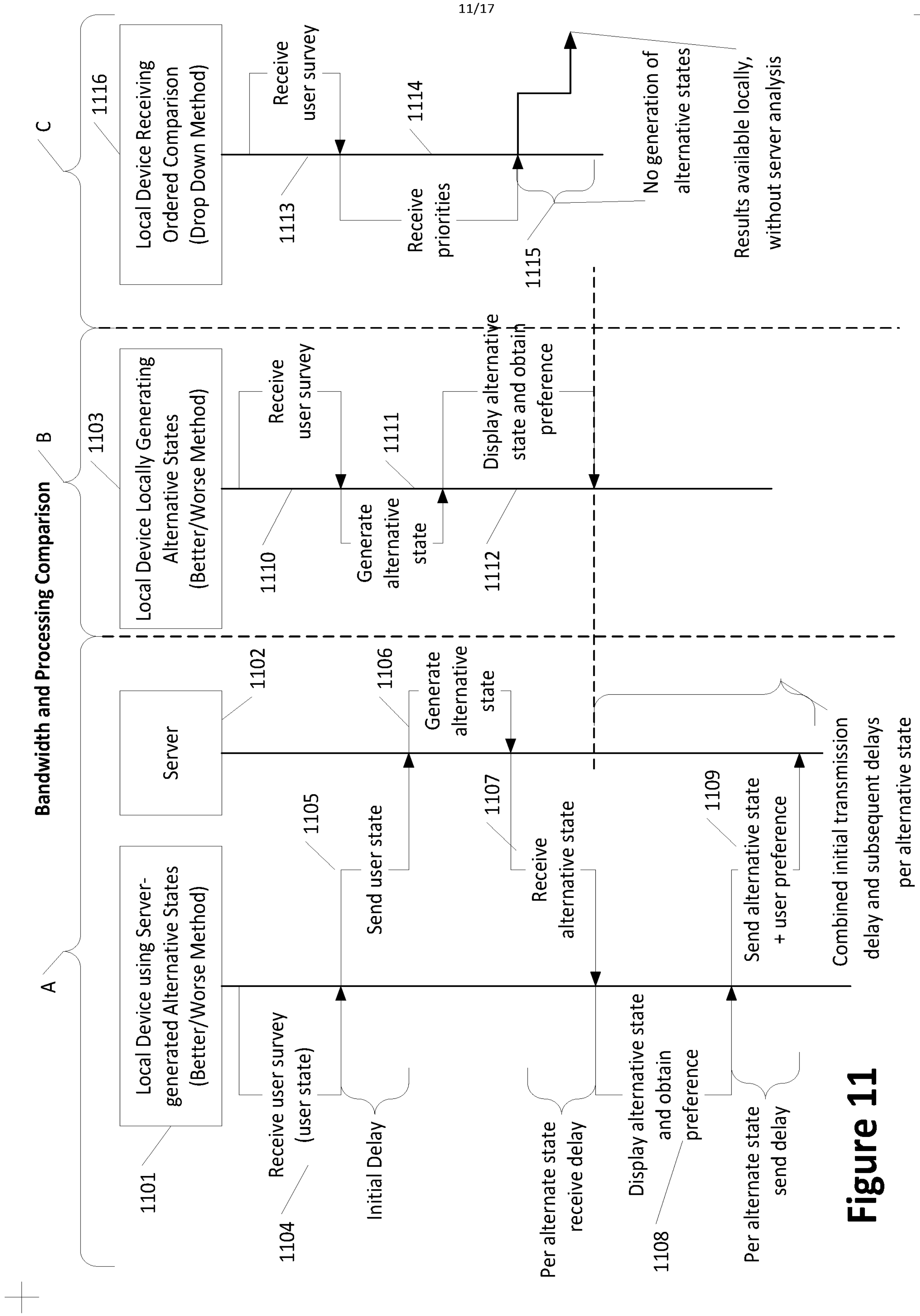

Bandwidth and Processing Comparison
A
B
C
Local Device using Server-generated Alternative States (Better/Worse Method)
1101
Server
1102
Local Device Locally Generating Alternative States (Better/Worse Method)
1103
Local Device Receiving Ordered Comparison (Drop Down Method)
1116
Receive user survey (user state)
1104
Initial Delay
Send user state
1105
1106
Generate alternative state
1107
Receive alternative state
Per alternate state receive delay
Display alternative state and obtain preference
1108
Send alternative state + user preference
1109
Per alternate state send delay
Combined initial transmission delay and subsequent delays per alternative state
1110
Receive user survey
Generate alternative state
1111
1112
Display alternative state and obtain preference
1113
Receive user survey
1114
Receive priorities
1115
No generation of alternative states
Results available locally, without server analysis

Figure 11

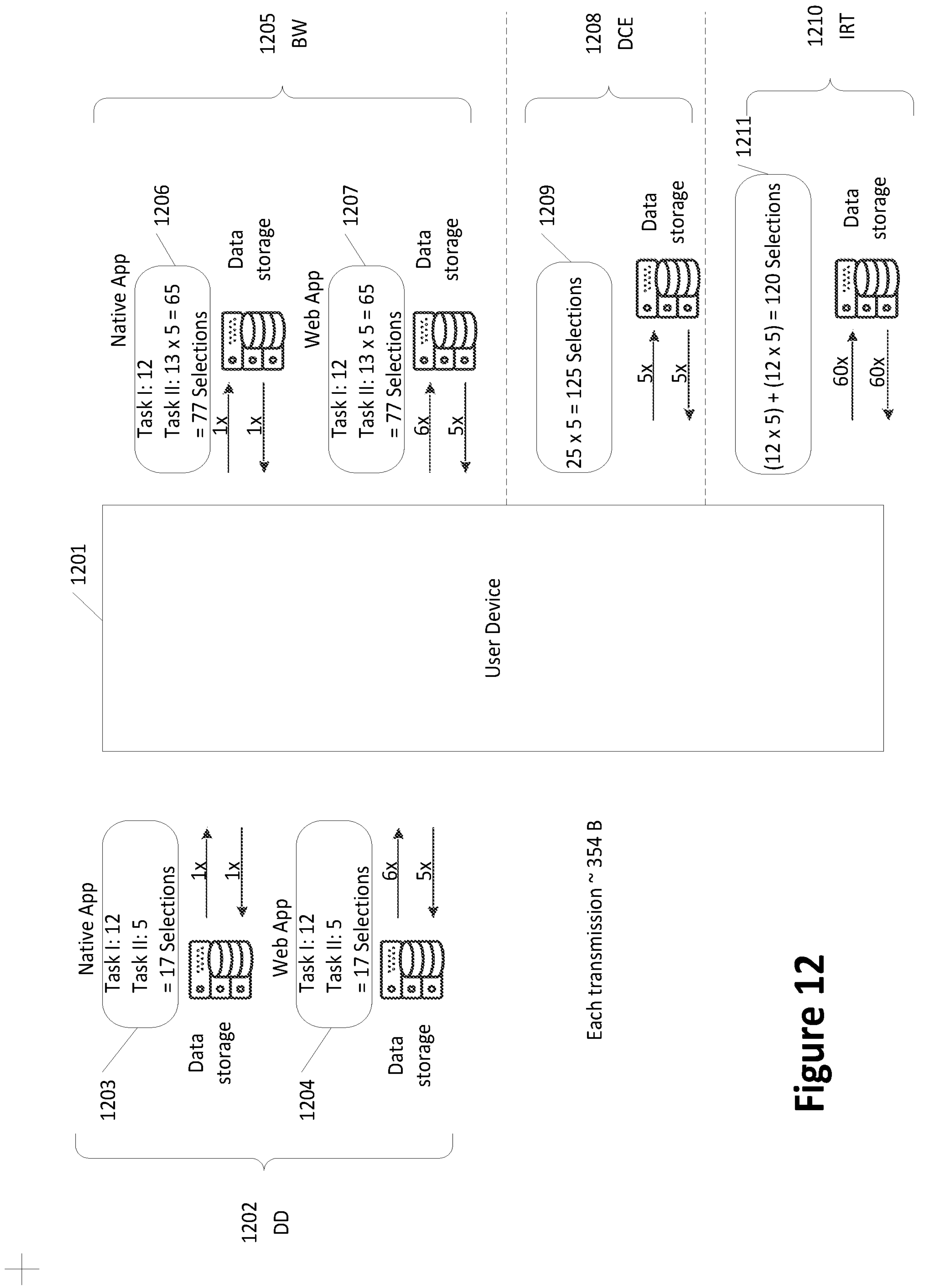

1202
DD
1203
Native App
Task I: 12
Task II: 5
= 17 Selections
1x
1x
Data storage
1204
Web App
Task I: 12
Task II: 5
= 17 Selections
6x
5x
Data storage
Each transmission ~ 354 B
1201
User Device
1205
BW
1206
Native App
Task I: 12
Task II: 13 x 5 = 65
= 77 Selections
1x
1x
Data storage
1207
Web App
Task I: 12
Task II: 13 x 5 = 65
= 77 Selections
6x
5x
Data storage
1208
DCE
1209
25 x 5 = 125 Selections
5x
5x
Data storage
1210
IRT
1211
(12 x 5) + (12 x 5) = 120 Selections
60x
60x
Data storage

Figure 12

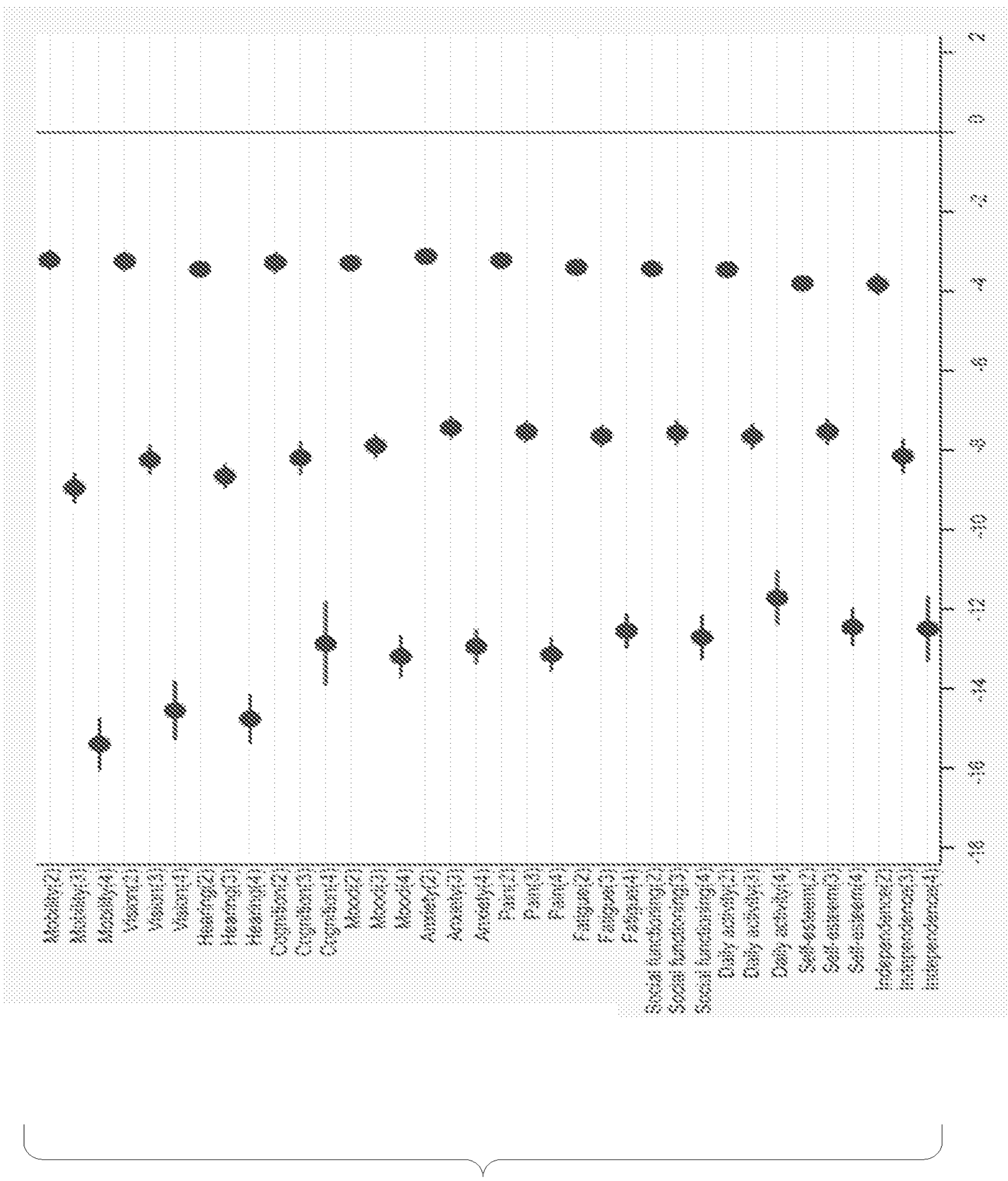


Figure 13

1301

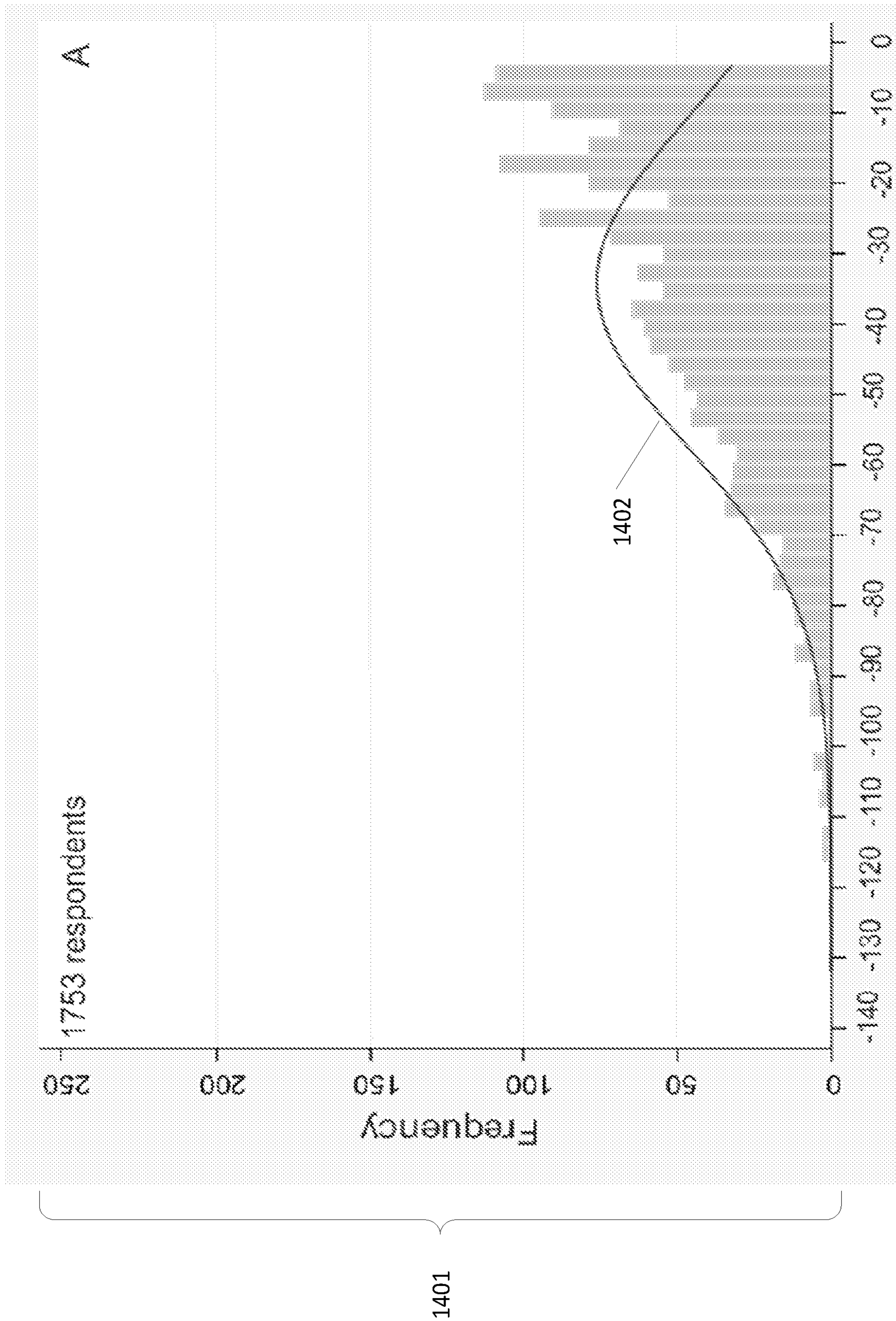

1753 respondents
A
Frequency
250
200
150
100
50
0
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
1402
1401

Figure 14

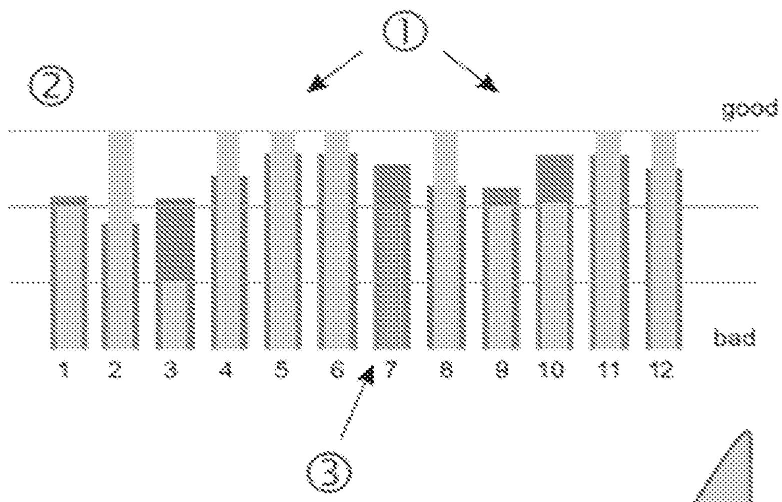


Figure 15A

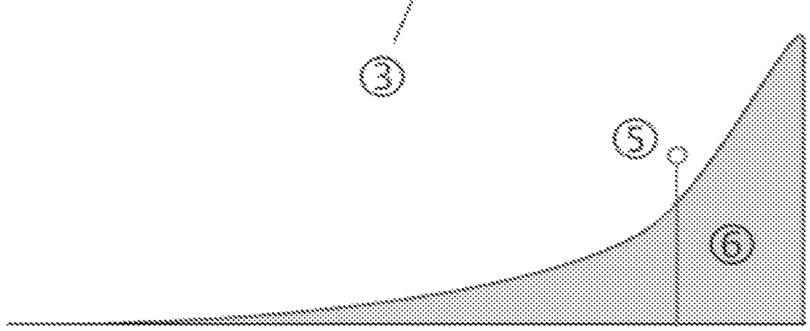


Figure 15B

Figure 15C

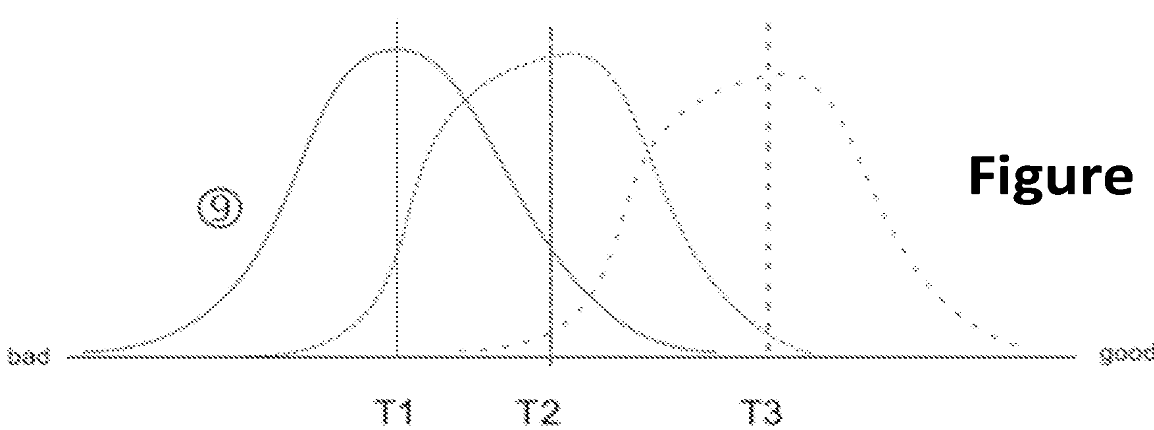


Figure 15D

Figure 16A

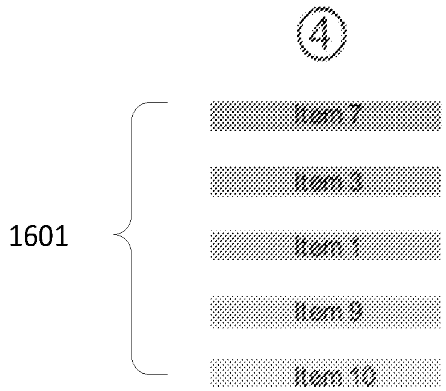


Figure 16B

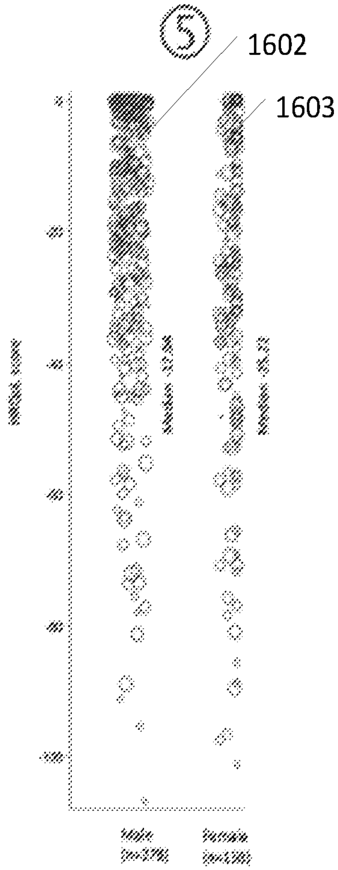


Figure 16C

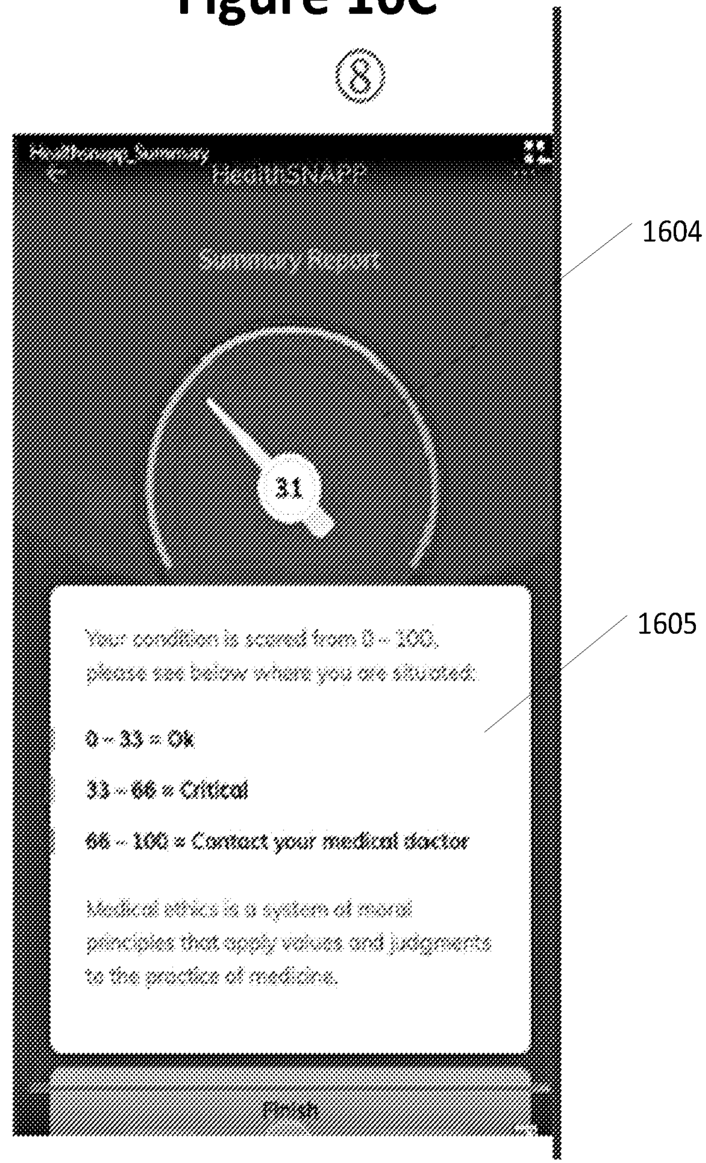
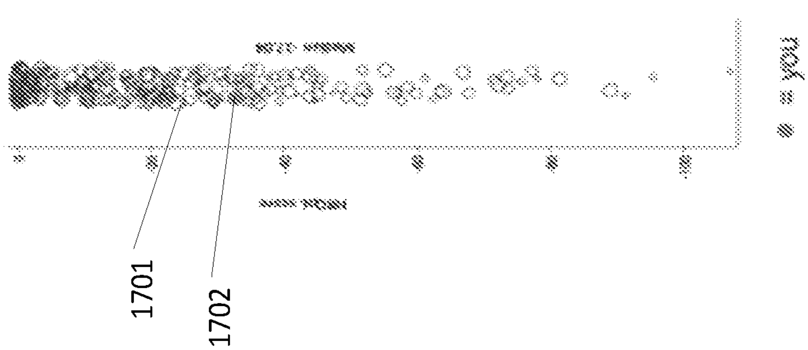


Figure 17



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APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
63/578,100	**08/22/2023 05:20:34 PM ET**	**005032.00438\US**

Title of Invention

Electronic Preference-Based Measurement with Reduced Communication Overhead

Application Information

APPLICATION TYPE	Utility - Provisional Application under 35 USC 111(b)	PATENT #	-
CONFIRMATION #	6278	FILED BY	Christopher Glembocki
PATENT CENTER #	62659850	FILING DATE	-
CUSTOMER #	22910	FIRST NAMED INVENTOR	Paul F. M. Krabbe
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 4

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
ADS.PDF	8	Application Data Sheet	2173 KB
Provisional.PDF	3	Provisional Cover Sheet (SB16)	2561 KB
DDProvisional.pdf	38	Specification	352 KB
DDProvisionalDrawings.pdf	17	Drawings-only black and white line drawings	2583 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

ADS.PDF	A19F726693BB27A13B6FF7B8D3FAC7310E414CED922DF50BA AD64FF0B0E605EA680B5F670843D4C5FC4F4CAF794391633F DDBA412C5AF19265E7DDCA5AB0DC96
Provisional.PDF	12253905BEC36F554DFE8F68A4746EEB603593C0CC3BABB18 3AC89C698FC8669457B9A5D2DD93E97FF651408337BC3216C A1AD686DF68BABBC9F56F2FB0423B8
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National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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Doc Code: **TR.PROV**
Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (01-22)
Approved for use through 05/31/2024. OMB 0651-0032
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)

Inventor 1 | Remove

Given Name	Middle Name	Family Name	City	State	Country
Paul	F. M.	Krabbe	Zeist		NL

All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. | Add

Title of Invention	Electronic Preference-Based Measurement with Reduced Communication Overhead
Attorney Docket Number (if applicable)	005032.00438\US

Correspondence Address

Direct all correspondence to (select one):

(●) The address corresponding to Customer Number	( ) Firm or Individual Name
Customer Number	22910

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

(●) No.

( ) Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:

( ) Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Doc Code: **TR.PROV**
Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (01-22)
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Entity Status
Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29

- (●) Applicant asserts small entity status under 37 CFR 1.27
- ( ) Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ( ) No

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Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/Christopher R. Glembocki/			Date (YYYY-MM-DD)	2023-08-22
First Name	Christopher R.	Last Name	Glembocki	Registration Number (If appropriate)	38800

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6. A record in this system of records may be disclosed, as a routine use, t o a n other federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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