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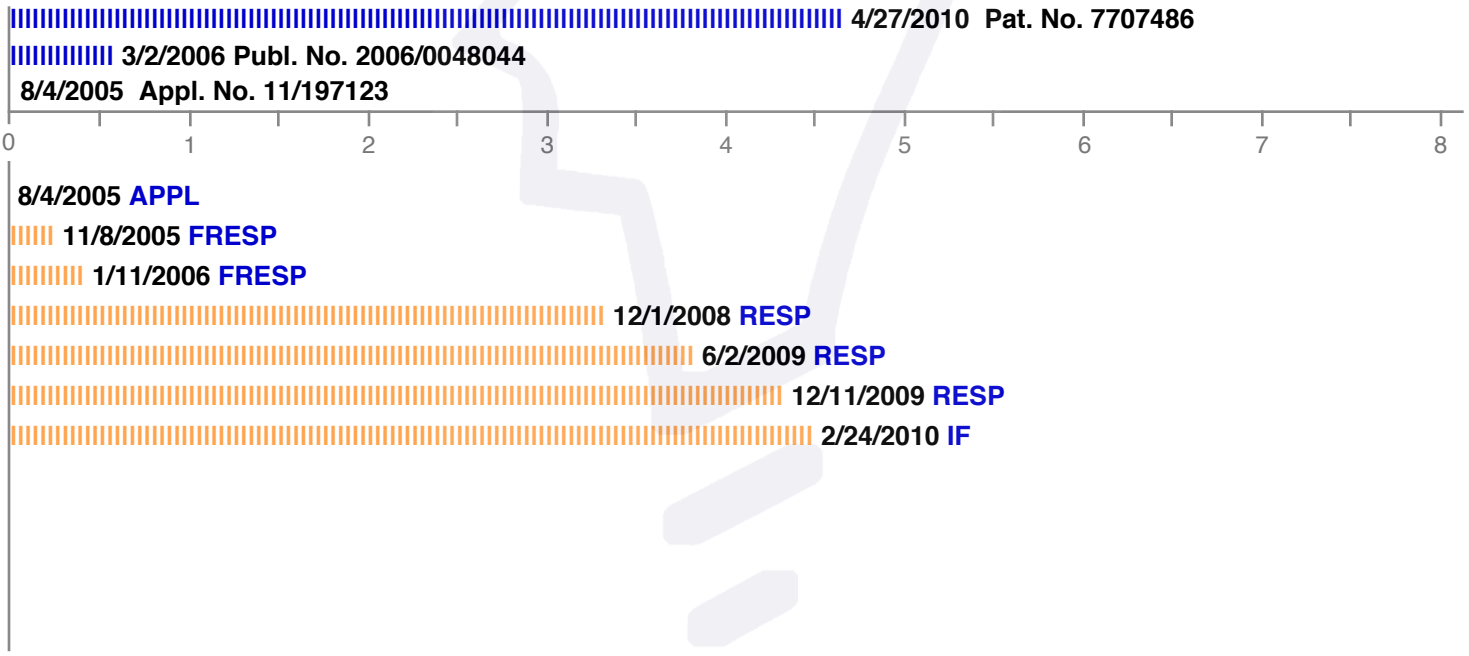

UTILITY PATENT APPLICATION OF

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for

LOGICAL SPREADSHEETS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from US provisional patent application number 60/599644 filed 8/6/2004, which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to computer-implemented methods and systems involving spreadsheets, specifically spreadsheets that use relational logic and handle inconsistencies.

BACKGROUND OF THE INVENTION

Traditional computerized spreadsheet systems have enjoyed great success, due primarily to their ability to automatically evaluate multiple mathematical formulas and display updated calculated values whenever user-entered data changes. Traditional spreadsheets employ a user interface for entering data and formulas into cells, combined with an underlying computation engine to support and perform operations on the data according to the formulas. A non-empty cell either contains a specific value entered by the user, or contains a computed value calculated using the formula in the cell. A formula in a cell is a single-valued function of other cells that assigns a unique value to the cell. The restriction to single-valued functions prevents ambiguities in calculated values. Circular references between formulas are not allowed, thus preventing inconsistencies from occurring. Thus, the propagation of values within the spreadsheet is one-way from cells containing specific user-entered data to computed cells containing formulas. For example, in the three-cell spreadsheet of FIG. 1, cells labeled A and B contain user-entered data, while cell C contains the formula C=A+B. The value of cell C is updated automatically based on the values of cells A and B. The user is not permitted to directly change the calculated value for cell C, nor is the spreadsheet permitted to change values in cells A and B. The propagation is thus one-way from cells A and B to cell C, and the distinction between calculated cells and cells containing user-entered values is explicitly determined by the placement of the formula in cell C. One can also observe that the formula C=A+B is a single-valued function which generates a unique value for C given values for A and B. Although these properties of traditional spreadsheets provide simplicity and enforce consistency, they do so at the cost of flexibility.

Another limitation of traditional spreadsheets is that the formulas are typically restricted to algebraic operators (e.g., +, –, ×, ÷, √, ∑) and logical connectives (e.g., ∧, ∨, ¬). While

these have sufficient expressive power for many applications, they are not powerful enough to express the formulas desired for other applications.

In view of the widespread use of spreadsheets for many applications, it would be an improvement in the art to overcome these limitations and other limitations.

SUMMARY OF THE INVENTION

The present invention provides a powerful computerized spreadsheet system with numerous advantages over existing systems. The many-to-one functions of traditional spreadsheets are generalized to many-to-many constraints. In contrast to traditional spreadsheets in which cells must have one value or one formula defining the cell value, cells in the present spreadsheet system can contain multiple values and be associated with multiple constraints. In addition, the constraints are separated from the cells. Because inconsistencies are not controlled by the restriction to unidirectional functions, the spreadsheet system provides an innovative technique for calculating non-explosive consequences for cells even in cases where the data is inconsistent with the constraints.

In contrast with traditional spreadsheets, the distinction between base cells and computed cells is not fixed but dynamic, and the restriction to unidirectional propagation that is found in traditional spreadsheets is relaxed to allow omni-directional propagation. In addition, the formula language is not limited to functions formed from logical connectives and/or algebraic operators, but can include general first-order logical relationships (e.g., allowing quantifiers ∀ and ∃). Moreover, the spreadsheet cells are structured, allowing rows and columns to be quantified over, providing the ability for the spreadsheet to be queried like a relational database.

In one aspect, the invention provides a computer-implemented method for displaying consequences in an electronic spreadsheet. A set of cells of the spreadsheet and a set of logical constraints on possible values of the cells is specified. At various times during interactive operation with a user, the set of cells may be dynamically partitioned into base cells and computed cells. A set of user-specified values is assigned to the base cells. Significantly, the user is allowed to specify values that may be inconsistent with the specified logical constraints. Non-explosive logical consequences of the user-specified values and the set of logical constraints are automatically computed to produce a complete set of entailed values for the set of computed cells. Some computed cells may have multiple entailed values. For each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell, a subset of the entailed values is selected, where the size of the subset is no more than the number of allowed values. Some of the entailed values and some of the user-specified values are displayed. (Although all cells and their values may be displayed, it is not necessary to display all cells and all values at once.)

Preferably, the cells are named cells, and may have structured names. The cells may also be able to contain multiple values. The logical constraints are preferably formulated as relational constraints expressed in a logical language encompassing first-order logic. The non-explosive logical consequences may be found by computing logical consequences of multiple consistent subsets of the user-specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values, e.g., by taking the union of the multiple subsets of the complete set of entailed values. If one of multiple entailed values for a cell matches an existing value contained in the cell, a subset of the entailed values for the cell may be taken by eliminating all but a single entailed value. If the cell was just explicitly emptied by the

user, the entailed values for the cell may be replaced by the empty set, eliminating all the entailed values for that cell.

The dynamic partitioning of the set of cells into base cells and computed cells may include one or more of the following: classifying a cell as a base cell when a user-specified value is explicitly assigned to the cell, unclassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell, unclassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed.

In one embodiment, the appearance of cells containing inconsistent values may be altered when they are displayed. The alteration may include, for example, dynamically changing the appearance of a subset of cells containing related inconsistent values when a user pointer hovers over the subset of cells. The displaying may also include providing a menu associated with a cell, where the menu contains a list of possible values. Preferably, the possible values are classified, e.g., by labeling them as either being non-explosively entailed, being non-explosively contradicted, or neither.

An interactive user interface may be provided for an electronic document such as a spreadsheet document, an HTML document, a word processing document, and a PDF document, in order to display the values and receive input from a user. Responsive to a user instruction, values may be specified for cells, or existing values in cells may be cleared. In addition, in response to a user instruction, values may be automatically assigned to empty cells such that the automatically assigned values are consistent with the logical constraints. A user may also give an instruction to execute an automatic altering values of cells to reduce conflicts with the logical constraints.

In brief, the present invention provides spreadsheet systems which allow for general logical constraints and omni-directional propagation. These spreadsheets provide greater benefits than traditional spreadsheets while preserving the key features of automatic calculation of values and ease of administration. They have applications in data management, design, and configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a traditional spreadsheet having two base cells and one computed cell.

FIG. 2 is a schematic diagram of a computer system which may be used to implement a spreadsheet system according to an embodiment of the invention.

FIG. 3 is a diagram illustrating the data structures contained within a spreadsheet.

FIG. 4 is a diagram illustrating a set of logical constraints that are used in a logical spreadsheet according to an embodiment of the invention.

FIG. 5 is a diagram illustrating a set of core instructions that are used in a spreadsheet.

FIG. 6 is a schematic diagram of a logical spreadsheet having three cells dynamically partitioned between base cells and computed cells according to an embodiment of the invention.

FIGS. 7A and 7B show two tables as they might be displayed to a user in a spreadsheet created using a spreadsheet system according to an embodiment of the invention.

FIG. 8 is a flowchart outlining steps performed by a spreadsheet system according to an embodiment of the invention.

FIGS. 9A-D are schematic diagrams of four tables of an exemplary spreadsheet in an early stage of modification by a user in accordance with an embodiment of the invention.

FIGS. 10A-D show the tables of the exemplary spreadsheet of FIGS. 9A-D in an intermediate stage of modification by a user.

FIGS. 11A-D show the tables of the exemplary spreadsheet of FIGS. 10A-D in a later stage of modification by a user.

FIGS. 12A-D show the tables of the exemplary spreadsheet of FIGS. 11A-D in a still later stage of modification by a user.

DETAILED DESCRIPTION

A key feature of the logical spreadsheets of the present invention is that they allow for inconsistency between the value assignments and the constraints. This approach differs from the traditional consistency-maintaining techniques. In addition to allowing for inconsistencies, these spreadsheets actually show the consequences of the value assignments, even when the assignments are inconsistent with the constraints. Consequences under inconsistency are computed using a non-explosive consequence relation. As with traditional electronic spreadsheets, the spreadsheets of the present invention may be implemented on a single computer 200 having a digital storage medium 202 and display 204, as shown in FIG. 2. Alternatively, the spreadsheet may be implemented in a distributed computing environment, in separate computers over a computer network, or in various other hardware and network architectures and computing environments. Those skilled in the art will appreciate that many such implementations and realizations are possible and that the invention is not in principle limited to any specific one.

Definitions

The following definitions will be used for terms used in this description. In its most abstract sense, a *spreadsheet* 300 can be defined as a collection of n cells 302 together

with a set of possible values for these cells 304, as shown in FIG. 3. The set of possible values for the cells is called the spreadsheet's *domain*. Cells can be associated with values in the domain. We represent these associations with sets of ground atomic sentences with a unary relation constant. The individual unary ground atomic sentences are called *value assignments*. A spreadsheet also includes a set of value assignments to the cells 306. A *value map* is a set of value assignments in which each cell is assigned at most one value. For example, $\{p(a), q(b)\}$ means that cell p has value a and cell q has value b. A value map is *complete* if and only if it provides a value for every cell; otherwise, it is *partial*. An *update request* is a value map together with a set of cells to be emptied.

A *logical spreadsheet* is a spreadsheet together with a set of logical constraints 400, as shown in FIG. 4. The vocabulary of the constraint language for logical spreadsheets consists of a finite set of unary relation constants, which serve as names for the cells of our spreadsheet, a set of interpreted n-ary relation constants including algebraic operators, along with a set of object constants, representing objects in the domains of the cells. Logical sentences are built up in the usual way from this vocabulary and the binary relation symbol = (equality), using the logical connectives ¬ (negation), ∧ (conjunction), ∨ (disjunction), ⇒ (implication) and ⇔ (equivalence) and the quantifiers ∀ (universal quantification) and ∃ (existential quantification). We use a standard model theory and proof theory. The constraints 400 typically include *basic constraints* 402 that are common to most spreadsheet documents in the spreadsheet system and *domain constraints* 404 that are customized by the user for each spreadsheet document.

Because spreadsheets are invariably realized on electronic computers as *electronic spreadsheets*, the term *spreadsheet* is often used interchangeably with *electronic spreadsheet*, and may also be used to include other associated features. For example, a spreadsheet typically has a set of core instructions 500 including instructions for a user

interface 502 and a computation engine 504 for updating calculated cells, as shown in FIG. 5. The update computation engine contains update semantics that specify the manner in which the values of cells automatically change after a user explicitly makes a modification to a cell. Update semantics include, for example, one or more notions of consequence that are used to compute the values in computed cells from user-specified values in base cells and the logical constraints. Spreadsheets of the present invention use a non-explosive or paraconsistent consequence relation. In preferred embodiments, the non-explosive consequence relation is called *existential* Ω-*entailment*. A set of value assignments Λ *existentially* Ω-*entails* a value assignment ϕ if and only if there is some subset of value assignments $\lambda \subseteq \Lambda$ consistent with a set of constraints Ω such that $\lambda \cup \Omega$ logically entails ϕ.

Embodiments of the present invention will now be described in detail with reference to the drawing figures. It will be appreciated that the following description contains many examples for illustrative purposes only. Accordingly, the full scope of the invention should not be limited by the specific details used below.

Illustrative Examples

It is instructive to illustrate the innovative features of spreadsheets of the invention by first considering some simple examples of these spreadsheets in action. For example, the three-cell traditional spreadsheet of FIG. 1 may be contrasted with the three-cell logical spreadsheet of FIG. 6. As already discussed above, the traditional spreadsheet has a one-way propagation from user-specified values in cells A and B to a calculated value determined by the function in cell C. That is, one can specify values for A and B and the spreadsheet will automatically calculate C, but one can not specify values for A and C and obtain the value for B. In contrast, the logical spreadsheet of FIG. 6 has three cells

and a separate formula C=A+B that acts as a constraint on the values of the three cells that allows propagation of values to take place in any direction. For example, if a user enters values in cells B and C, then a value for cell A is computed as a consequence. Or, if a user enters values in cells A and C, then a value for cell B is computed. This example not only illustrates the omni-directional propagation, but also shows how cells dynamically change between computed cells and base cells. This increased flexibility introduces the possibility that the user may enter values in all three cells that are inconsistent with the constraints on those cells. For example, a user may enter 1 in cell A, 1 in cell B, and 3 in cell C. Since $1+1\neq3$, these user-specified values are inconsistent with the relation A+B=C. Accordingly, logical spreadsheets of the present invention include various innovative techniques to handle the complexities that arise from this increase in flexibility, as will be described in more detail below.

LAYING OUT CELLS AND TABLES

In a preferred embodiment, a user creating a new logical spreadsheet document is presented with a blank canvas, a textual constraint editor, and a domain editor. The user begins by placing cells and textual labels on the canvas. The user may also place static text onto the canvas, change the color scheme, etc. A cell may have any number of modalities, such as a drop-down list or a type-in field. In addition, cells may be arranged into tables, complete with row and column names. This arrangement of cells into tables serves not only to visually organize cells, but also allows cells to be given names based on their rows and columns. For example, FIGS. 7A and 7B show two tables as they might be displayed to a user in a spreadsheet created to implement a simple room management system. The Event table in FIG. 7A has three rows (E1, E2, E3), representing events which need to be scheduled, and four columns (Owner, Projection, Room, Time), containing some properties of the events, namely their owner, whether a projector is required, their room, and their time. The Schedule table shown in FIG. 7B represents the schedule for the

rooms, where each cell contains the event scheduled in a given room at a given time. It has three rows (Morning, Afternoon, Evening) representing the available times and three columns (G100, G200, G300), representing the available rooms.

DEFINING CELL DOMAINS

The user can also create domains for cells using a textual editor and associate each cell with a domain. These domains are used to populate cell drop-down lists. For example, the cells in the table of FIG. 7B take values from a list of events (E1, E2, E3). In FIG. 7A, the cells in the Owner column take values from a list of names (Amy, Bob, Cal), the Projection column takes values from a Yes/No list, the Room column takes values from a list of available rooms (G100, G200, G300), and the Time column takes values from a list of available times (Morning, Afternoon, Evening). In some embodiments, the number and rows and columns as well as the labels for the row and column heads are automatically updated as appropriate when the corresponding domains are redefined.

With the row and column labels, the cells acquire structured names. For example, the structured name schedule[morning,g100] refers to the cell in the schedule table in the Morning row and the g100 column. This structured name allows rows and columns to be quantified over. In addition to improving the user experience by reducing the replication typically required in a traditional spreadsheet, structured names allow tables to be queried in a manner similar to database tables. Indeed, since all rows in a table are named, one can either treat a row as a tuple with attributes named by the columns, or treat a column as a tuple with attributes named by the rows.

FORMULA LANGUAGE AND CONSTRAINTS

Once the cells and tables are laid out, the user can create constraints that express relationships between cells. The constraints may be written as textual formulas using a

variant of first order logic. Formulas can be built up from these structured names and the binary relation symbol = (equality), using the logical connectives ¬ (negation), ∧ (conjunction), ∨ (disjunction), ⇒ (implication) and ⇔ (equivalence) and the quantifiers ∀ (universal quantification) and ∃ (existential quantification). There are no restrictions on these formulas.. For convenience, users may define new n-ary relations using ⇔ and use these in an unrestricted manner. Decidability is preserved since these n-ary relations are reducible to unary ones. For example, Table 1 shows the set of constraints for the room manager spreadsheet shown in FIGS. 7A and 7B. Note that free variables are considered to be universally quantified.

No.	Constraint
1	event[E,room](g100) or event[E,room](g200) or event[E,room](g300)
2	event[E,time](morning) or event[E,time](afternoon) or event[E,time](evening)
3	schedule[T,R](E) ⇔ event[E,time](T) ∧ event[E,room](R)
4	event[E,projection](yes) ∧ event[E,room](R) ⇒ room[R,projector](yes)
5	event[E,owner](P) ∧ person[P,faculty](no) ⇒ ¬ event[E,room](g100)

Table 1

The constraints 1 and 2 dictate that every event has a room and a time in the room and time domains, respectively. Constraint 3 relates the schedule table in FIG. 7A to the event table in FIG. 7B. Constraint 4 states that if an event requires a projector then it must be scheduled in a room with a projector. Constraint 5 states that only faculty members can reserve room g100.

UPDATES AND COMPUTING CONSEQUENCES

Once the spreadsheet is set up, the user may proceed to use the newly created spreadsheet. As the user enters and deletes values from cells, the values in other cells may be changed automatically based on the logical constraints which have been defined. An overview of the process is shown in the flowchart of FIG. 8. In step 802 a user makes an explicit change to a cell, e.g., if the cell has a value, either changing the value or clearing the cell; and if the cell is empty, entering a value in the cell. In step 804 the cells are

automatically partitioned into base cells and computed cells. The non-explosive consequences of base cells are computed in step 806, producing sets of entailed values for the computed cells. In some cases, the number of entailed values for a cell may be reduced in step 808. Step 810 then displays values of the base cells and computed cells. The above steps will now be described in more detail.

In preferred embodiments, a user interface is provided to allow a user to make changes to the values in cells (step 802). The user interface may include, for example, a display of some or all of the cells, with drop-down or pop-up menus to facilitate data entry. The menus may contain lists of values which may be organized or categorized to further facilitate interactivity with the user. A user can modify a cell in one of three ways: The user can assign a value to a previously empty cell, change a value currently assigned to a cell to another value, or empty a cell that currently has a value.

Once a user-specified change has been made to a cell, the cells are dynamically partitioned into “base cells” and “computed cells” (step 804). In particular, if a cell has been directly modified by the user, the cell is classified automatically as a base cell. In addition, some other cells then lose their status as base cells and are reclassified as computed cells. Specifically, in the case of a new value assignment to a cell, any base cells with values that, together with the constraints, directly contradict the newly assigned value are reclassified as computed cells. In the case of a cell that is emptied of a value, any cells with values that, together with the constraints, directly entail a value in the emptied cell are reclassified as computed cells. In the case where two or more base cells have values that together contradict the newly assigned value but none does individually, these cells are left as is and do not lose their status as base cells. This leads to inconsistency. Similarly, if two or more cells have values that together entail a value in the newly emptied cell but none does individually, these cells are left as is and remain base cells.

This leads to the newly empty base cell having an entailed value. Note that since the newly emptied cell is now a base cell, the cell does not contain a computed value and remains empty. This completes the dynamic partitioning of cells.

After the partitioning of base and computed cells, the set of entailed values is calculated (step 806). The entailed values are the non-explosive consequences of the values in the base cells and the specified logical constraints. To calculate the non-explosive consequences, a paraconsistent consequence relation called existential Ω-entailment is preferably used. In other words, the non-explosive logical consequences may be found by 1) identifying subsets of the set of values in the base cells that are consistent with the logical constraints, using for example the resolution proof technique to determine consistency, 2) computing the logical consequences of the identified consistent subsets and the logical constraints to produce corresponding sets of entailed values for the computed cells, and 3) combining the computed sets of entailed values to form a complete set of entailed values, e.g., by taking their union or intersection. Which particular combination is used will depend on the application, though in the preferred embodiment, the union is taken.

The next step is to fill the computed cells with the existential Ω-consequences of the base values and the constraints. However, the complete set of entailed values does not necessarily provide one unique value for each computed cell, so in some cases the set of entailed values may be subsetted (step 808). If a computed cell is allowed to contain just one value, but more than one entailed value is computed for the cell, then the number of entailed values may be reduced to one using inertia as a tie-breaker: if the cell contained a value before the update and the value is still existentially Ω-entailed, then that value remains in the cell. If there are multiple existentially Ω-entailed values for a computed cell but none of these was in the cell before the update, the cell is left empty. Similarly, if a

cell can contain multiple values, but the number of entailed values exceeds the number of allowed values, then the number of entailed values may be reduced to the required number using inertia as a tie-breaker: if the cell contained a value before the update and that value is still existentially Ω-entailed, then that value remains in the cell. Again, if there are more than the maximum allowed existentially Ω-entailed values for a computed cell but none of these was in the cell before the update, the cell is left empty.

Finally, the values are displayed to the user via a user interface (step 810). Some or all of the values for the base cells and computed cells may be displayed, depending on the particular layout in current use. In the case of a layout that contains all tables and cells, all the values might be displayed. Other layouts may display a subset of the base cells and computed cells, in which case a subset of the values is displayed. Spreadsheet systems of the present invention may be implemented with many different user interfaces. In a preferred embodiment, the user interface implements features such as drop-down menus to select values from domains and shaded cells to indicate inconsistent values. Shading, coloring, and various other types of markings or highlighting of cells can also be used to show which cells are base cells, computed cells, never-modified cells, recently modified cells, and newly modified cells. In addition, a mouse-over (i.e., placing a user-controllable pointer over a cell) can result in a highlight of a group of cells that are related (e.g., cells that are in conflict with a common constraint, or cells that are related by a common constraint). A group of cells in conflict with a particular constraint can be determined using standard database techniques to query for values that do not satisfy the constraint.

UPDATE ILLUSTRATION

The technique described above for updating cells will now be illustrated using the room management system discussed earlier in relation to FIGS. 7A and 7B. The room manager

consists of four tables, named event, schedule, room, and person, shown schematically in FIGS. 9A-D, respectively. The event table contains event requests, each of which has an owner, a specification of whether a projector is needed, a room, and a time. The schedule table contains a schedule of the events. The information is redundant with the first table but is useful because it offers a different view. The room table lists whether or not each room has a projector. The person table lists whether each person is a faculty member or not. The values in the person and room tables are entered by the user before scheduling specific events.

An administrator using the spreadsheet has the task of assigning to three new events a room and a time. The user begins by specifying values for cells in the owner and projection columns of the event table, as shown in FIG. 9A. These values specify, for each event, the event owner's name and whether a projector is needed.

After entering a value in a cell, the spreadsheet system responds by automatically updating the spreadsheet. First, the system determines which cells are base cells and which are computed cells. As shown in the figures, base cells are marked with a triangle in the upper left-hand corner of the cell, while computed cells are not. These are the cells in which the user has explicitly specified values. The system then automatically computes the non-explosive consequences of the base cells. In this example, the system automatically computes the and displays a value g100 for the room of event e3 in the event table. This value is entailed by the logical constraints since the user specified that e3 requires a projector, and g100 is the only room with a projector.

As shown in FIGS. 10A-D, the user then specifies additional properties for event e1 in the event table. In particular, the user selects g100 as the room for event e1 and morning as its time. The system responds by classifying these cells as base cells and

displaying them with a triangle, as shown in FIG. 10A. The system also responds by automatically calculating entailed values. Specifically, the user's specification of a room and time for event e1 in the event table causes e1 to show up in the corresponding cell in the schedule table, as shown in FIG. 10B. The user then directly modifies a cell in the schedule table by assigning the value e2 to room g200 in the afternoon. The system responds by automatically calculating the entailed values and displaying them in row e2 of the event table, as shown in FIG. 10A. This example illustrates the spreadsheet's ability to propagate values in multiple directions. That is, user modifications of values for cells in the event table result in entailed values appearing in cells of the schedule table, and vice versa.

Next, as shown in FIGS. 11A-D, the user moves e1 from morning to evening by clearing the g100 morning cell and entering e1 in the g100 evening cell of the schedule table. The spreadsheet system responds by reclassifying the e1 time cell of the event table from a base cell to a computed cell. It also computes and displays the entailed value evening for that cell, over-riding the previously specified morning value for the cell. This illustrates how the automatic update of the spreadsheet deals with a direct conflict between a value previously specified for a cell and a new entailed value for the cell that is a consequence of a newly specified value in another cell.

As illustrated in FIGS. 11A-D, the user then changes the room assignment for e3 from g100 to g200 by modifying the appropriate cell in the event table. The system responds by reclassifying the cell from a computed cell to a base cell. The system also responds by computing the entailed values. However, since e3 requires a projector and g200 lacks a projector, these user-specified values are inconsistent with the logical constraints. Nevertheless, the system allows the conflicting values to be entered. Since the inconsistency is caused by multiple cells, the system responds by coloring or shading the

conflicting cells. Specifically, a cell is colored if it contains a value that is non-explosively contradicted by the values in the other cells. Note that if the conflict had been caused by a value in just one cell, the system would have modified the existing value in the cell to eliminate the conflict, as shown in the previous example. This example shows how the spreadsheet system deals with conflicts caused by values in multiple cells.

The user does not have to resolve the conflict immediately. For example, as shown in FIGS. 12A-D, the user may instead proceed to set the time of event e3 to the morning by modifying the appropriate cell of the event table. The modified cell is automatically marked as a base cell and event e3 appears automatically in the appropriate cell of the schedule table. Thus, even though the specified values in the base cells remain inconsistent with the constraints, the system is still able to compute entailed values using existential Ω-entailment and display the consequences of the (inconsistent) base assignments. The administrator can remove the inconsistency and complete the event scheduling by moving the projector from g100 into g200 (not shown).

VARIATIONS

Although the example spreadsheet illustrated above shows many of the features enjoyed by most implementations of logical spreadsheets, there are some variations that are worthy of explicit mention. The domains for cells may include various types of numbers and logical values in addition to alphanumeric strings. Cells are not necessarily limited to containing just one value, but could contain multiple values (e.g., someone's three children). Cells could also store vectors, arrays, matrices, tables, or other structured values. In addition to constraints on the values of cells, logical constraints may also embody constraints on changes in the values of the cells. It should also be emphasized that the particular techniques for updating cells illustrated in the example above is just one specific approach. There are other reasonable interpretations of what it means to be a

consequence of an inconsistent spreadsheet, and such alternate interpretations may be preferred in specific application areas. Moreover, alternate embodiments may include user-selectable preferences that control the automatic update behavior.

Spreadsheet systems of the present invention may also include other additional features such as an auto-complete feature and a deconfliction feature. In response to a user instruction to auto-complete a spreadsheet, the system will fill in empty spreadsheet cells with consistent values. The user can then alter or adjust the values to further customize the solution. If deconfliction is activated, the system will change existing values that are inconsistent to reduce or preferably eliminate inconsistencies. The user can then adjust the values of cells to arrive at a suitable solution. Auto-completion can be implemented, for example, by querying for empty cell values that satisfy the constraints given the current cell values, using standard database query techniques. Similarly, an implementation of deconfliction can query for conflicted cell values that satisfy the constraints given the non-conflicting cell values.

APPLICATIONS

It will be evident to those skilled in the art that the spreadsheet systems of the present invention have many applications and uses. Here we mention just a few of the many possible types applications. First, logical spreadsheets have applications to data management. Logical spreadsheets facilitate the entry and editing of symbolic data governed by symbolic constraints. “Correct on capture” data entry systems and resource management systems, like the one illustrated in this description, are examples of this capability. Logical spreadsheets could also be used as a “data browser” for the Semantic Web. A Web-aware logical spreadsheet could be used to integrate data from different sources and the translate data from one schema to another. Logical spreadsheets also are useful in design applications. Configuration systems are good examples of the use of

logical spreadsheets in design. Consider, for example, a configuration system to help users design their own cars or computer systems. Another application of logical spreadsheets is implementing smart forms. A spreadsheet with an HTML front end would allow users to fill out online forms in which data is checked for semantic well-formedness. Interactive documents are another application of logical spreadsheets. Systems can return "interactive answers" to users, e.g. simulations, which allow a user to experiment by varying certain parameters while the system automatically propagates the consequences of those variations. Consider, for example, a student learning how lenses refract light by experimenting with different lens shapes. Spreadsheets could also support collaborative applications if they were linked, with automatic propagation of values and constraints among the connected spreadsheets. Linked spreadsheets of this sort would support a wide variety of applications in cooperative design and collaborative management. In addition, linking would allow the creation of a World Wide Spreadsheet.

CLAIMS

1. A method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells;

dynamically partitioning the set of cells into base cells and computed cells;

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints;

computing non-explosive logical consequences of the user-specified values and the set of logical constraints to produce a complete set of entailed values for the set of computed cells;

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell; and

displaying a subset of the entailed values and a subset of the user-specified values.

2. The method of claim 1 wherein the cells are named cells.

3. The method of claim 2 wherein the named cells have structured names.

4. The method of claim 1 wherein the cells are able to contain multiple values.

5. The method of claim 1 wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the

user-specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values.

6. The method of claim 5 wherein the combining is done by taking the union of the multiple subsets of the complete set of entailed values.

7. The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to the cell.

8. The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell.

9. The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed.

10. The method of claim 1 wherein the logical constraints are formulated as relational constraints expressed in a logical language encompassing first-order logic.

11. The method of claim 1 wherein the displaying comprises altering an appearance of cells containing inconsistent values.

12. The method of claim 11 wherein the altering the appearance of cells containing inconsistent values comprises dynamically changing the appearance of a subset of

cells containing related inconsistent values when a user pointer hovers over the subset of cells.

13. The method of claim 1 wherein the displaying comprises providing a menu associated with a cell, wherein the menu comprises a list of possible values classified as being non-explosively entailed, being non-explosively contradicted, or neither.

14. The method of claim 1 wherein the displaying comprises providing an interactive user interface for an electronic document.

15. The method of claim 14 wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document.

16. The method of claim 1 further comprising, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical constraints.

17. The method of claim 1 further comprising, responsive to a user instruction, automatically altering values of cells to reduce conflicts with the logical constraints.

18. The method of claim 1 wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed value matches an existing value contained in the cell.

ABSTRACT OF THE DISCLOSURE

A computerized spreadsheet system includes a set of cells and a separate set of logical constraints on the values of cells. The constraints may be many-to-many relationships that permit omni-directional propagation of values between cells. The constraints may be expressed in a language encompassing first-order logic. Cells are dynamically reclassified as base cells or computed cells as a user specifies values for cells. Non-explosive consequences of the base cell values are computed and displayed in computed cells, even when the values in the base cells are inconsistent with the constraints. The spreadsheet system may also include an auto-complete feature that automatically fills in empty cells with values consistent with the logical constraints and an auto-deconflict feature that automatically changes values in cells to reduce conflicts with the logical constraints.

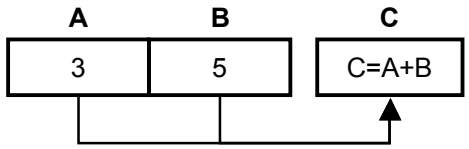

Fig. 1

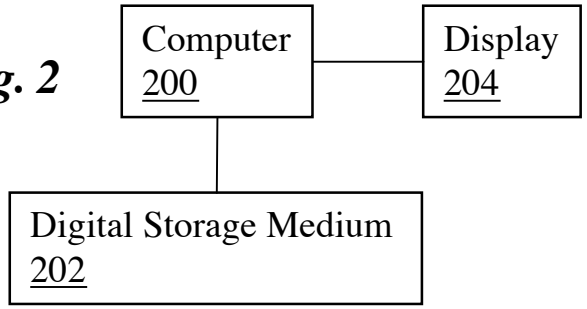

Fig. 2

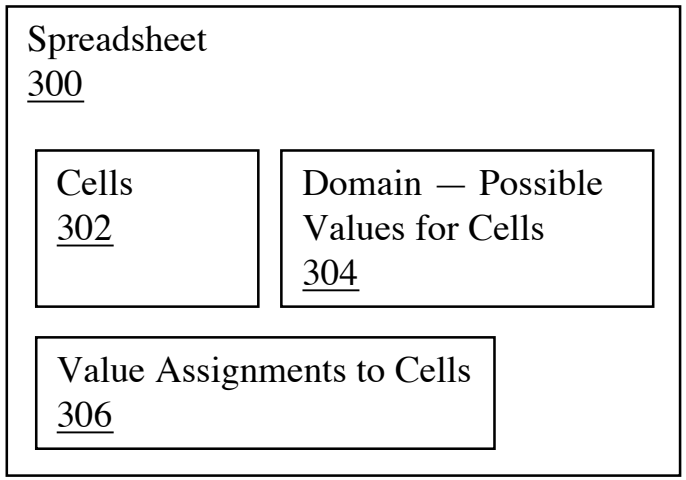

Fig. 3

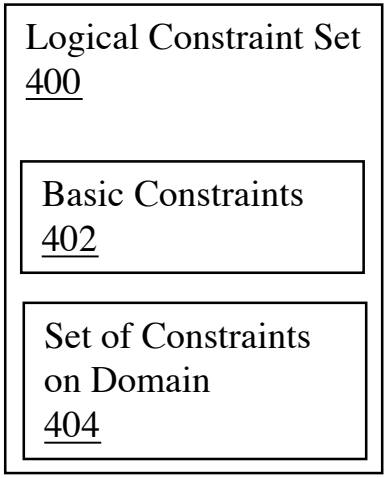

Fig. 4

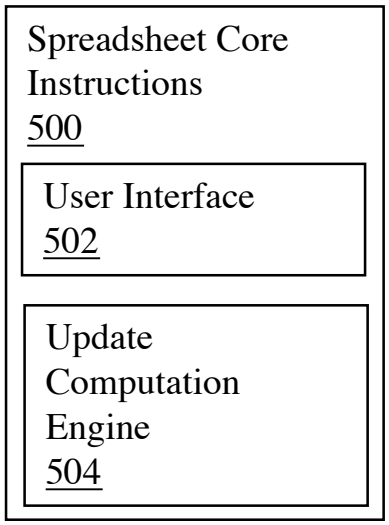

Fig. 5

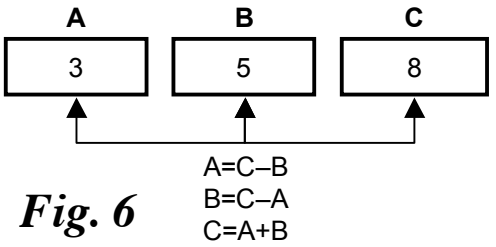

Fig. 6

Event	Owner	Projection	Room	Time
E1	Amy	No	G100	Morning
E2	Bob	Yes	G200	Afternoon
E3	Cal	No	G100	

Fig. 7A

Schedule	G100	G200	G300
Morning	E1		
Afternoon			
Evening			

Fig. 7B

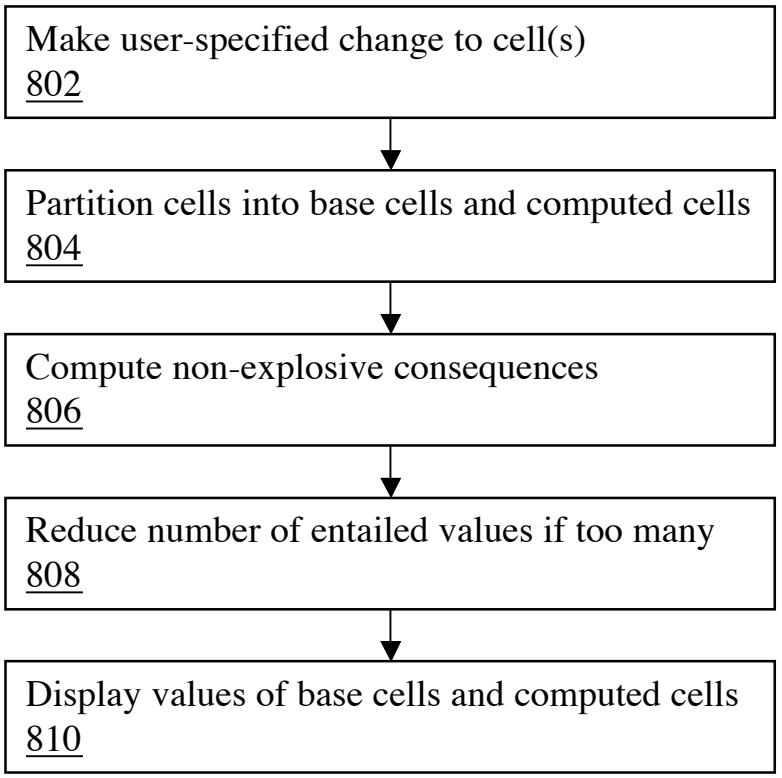

Fig. 8

Fig. 9A

Fig. 9B

Fig. 9C

Fig. 9D

Fig. 10A

Fig. 10B

Fig. 10C

Fig. 10D

Fig. 11A

event	owner	projection	room	time
e1	amy	no	g100	evening
e2	bob	no	g200	afternoon
e3	cal	yes	g200	

schedule	g100	g200	g300
morning			
afternoon		e2	
evening	e1		

Fig. 11B

room	projector
g100	yes
g200	no
g300	no

Fig. 11C

person	faculty
amy	yes
bob	no
cal	yes

Fig. 11D

Fig. 12A

event	owner	projection	room	time
e1	amy	no	g100	evening
e2	bob	no	g200	afternoon
e3	cal	yes	g200	morning

schedule	g100	g200	g300
morning		e3	
afternoon		e2	
evening	e1		

Fig. 12B

room	projector
g100	yes
g200	no
g300	no

Fig. 12C

person	faculty
amy	yes
bob	no
cal	yes

Fig. 12D

PTO/SB/01 (04-05)
Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted With Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	S04-076/US
First Named Inventor	Michael R. Genesereth
COMPLETE IF KNOWN	
Application Number	11/197123
Filing Date	8/4/2005
Art Unit	2176
Examiner Name	Not Yet Assigned

I hereby declare that:

Each inventor's residence, mailing address, and citizenship are as stated below next to their name.

I believe the inventor(s) named below to be the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Logical Spreadsheets

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 8/4/2005 as United States Application Number or PCT International Application Number 11/197123 and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
	US		☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

PTO/SB/01 (04-05)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION — Utility or Design Patent Application

Direct all correspondence to:	☑ The address associated with Customer Number:	30869	OR ☐	Correspondence address below

Name: Lumen Intellectual Property Services, Inc.			
Address: 2345 Yale Street, 2nd Floor			
City: Palo Alto	State: CA	ZIP: 94306	
Country: US	Telephone: 650-424-0100	Email:	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

NAME OF SOLE OR FIRST INVENTOR:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any]): Michael R.	Family Name or Surname: Genesereth		
Inventor's Signature: *[signature]*		Date: 11/03/05	
Residence: City: Palo Alto	State: CA	Country: US	Citizenship: US
Mailing Address: 1242 Forest Avenue			
City: Palo Alto	State: CA	Zip: 94301	Country: US

NAME OF SECOND INVENTOR:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any]): Michael	Family Name or Surname: Kassoff		
Inventor's Signature: *[signature]*		Date:	
Residence: City: Mountain View	State: CA	Country: US	Citizenship: US
Mailing Address: 938 Clark Avenue Apt 55			
City: Mountain View	State: CA	Zip: 94040	Country: US

☒ Additional inventors or a legal representative are being named on the 1 supplemental sheet(s) PTO/SB/02A or 02LR attached hereto.

PTO/SB/02A (09-04)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page 1 of 1

Name of Additional Joint Inventor, if any: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any))	Family Name or Surname
Nathaniel C.	Love

Inventor's Signature: Nathaniel C. Love — Date:

Residence: City	State	Country	Citizenship
San Francisco	CA	US	US

Mailing Address: 51 Brewster St.

City	State	Zip	Country
San Francisco	CA	94110	

Name of Additional Joint Inventor, if any: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any))	Family Name or Surname

Inventor's Signature — Date:

Residence: City	State	Country	Citizenship

Mailing Address

City	State	Zip	Country

Name of Additional Joint Inventor, if any: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any))	Family Name or Surname

Inventor's Signature — Date:

Residence: City	State	Country	Citizenship

Mailing Address

City	State	Zip	Country

Attorney Docket No: **S04-076/US**

ASSIGNMENT

THIS ASSIGNMENT, by

Michael R. Genesereth, Michael Kassoff, and Nathaniel C. Love

(hereinafter referred to as the Assignors), residing at **Palo Alto, California; Mountain View, California; and San Francisco, California,** respectively, witnesseth:

WHEREAS, said Assignors have invented certain new and useful improvements in

LOGICAL SPREADSHEETS

for which application no. 11/197123 has been executed on 1/10/2006

WHEREAS,

The Board of Trustees of the Leland Stanford Junior University

(hereinafter referred to as the Assignee), a body having corporate powers under the laws of the state of **CALIFORNIA, STANFORD, CALIFORNIA 94305,** is desirous of obtaining the entire right, title and interest in and to said inventions and said application for Letters Patent, and in and to any Letters Patent, United States or foreign, to be obtained therefor and thereon;

WHEREAS, said Assignors and said Assignee have executed an Agreement Concerning Rights in Invention.

NOW, THEREFORE, in consideration of the sum of One Dollar ($1.00) and for other good and sufficient considerations, the receipt of which is hereby acknowledged:

1. The Assignors have sold, assigned, transferred and set over, and do hereby sell, assign, transfer and set over unto said Assignee, the entire right, title and interest in, to and under said inventions; said application for Letters Patent; any Letters Patent which may be granted for said inventions in the United States of America and any foreign country; any division of said application, continuation of said application, and any continuation-in-part of said application which is subject to said agreement concerning rights in invention; any reissue or extension of said Letters Patent; and all rights under the International Convention for the Protection of Industrial Property; said right, title and interest to be held and enjoyed by said Assignee for its own use and behoove to the full end of the term for which Letters Patent may be granted, as fully and entirely as the same would have been held and enjoyed by the Assignors, had this sale and assignment not been made.

2. Said Assignors hereby jointly and severally represent to the best of their knowledge that, at the time of execution and delivery of these presents, said Assignors are the joint and lawful owners of the entire right, title and interest in and to said inventions and said application for Letters Patent, and that the same have not entered into any assignment, contract or understanding in conflict herewith.

3. Said Assignors hereby jointly and severally covenant and agrees to assist and cooperate with said Assignee, whereby said Assignee may enjoy to the fullest extent said right, title and interest herein conveyed, provided, however, that the entire expense which may be incurred by said Assignors in lending such assistance and cooperation be paid by Assignee. Such cooperation shall include: (a) prompt execution of all papers (prepared at the expense of Assignee) which are deemed necessary or desirable by Assignee to perfect said right, title and interest herein conveyed, (b) prompt execution of all petitions, oaths, specifications, declarations and other papers (prepared at the expense of Assignee) which are deemed necessary or desirable by Assignee for filing or prosecuting in the United States or any foreign country said application, any application which is a division of said application, continuation of said application, or any continuation-in-part of said application which is subject to said agreement concerning rights in

invention, any reissue application for any Letters Patent granted on said application, or for any interference proceeding involving said application or Letters Patent granted thereon; and (c) prompt assistance and cooperation in the prosecution of all legal proceedings involving said inventions, said application, or Letters Patent granted thereon, including oppositions, cancellation proceedings, priority contests, public use proceedings and court actions.

4. The terms, covenants and conditions of this Assignment shall inure to the benefit of said Assignee, its successors, assigns and/or other legal representatives, and shall be binding upon said Assignors, their heirs, legal representatives and assigns.

5. The terms, covenants and conditions of this Assignment are subject to the payment of royalty by Assignee to Assignors in accordance with the provisions of said Agreement Concerning Rights in Invention.

6. Said Assignors hereby request the Commissioner of Patents and Trademarks to issue said Letters Patent of the United States to said Assignee as the assignee of said inventions.

IN WITNESS WHEREOF said Assignors have executed and delivered this instrument on the respective dates noted below.

Date: 1/9/06 _____
Michael R. Genesereth

State: _____ County: _____

Subscribed and sworn to before me on this _____ day of _____, 20____

_____
Notary Public

Date: 1/9/06 _____
Michael Kassoff

State: _____ County: _____

Subscribed and sworn to before me on this _____ day of _____, 20____

_____
Notary Public

Date: 1/10/2006

Nathaniel C. Love

State: _____ County: _____

Subscribed and sworn to before me on this _____ day of _____, 20____

Notary Public

POWER OF ATTORNEY BY ASSIGNEE

The undersigned assignee of the entire interest in application no. 11/197123 filed 8/4/2005 for the invention entitled:

Logical Spreadsheets

hereby appoints Ron Jacobs, Reg. No. 50,142, Thomas J. McFarlane, Reg. No. 39,299, Marek Alboszta, Reg. No. 39,894, Robert Lodenkamper, Reg. No. 55,399, Kenneth M. Benderly, Reg. No. 51,453, and Miriam Kaplan, Reg. No. 55,315, as its agents to prosecute the attached application and to transact all business in the Patent and Trademark Office connected therewith, said appointment to be to the exclusion of the inventor(s) and their attorney(s) in accordance with the provisions of Rule 32 of the Patent Office Rules of Practice.

Please direct all communication relative to said application to the following correspondence address:

LUMEN INTELLECTUAL PROPERTY SERVICES, INC.

2345 Yale Street, Second Floor
Palo Alto, CA 94306
Phone: (650) 424-0100
Fax: (650) 424-0141

I am duly authorized to sign this instrument on behalf of assignee. I hereby declare that, to the best of my knowledge and belief, title is in the assignee and believe that said application has been assigned to assignee and that assignee therefore has the right to make this Power of Attorney and Exclusion of Inventor(s).

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

ASSIGNEE: The Board of Trustees of the Leland Stanford Junior University

Stanford University
Office of Technology Licensing
1705 El Camino Real
Palo Alto, CA 94306

Official Authorized to Act on Behalf of Assignee:

Signature: Katharine Ku Date: 10/31/05

Name: Katharine Ku

Title: Director, Office of Technology Licensing

Appl. No.:	11/197123
Conf. No.:	4774
First named inventor:	Genesereth, Michael R.
Filing date:	8/4/2005
Title:	Logical Spreadsheets
TC/A.U.:	2178
Examiner:	Stork, Kyle R
Docket No.:	S04-076/US
Customer No.:	30869

Commissioner for Patents
PO Box 1450
Alexandria VA 22313-1450

RESPONSE TO ACTION

Sir:

In response to the Office action of 6/24/2008, please reconsider the above-identified application in view of the following amendments and/or remarks.

Amendments to the Claims

Replace all prior versions and listings of claims in the application with the following list of claims.

1. (**currently amended**) A method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells;

dynamically partitioning the set of cells into base cells and computed cells;

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints;

computing non-explosive logical consequences of the user-specified values and the set of logical constraints to produce a complete set of entailed values for the set of computed cells;

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell;

and

displaying a subset of the entailed values and a subset of the user-specified values **[[.]]** **;**

wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user-specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values.

2. (**original**) The method of claim 1 wherein the cells are named cells.

3. (**original**) The method of claim 2 wherein the named cells have structured names.

4. (**original**) The method of claim 1 wherein the cells are able to contain multiple values.

5. (**cancelled**)

6. (**currently amended**) The method of claim **[[5]] 1** wherein the combining is done by taking the union of the multiple subsets of the complete set of entailed values.

7. (**original**) The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to the cell.

8. (**original**) The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell.

9. (**original**) The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed.

10. (**original**) The method of claim 1 wherein the logical constraints are formulated as relational constraints expressed in a logical language encompassing first-order logic.

11. (**original**) The method of claim 1 wherein the displaying comprises altering an appearance of cells containing inconsistent values.

12. (**original**) The method of claim 11 wherein the altering the appearance of cells containing inconsistent values comprises dynamically changing the appearance of a subset of cells containing related inconsistent values when a user pointer hovers over the subset of cells.

13. (**original**) The method of claim 1 wherein the displaying comprises providing a menu associated with a cell, wherein the menu comprises a list of possible values classified as being non-explosively entailed, being non-explosively contradicted, or neither.

14. (**original**) The method of claim 1 wherein the displaying comprises providing an interactive user interface for an electronic document.

15. (**original**) The method of claim 14 wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document.

16. (**original**) The method of claim 1 further comprising, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical constraints.

17. (**original**) The method of claim 1 further comprising, responsive to a user instruction, automatically altering values of cells to reduce conflicts with the logical constraints.

18. (**original**) The method of claim 1 wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed value matches an existing value contained in the cell.

REMARKS/ARGUMENTS

Remarks concerning amendments to claims

Claim 1 and 6 are amended. Claim 5 is cancelled. Claims 1-4 and 6-18 remain.

Response to rejections

In the most recent Action, the Office rejected claims 1, 4-5, 7-11, and 14-18 under 35 USC 102(b) as being anticipated by Felfernig. Claims 2-3 and 6 were rejected under 35 USC 103(a) as being unpatentable over Felfernig. Claims 12 and 13 were rejected under 35 USC 103(a) as being unpatentable over Felfernig in view of Wilson.

Regarding claim 1, Applicant respectively disagrees with the allegation that Felfernig teaches all the limitations of the claim. Although Felfernig teaches an extension of the functionality of conventional spreadsheet systems, Felfernig neither teaches nor suggests several features that are explicitly claimed.

The Action alleges that Felfernig teaches the claimed computing of non-explosive consequences, producing a complete set of entailed values from possibly inconsistent user specified values. Applicant disagrees. In fact, Felfernig does not teach computing a *complete set of entailed values*. Felfernig's system merely provides a technique for enforcing logical constraints on cells using a constraint solver. That is, Felfernig's system is limited to finding consistent solutions: "If - during the propagation process of the user inputs - the solver detects a constraint violation...the user will be prompted the information *which of his/her selections caused a constraint violation and which value selections have to be undone or changed*." (Felfernig, page 3, column 2). Felfernig's constraint solver system is not capable of finding solutions to possibly inconsistent variable assignments by the user: "A solution to a CSP is a value assignment to each problem variable such that *no constraint is violated*" (Felfernig, page 2, column 1).

In contrast with Felfernig, the claimed invention computes a complete set of *entailed* values for the set of computed cells by computing non-explosive logical consequences of the *possibly*

inconsistent user-specified values and the set of logical constraints. Computing a set of *consistent* solutions, as taught by Felfernig, is not the same as computing a *complete set of entailed* values, as claimed. For example, in the case of inconsistent user-specified values, Felfernig's constraint solver will produce no *consistent* solutions unless the inconsistent values are undone or changed. In contrast, the complete set of *entailed* values produced by the claimed method will include computed values of inconsistent values because the entailed values are not all required to be consistent. The meaning of entailment is described in the following passage from the specification:

> After the partitioning of base and computed cells, the set of entailed values is calculated (step 806). The entailed values are the non-explosive consequences of the values in the base cells and the specified logical constraints. To calculate the non-explosive consequences, a paraconsistent consequence relation called existential Ω-entailment is preferably used. In other words, the non-explosive logical consequences may be found by 1) identifying subsets of the set of values in the base cells that are consistent with the logical constraints, using for example the resolution proof technique to determine consistency, 2) computing the logical consequences of the identified consistent subsets and the logical constraints to produce corresponding sets of entailed values for the computed cells, and 3) combining the computed sets of entailed values to form a complete set of entailed values, e.g., by taking their union or intersection.

In order to clarify these significant differences between the claimed method and Felfernig's system, the Applicant has amended claim 1 to make explicit the claimed computing of entailed values. Specifically, claim 1 is amended to state that the computing of the non-explosive logical consequences comprises computing logical consequences of *multiple consistent subsets* of the user-specified values to produce *multiple subsets of the complete set of entailed values*, and *combining the multiple subsets* of the complete set of entailed values. Felfernig does not teach or suggest any of these limitations.

More generally, neither Felfernig nor any other cited references teaches or fairly suggests an extended spreadsheet system that produces a complete set of entailed values from possibly inconsistent values specified by the user.

In addition, the claimed invention recites *dynamic partitioning* of the cells into base cells and computed cells. Applicant respectfully disagrees with the Action's allegation that Felfernig teaches this claimed limitation. The Examiner reasons: "because the constraint values [of Felfernig] are dynamically added to the problem space...these constraints are dynamic, and thus

the cells which the constraints apply to are dynamic." However, Felfernig's *dynamic addition of constraints* does not imply *dynamic partitioning of cells*. Dynamic constraints may reasonably be argued to result in dynamic modification of the *values* assigned to cells, but dynamic constraints do not imply the claimed dynamic *partitioning* of the *cells* into base cells and computed cells. Accordingly, Felfernig does not, in fact, teach the claimed limitation.

Applicant also respectfully disagrees with the Action's allegation that Felfernig teaches the claimed reducing of the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell. Firstly, Felfernig nowhere teaches or suggests any predetermined number of allowed values for any cell. Nor does Felfernig teach or suggest any comparison of such predetermined number with a computed number of entailed values for a computed cell. The cited passage of Felfernig (page 5, column 2) teaches "While mathematical models in many cases are able to compute *one* optimal solution, the search method used in our approach gives the user the possibility to compute multiple alternative solutions." Felfernig does not teach here the claimed reduction of entailed values *for each computed cell* to a predetermined number of allowed values *for each computed cell*. Felfernnig merely compares other methods that compute one optimal solution with his approach which computes multiple alternative solutions. Felfernig does not teach any selection of one of these alternatives or the specific reduction of entailed values for each computed cell to a predetermined number of allowed values for each computed cell.

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Respectfully submitted,

/ Thomas J. McFarlane /

Thomas J. McFarlane, Reg. No 39,299

LUMEN PATENT FIRM
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Appl. No.:	11/197123
Conf. No.:	4774
First named inventor:	Genesereth, Michael R.
Filing date:	8/4/2005
Title:	Logical Spreadsheets
TC/A.U.:	2178
Examiner:	Stork, Kyle R
Docket No.:	S04-076/US
Customer No.:	30869

Commissioner for Patents
PO Box 1450
Alexandria VA 22313-1450

RESPONSE TO ACTION

Sir:

In response to the Office action of 3/4/2009, please reconsider the above-identified application in view of the following remarks.

REMARKS/ARGUMENTS

In the most recent Action, the Office rejected claims 1, 4, 7-11, and 14-18 under 35 USC 102(b) as being anticipated by Felfernig. Claims 2-3 and 6 were rejected under 35 USC 103(a) as being unpatentable over Felfernig. Claims 12 and 13 were rejected under 35 USC 103(a) as being unpatentable over Felfernig in view of Wilson.

In response, Applicant traverses the rejections on the grounds that Felfernig does not teach or suggest the claimed limitations. Although Felfernig teaches computing values that are logically ***consistent*** with constraints, Felfernig does not teach computing values that are logically ***entailed*** from constraints. Applicant respectfully submits that the rejection is improper because, among other things, it is based on a confusion of these distinct concepts.

The following discussion may assist in clarifying the difference between these concepts.

Logical consistency: A constraint and one or more value assignments are consistent if and only if their logical conjunction does not imply a logical contradiction.

Logical consequence: A constraint and given value assignments logically entail a value if the value is a logical implication of the constraint and value assignments.

Example 1. Consider the constraint “p or q” and a value assignment set {“p is true”}. These are ***consistent*** with the value assignment “q is true” because “true or true” is not a logical contradiction. They are also ***consistent*** with the value assignment “q is false” because “true or false” is not a logical contradiction. However, neither “q is true” nor “q is false” is a logical ***consequence***. Thus, although these two value assignments for q are ***consistent*** with the constraint “p or q” and value assignment “p is true”, they are not ***consequences*** of them.

Example 2. Consider the constraints “not p or not q” and “p=> r” and the set of value assignments {“p is true”, “q is true”}. Because the constraints and value assignments for p and q

are not mutually ***consistent***, no value assignment for r is consistent. However, because any consequence is an implication of a contradiction, both "r is true" and "r is false" are ***consequences***. Moreover, "r is true" is a consequence of the constraints "not p or not q" and "p=> r" and the subset of the value assignments {"p is true"}, although "r is false" is not a consequence of the constraints for any subset of the value assignments. Thus, r is a ***non-explosive*** logical consequence.

The above examples clearly show that ***logical consistency*** and ***logical consequence*** are distinct concepts. In particular, values that are ***consistent*** with constraints are not the same as values that are ***consequences*** of those constraints.

Claim 1 recites the limitation of "computing non-explosive ***logical consequences*** of the user-specified values and the set of logical constraints to produce a complete set of ***entailed values*** for the set of computed cells."

On page 3 of the Action, the Office alleges that this claim limitation is taught on page 3 of Felfernig: "if a base input is non-compliant with the constraints, the underlying constraint propagator dynamically infers a set of compliant values for the remaining computed cells." Felfernig does not teach "compliant" values. It is not clear to the Applicant what the Office means by "compliant" values. Felfernig actually teaches that the constraint propagator calculates consistent values: "The underlying constraint propagator is capable of inferring the set of still ***consistent*** (allowed) values...At any stage, the user can initiate the search process such that the constraint engine computes ***consistent*** values" (Felfernig, page 3, column 2). That is, Felfernig teaches computing values that are ***consistent*** with the constraints and user-specified values, not values that are logical ***consequences*** of the constraints and user-specified values. Thus, the Office has not presented convincing evidence or reasoning that the recited limitation is in fact taught by Felfernig.

Claim 1 also recites "computing logical ***consequences*** of multiple consistent subsets of the user-specified values to produce multiple ***subsets of the complete set of entailed values***, and combining the multiple subsets of the ***complete set of entailed values***."

On page 4 of the Action (and again on page 11), the Office alleges that this claim limitation is taught on pages 3-4 of Felfernig: "Here, a subset of computed values is generated for each remaining computed cell based upon the input to the base cell. Each subset consists of computed cell values that meet the defined constraints." Indeed, Felfernig teaches computing values that are ***consistent*** with the constraints: "If the constraint solver finds a consistent assignment the result is displayed in the output area" (Felfernig, page 3, column 2). But Felfernig does not teach the claimed limitation of computing values that are ***consequences*** of the constraints. Nor does Felfernig teach computing ***consequences*** of ***multiple consistent subsets***. Because logically consistent values are not the same as values that are logical consequences, the Office has not presented convincing evidence or reasoning that the recited limitation is in fact taught by Felfernig.

The Office argues on page 11 of the Action that "Felfernig discloses base cells having applied logical constraints (page 3). Here, the cells may contain arithmetic and logical operators or constraints (page 3, left column). Additionally, cells may have Constraint Satisfaction problems applied. Therefore, Felfernig discloses the use of entailed values." Applicant respectfully disagrees. Felfernig's application of logical constraints to cells is not the same as the claimed computation of entailed values (i.e., logical consequences). Nor has Felfernig taught anything resembling the claimed limitation of computing ***non-explosive*** logical consequences.

Claim 1 also recites "reducing the number of ***entailed*** values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell."

On page 4 of the Action, the Office alleges that this claim limitation is taught on page 5 of Felfernig: "Here, one optimal solutions is calculated from multiple alternative solutions." Indeed, selection of an optimal solution from multiple alternative solutions reduces the solutions. But the Office has not shown that Felfernig teaches the claimed limitation that ***entailed*** values are reduced. Nor has the Office shown that Felfernig teaches the claimed limitation that the number of entailed values exceeds predetermined number of allowed values for a computed cell. Because

the Office has not considered these limitations in the claim, Applicant respectfully submits that the rejection is improper.

In summary, it is clear from the above that Felfernig's system provides a technique for enforcing logical ***constraints*** on cells using a constraint solver. That is, Felfernig's system is limited to finding ***consistent*** solutions. Felfernig does not, however, teach or suggest any method for finding logical ***consequences*** or for finding ***non-explosive*** logical consequences of cells. Moreover, none of the other cited references teaches or suggests the claimed limitations as described above. Accordingly, Applicant respectfully submits that the claim 1 is patentable over the cited references.

The above arguments apply also to claims 2-4 and 6-18, which dependent upon claim 1. In addition, these claims recite various features that are not taught by the cited references, as explained in the previously filed response.

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Respectfully submitted,

/ Thomas J. McFarlane /

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Commissioner for Patents
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RESPONSE TO ACTION

Sir:

In response to the Office action of 8/12/2009, please reconsider the above-identified application in view of the following amendments and remarks.

Amendments to the Claims

Replace all prior versions and listings of claims in the application with the following list of claims.

1. (**currently amended**) A method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells;

dynamically partitioning the set of cells into base cells and computed cells;

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints;

computing non-explosive logical consequences of the user-specified values and the set of logical constraints **using a paraconsistent consequence relation** to produce a complete set of entailed values for the set of computed cells;

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell;

and

displaying a subset of the entailed values and a subset of the user-specified values;

wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user-specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values.

2. (**original**) The method of claim 1 wherein the cells are named cells.

3. (**original**) The method of claim 2 wherein the named cells have structured names.

4. (**original**) The method of claim 1 wherein the cells are able to contain multiple values.

5. (**cancelled**)

6. (**previously presented**) The method of claim 1 wherein the combining is done by taking the union of the multiple subsets of the complete set of entailed values.

7. (**original**) The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to the cell.

8. (**original**) The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell.

9. (**original**) The method of claim 1 wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed.

10. (**original**) The method of claim 1 wherein the logical constraints are formulated as relational constraints expressed in a logical language encompassing first-order logic.

11. (**original**) The method of claim 1 wherein the displaying comprises altering an appearance of cells containing inconsistent values.

12. (**original**) The method of claim 11 wherein the altering the appearance of cells containing inconsistent values comprises dynamically changing the appearance of a subset of cells containing related inconsistent values when a user pointer hovers over the subset of cells.

13. (**original**) The method of claim 1 wherein the displaying comprises providing a menu associated with a cell, wherein the menu comprises a list of possible values classified as being non-explosively entailed, being non-explosively contradicted, or neither.

14. (**original**) The method of claim 1 wherein the displaying comprises providing an interactive user interface for an electronic document.

15. (**original**) The method of claim 14 wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document.

16. (**original**) The method of claim 1 further comprising, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical constraints.

17. (**original**) The method of claim 1 further comprising, responsive to a user instruction, automatically altering values of cells to reduce conflicts with the logical constraints.

18. (**original**) The method of claim 1 wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed value matches an existing value contained in the cell.

REMARKS/ARGUMENTS

In the most recent Action, the Office rejected claims 1-4, 6-11, and 14-18 under 35 USC 103(a) as being unpatentable over Felfernig et al in view of Breuer. Claims 12-13 were rejected under 35 USC 103(a) as being unpatentable over Felfernig and Breuer, and further in view of Wilson.

In response, Applicant amends claim 1 to clarify further the significant distinctions between the claimed invention and the cited art. In addition, the Applicant traverses the rejections on the grounds that the cited references do not teach all the features recited in the claims.

The claims, as amended, recite computing non-explosive logical consequences of the user-specified values and the set of logical constraints ***using a paraconsistent consequence relation*** to produce a complete set of entailed values for the set of computed cells. None of the cited references can be reasonably interpreted as teaching the use of a paraconsistent consequence relation to compute non-explosive logical consequences.

According to traditional logic, anything can be derived from a contradiction. The traditional relation of logical consequence is thus said to be *explosive*. In contrast, a *paraconsistent* consequence relation is non-explosive. The Stanford Encyclopedia of Philosophy defines a *paraconsistent consequence relation* as follows:

> A logical consequence relation, $\models$, is said to be *paraconsistent* if it is not explosive. Thus, if $\models$ is paraconsistent, then even if we are in certain circumstances where the available information is inconsistent, the inference relation does not explode into triviality. <<http://plato.stanford.edu/entries/logic-paraconsistent/>>

In other words, while a traditional consequence relation will give explosive consequences from inconsistent information, a paraconsistent consequence will not. None of the cited references, however, teaches a paraconsistent consequence relation. Specifically, none teaches computing ***non-explosive logical consequences*** of the user-specified values and the set of logical

constraints ***using a paraconsistent consequence relation*** to produce a ***complete*** set of ***entailed*** values for the set of computed cells.

Felfernig does not teach the claimed use of a paraconsistent consequence relation for computing entailed values. Felfernig's constraint solver system is not capable of finding solutions to possibly inconsistent variable assignments by the user: "A solution to a CSP is a value assignment to each problem variable such that *no constraint is violated*" (Felfernig, page 2, column 1). Thus, Felfernig does not teach the claimed use of a paraconsistent consequence relation to compute entailed values.

The claims, as amended, recite computing ***non-explosive logical consequences*** of the user-specified values and the set of logical constraints using a paraconsistent consequence relation to produce a complete set of entailed values for the set of computed cells. Felfernig, in contrast, does not teach computing non-explosive logical consequences. Felfernig only teaches a constraint propagator that calculates ***consistent*** values: "The underlying constraint propagator is capable of inferring the set of still ***consistent*** (allowed) values...At any stage, the user can initiate the search process such that the constraint engine computes ***consistent*** values" (Felfernig, page 3, column 2). That is, Felfernig teaches computing values that are ***consistent*** with the constraints: "If the constraint solver finds a consistent assignment the result is displayed in the output area" (Felfernig, page 3, column 2). Felfernig's computed values are merely ***consistent*** values. However, consistent values are not that same as the claimed non-explosive logical ***consequences***.

Moreover, Felfernig's consistent values are different from the claimed ***non-explosive consequences***. As explained above, non-explosive consequences are the result of a paraconsistent consequence relation, which allows consequences to be derived from inconsistent information. Clearly, Felfernig's consistent values are not consequences of a paraconsistent consequence relation. Thus, Felfernig does not teach the computing ***non-explosive logical consequences*** of the user-specified values and the set of logical constraints using a paraconsistent consequence relation to produce a complete set of entailed values for the set of computed cells.

In addition, the Action mischaracterizes the claimed invention and incorrectly misquotes the claim language in various places. For example, page 4 of the Action incorrectly states that the claim recites "computing non-explosive logical ***consistencies*** [sic]." The claim actually recites "computing non-explosive logical ***consequences***." Similarly on page 5 of the Action, the Action mischaracterizes the claim as reciting "computing the logical ***consistencies*** [sic]" and "computing non-explosive logical ***constraints*** [sic]." In fact, the claim recites computing non-explosive logical ***consequences***. Logical consequences are not the same as logical constraints and not the same as logical consistencies. Again on page 6 of the Action, the Office misquotes the claim as reciting "computing the logical ***constraints*** [sic]." The claim actually recites "computing logical ***consequences***." The Office has therefore inaccurately characterized the claim limitations is numerous places and based its rejection on misreadings of the claims.

The Office alleges on page 6 of the Action that Brauer teaches various limitations of claim 1 in Fig. 10 and paragraphs 0015-0016 and 0062-0063. Applicant respectfully disagrees. Fig. 10 shows a conventional spreadsheet whose cells have circular references. The cited paragraphs merely describe a method for providing an option to a user to manually change a non-circular reference to a circular reference, and a method for making the cells ***self-consistent***. Like Felfernig, Brauer's method has only to do with determining ***consistency*** of values. Brauer does not teach computing logical ***consequences***, does not teach ***non-explosive*** logical consequences, and does not teach combining logical ***consequences*** of ***multiple consistent subsets*** of user-specified values.

The Office argues that it would have been obvious to combine Felfernig with Brauer "since it would have allowed a user to derive consistency within a spreadsheet from logically constrained values." The claimed invention, however, provides a method that allows for inconsistencies within a spreadsheet, not for deriving consistencies. Combining Felfernig and Brauer would not yield the claimed method for computing non-explosive logical consequences using a paraconsistent consequence relation.

The above arguments apply also to the dependent claims, which all depend from claim 1. In addition, the dependent claims recite various features that are not taught by the cited references, as explained in the previously filed responses.

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Respectfully submitted,

/ Thomas J. McFarlane /

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ISSUE FEE AND/OR PUBLICATION FEE TRANSMITTAL

This form is an equivalent of Part B of the Notice of Allowance and Fee(s) Due, and is in compliance with the requirement on how to reply to the Notice (Item II, Page 1 of Notice)

CURRENT CORRESPONDENCE ADDRESS

30869 7590 2/19/2010

LUMEN PATENT FIRM
350 CAMBRIDGE AVE SUITE 100
PALO ALTO, CA 94306

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop ISSUE FEE , Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, or being facsimile transmitted to the USPTO (571) 273-2885, on the date shown below:

Patricia Shepherd	(Depositor's name)
/ Patricia Shepherd /	(Signature)
2/24/10	(Date)

Application No.	Filing Date	First Named Inventor	Docket No.	Confirmation No.
11/197123	8/4/2005	Michael R. Genesereth	S04-076/US	4774

Title: LOGICAL SPREADSHEETS

Appl. Type	Small Entity	Issue Fee Due	Pub. Fee Due	Prev. Paid IF	Total Fee Due	Date Due
nonprovisional	YES	755	300	$0	$1055	5/19/2010

Examiner	Art Unit	Class-SubClass
Stork, Kyle R	2178	715/500

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363):
   - ☐ Change of correspondence address attached.
   - ☐ "Fee address" indication attached.

2. For printing on the patent front page list firm name:
   LUMEN PATENT FIRM

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT.
Unless an assignee is identified below, no assignee will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE	(B) RESIDENCE (City and State or Country)
The Board of Trustees of the Leland Stanford Junior University	Palo Alto, CA

Please check the appropriate assignee category/categories: ☐ Individual ☒ Corporation or Private Group Entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☒ Publication Fee
- ☐ Advance Order - # of Copies _____

4b. Payment of fee(s):
- ☐ Check is enclosed
- ☒ Payment by credit card (form is attached)
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account No. _____ (enclose extra copy)

5. **Change in entity status** (from previous established status)
- ☐ a. Applicant claims SMALL ENTITY status
- ☐ b. Applicant is no longer claiming SMALL ENTITY status

SIGNATURE OF APPLICANT, REGISTERED ATTORNEY, OR REGISTERED AGENT

SIGNATURE	/ Thomas J. McFarlane / Reg.No. 39,299	DATE	2/24/10
PRINTED NAME	Thomas J. McFarlane	REG. NO.	39,299

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPL NO.	FILING OR 371 (c) DATE	ART UNIT	FIL FEE REC'D	ATTY.DOCKET NO	DRAWINGS	TOT CLMS	IND CLMS
11/197,123	08/04/2005	2176	0.00	S04-076/US	4	18	1

CONFIRMATION NO. 4774

30869
LUMEN INTELLECTUAL PROPERTY SERVICES, INC.
2345 YALE STREET, 2ND FLOOR
PALO ALTO, CA 94306

FILING RECEIPT

OC000000016957128

Received
Lumen 9/12/05

Date Mailed: 09/08/2005

Receipt is acknowledged of this regular Patent Application. It will be considered in its order and you will be notified as to the results of the examination. Be sure to provide the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please mail to the Commissioner for Patents P.O. Box 1450 Alexandria Va 22313-1450. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).**

Applicant(s)

Michael R. Genesereth, Residence Not Provided;
Michael A. Kassoff, Residence Not Provided;
Nathaniel C. Love, Residence Not Provided;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This appln claims benefit of 60/599,644 08/06/2004

Foreign Applications

If Required, Foreign Filing License Granted: 09/07/2005

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is US11/197,123

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No

** SMALL ENTITY **

Title

Logical spreadsheets

Preliminary Class

715

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

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Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US

CONFIRMATION NO. 4774

30869
LUMEN INTELLECTUAL PROPERTY SERVICES, INC.
2345 YALE STREET, 2ND FLOOR
PALO ALTO, CA 94306

FORMALITIES LETTER

Date Mailed: 09/08/2005

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
  Applicant must submit $ **150** *to complete the basic filing fee for a small entity.*
- The oath or declaration is missing. *A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.*
  Note: If a petition under 37 CFR 1.47 is being filed, an oath or declaration in compliance with 37 CFR 1.63 signed by all available joint inventors, or if no inventor is available by a party with sufficient proprietary interest, is required.

The applicant needs to satisfy supplemental fees problems indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.16(f) of $65 for a small entity in compliance with 37 CFR 1.27, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$565** for a Small Entity

- **$150** Statutory basic filing fee.
- **$65** Surcharge.

- The application search fee has not been paid. Applicant must submit **$250** to complete the search fee.

- The application examination fee has not been paid. Applicant must submit **$100** to complete the examination fee for a small entity in compliance with 37 CFR 1.27

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Office of Initial Patent Examination (571) 272-4000, or 1-800-PTO-9199, or 1-800-972-6382
PART 1 - ATTORNEY/APPLICANT COPY

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received 3.13.06 lumen

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US

CONFIRMATION NO. 4774

30869
LUMEN INTELLECTUAL PROPERTY SERVICES, INC.
2345 YALE STREET, 2ND FLOOR
PALO ALTO, CA 94306

OC000000018176830

Title: Logical spreadsheets

Publication No. US-2006-0048044-A1
Publication Date: 03/02/2006

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

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In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Pre-Grant Publication Division, 703-605-4283

Received
4-24-06 Lumen

UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER SECRETARY OF COMMERCE FOR INTELLECTUAL PROPERTY AND
DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

S04-076/US

APRIL 13, 2006

PTAS

103160982A

LUMEN INTELLECTUAL PROPERTY
SERVICES, INC.
2345 YALE STREET, 2ND FLOOR
PALO ALTO, CA 94306

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THE ENCLOSED DOCUMENT HAS BEEN RECORDED BY THE ASSIGNMENT DIVISION OF THE U.S. PATENT AND TRADEMARK OFFICE. A COMPLETE MICROFILM COPY IS AVAILABLE AT THE ASSIGNMENT SEARCH ROOM ON THE REEL AND FRAME NUMBER REFERENCED BELOW.

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RECORDATION DATE: 01/13/2006

REEL/FRAME: 017466/0104
NUMBER OF PAGES: 4

BRIEF: ASSIGNMENT OF ASSIGNOR'S INTEREST (SEE DOCUMENT FOR DETAILS).

ASSIGNOR:
GENESERETH, MICHAEL R.

DOC DATE: 01/09/2006

ASSIGNOR:
KASSOFF, MICHAEL

DOC DATE: 01/09/2006

ASSIGNOR:
LOVE, NATHANIEL C.

DOC DATE: 01/10/2006

ASSIGNEE:
THE BOARD OF TRUSTEES OF THE
LELAND STANFORD JUNIOR
UNIVERSITY
1705 EL CAMINO REAL
PALO ALTO, CALIFORNIA 94305

SERIAL NUMBER: 11197123
PATENT NUMBER:
TITLE: LOGICAL SPREADSHEETS

FILING DATE: 08/04/2005
ISSUE DATE:

MARCUS KIRK, EXAMINER
ASSIGNMENT SERVICES BRANCH
PUBLIC RECORDS DIVISION

Form PTO-1595 (Rev. 07/05)
OMB No. 0651-0027 (exp. 6/30/2008)

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01-19-2006

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United States Patent and Trademark Office

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1/13/6

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1. Name of conveying party(ies)

Michael R. Genesereth
Michael Kassoff
Nathaniel C. Love

Additional name(s) of conveying party(ies) attached? ☐ Yes ☑ No

2. Name and address of receiving party(ies)

Name: The Board of Trustees of the Leland Stanford Junior University

Internal Address:

Street Address: 1705 El Cmaino Real

City: Palo Alto

State: CA

Country: US Zip: 94305

Additional name(s) & address(es) attached? ☐ Yes ☑ No

3. Nature of conveyance/Execution Date(s):

Execution Date(s) 1/10/2006

☑ Assignment ☐ Merger
☐ Security Agreement ☐ Change of Name
☐ Joint Research Agreement
☐ Government Interest Assignment
☐ Executive Order 9424, Confirmatory License
☐ Other

4. Application or patent number(s):

☐ This document is being filed together with a new application.

A. Patent Application No.(s)
11/197,123

B. Patent No.(s)

01/13/2006 HDESTA1 00000011 11197123
01 FC:8021 40.00 OP

Additional numbers attached? ☐ Yes ☑ No

5. Name and address to whom correspondence concerning document should be mailed:

Name: Lumen Intellectual Property Services, Inc.

Internal Address:

Street Address: 2345 Yale Street, 2nd Floor

City: Palo Alto

State: CA Zip: 94306

Phone Number: 650-424-0100

Fax Number: 650-424-0141

Email Address:

6. Total number of applications and patents involved: 1

7. Total fee (37 CFR 1.21(h) & 3.41) $ 40.00

☑ Authorized to be charged by credit card
☐ Authorized to be charged to deposit account
☐ Enclosed
☐ None required (government interest not affecting title)

8. Payment Information

a. Credit Card Last 4 Numbers 9737
Expiration Date 10/06

b. Deposit Account Number

Authorized User Name

9. Signature:

Thomas J. McFarlane
Signature

11 JAN 2006
Date

Thomas McFarlane Reg. No.: 39,299
Name of Person Signing

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US	4774

30869 7590 06/24/2008

LUMEN PATENT FIRM, INC.
2345 YALE STREET
SECOND FLOOR
PALO ALTO, CA 94306

EXAMINER	
STORK, KYLE R	

ART UNIT	PAPER NUMBER
2178	

MAIL DATE	DELIVERY MODE
06/24/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/197,123	GENESERETH ET AL.	
	Examiner	Art Unit	
	KYLE R. STORK	2178	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *04 August 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-18* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *04 August 2005* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *8.4.05*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. This non-final office action is in response to the application filed 4 August 2005.

2. Claims 1-18 are pending. Claim 1 is an independent claim.

Information Disclosure Statement

3. The information disclosure statement (IDS) submitted on 4 August 2005 is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

Drawings

4. The examiner accepts the drawings filed 4 August 2005.

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

6. Claims 1, 4-5, 7-11, and 14-18 are rejected under 35 U.S.C. 102(b) as being anticipated by Felfernig et al. ("Developing constraint-based applications with

spreadsheets," published 1 January 2003 by Sprinter Berlin/Heidelberg, pp. 1-6, hereafter Felfernig).

As per independent claim 1, Felfernig discloses a method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells (Figure 1; page 3, left column: Here, a user defines the variables with their domain, and the problem constraints to be applied to the values within the domain)

dynamically partitioning the set of cells into base cells and computed cells (page 3, left column- page 3, right column: Here, based upon the constraints, one set of cells inherently is a set of base cells, while a second set of cells is inherently a set of computed cells. In the situation where an if-then-else constraint is used, the cell in which the "if" statement is applied is a base cell. Further, the cell or cells in which the "then" and "else" statements are applied to represent a set of computed cells, as these cells are based upon the computation of the base cell. Further, because the constraint values are dynamically added to the problem space (page 3, left column, final paragraph), these constraints are dynamic, thus the cells which the constraints apply to are similarly dynamic)

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints (page 3, left column- page 3, right column: Here, the user assigns inputs. Further, these inputs

may not initially comply with the underlying rules. However, a new set of values is calculated for the remaining variables in order to maintain compliance)

computing non-explosive logical consequences of the user-specified values and the set of logical constraints to produce a complete set of entailed values for the set of computed cells (page 3, left column- page 3, right column: Here, if a base input is non-compliant with the constraints, the underlying constraint propagator dynamically infers a set of compliant values for the remaining computed cells)

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell (page 5, left column- page 5, right column: Here, one optimal solutions is calculated from multiple alternative solutions)

displaying a subset of the entailed values and a subset of the user-specified values (page 3, right column: If the constraint solver obtains a suitable result, the data is displayed)

As per dependent claim 4, Felfernig discloses wherein the cells are able to contain multiple values (page 3, left column- page 3, right column: Here, each computed cell is capable of having a plurality of possible values based upon the entered value of the base cell. These possible values are values which meet the defined constraints).

As per dependent claim 5, Felfernig discloses wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set

of entailed values (page 3, left column- page 4, right column: Here, a subset of computed values is generated for each remaining computed cell based upon the input to the base cell. Each subset consists of computed cell values that meet the defined constraints).

As per dependent claim 7, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to a cell (page 3, left column).

As per dependent claim 8, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises declassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell (page 3, left column- page 3, right column: Here, the *AllDifferent* constraint is taught. This constraint requires that all cells contain different values. Based upon this constraint, the original cell, containing a user specified value, would be declassified as a base cell, and therefore become a computed cell).

As per dependent claim 9, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises declassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed (page 3, left column- page 3, right column).

As per dependent claim 10, Felfernig discloses wherein the logical constraints are formulated as relational constraints expressed in a logic language encompassing first-order logic (page 3, left column).

As per dependent claim 11, Felfernig discloses wherein the displaying comprises altering an appearance of cells containing inconsistent values (page 3, right column: Here, a user inputs values. These values may create conflicts with calculated cells. However, the calculated cells are recalculated based upon the inputted values, and the new calculated values are propagated to remove inconsistencies. Therefore, the appearance of the cells changes, as the old values are replaced with the new values).

As per dependent claim 14, Felfernig discloses wherein the displaying comprises providing an interactive user interface for an electronic document (page 3, right column).

As per dependent claim 15, Felfernig discloses wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document (page 3, right column: Here, the document is a spreadsheet document).

As per dependent claim 16, Felfernig discloses, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical constraints (page 3, left column- page 3, right column).

As per dependent claim 17, Felfernig discloses, responsive to a user instruction, automatically altering values of cells to reduce conflicts with logical constraints (page 3, right column).

As per dependent claim 18, Felfernig discloses wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed

value matches an existing value contained in the cell (page 5, left column- page 5, right column).

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

9. Claims 2-3 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Felfernig.

As per dependent claim 2, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig fails to specifically

disclose wherein the cells are named cells. However, the examiner takes official notice that it was notoriously well known in the art a the time of the applicant's invention that spreadsheet programs such as Microsoft(r) Excel(r) disclosed, at the time of the applicant's invention, spreadsheets containing named cells, where the name of a cell referred to the cells row and column. This naming convention allowed for the cells to be referenced via functions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known naming of cells with Felfernig, thereby allowing for cells to be referenced for computing functions.

As per dependent claim 3, Felfernig discloses the limitations similar to those in claim 2, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the named cells have structured names. However, the examiner takes official notice that programs such as Microsoft(r) Excel(r) disclosed, at the time of the applicant's invention, spreadsheets containing named cells, where the name of a cell referred to the cells row and column. The naming convention of using rows and columns creates a structured naming convention. Further, this naming convention allowed for the cells to be referenced via functions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known naming of cells with Felfernig, thereby allowing for cells to be referenced for computing functions.

As per dependent claim 6, Felfernig discloses the limitations similar to those in claim 5, and the same rejection is incorporated herein. Felfernig discloses determining an optimal solution (page 5, left column- page 5, right column: Here, one optimal

solutions is calculated from multiple alternative solutions). Felfernig fails to specifically disclose that the union of multiple subsets is used to determine entailed values. However, it was notoriously well known in the art at the time of the applicant's invention that, mathematically, a union is the overlap of multiple subsets. Therefore, applying a union operation to the multiple subsets would determine the most commonly occurring values for a plurality of computed cells, thereby creating an optimal set of solutions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known with Felfernig, since it would have allowed for determination of a more optimal solution for calculated cells.

10. Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Felfernig, and further in view of Wilson (US 2005/0226505, filed 31 March 2004).

As per dependent claim 12, Felfernig discloses the limitations similar to those in claim 11, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the changing the appearance of cells occurs in response to a user pointer hovering over the subset of cells. However, Wilson discloses the use of a hover in order to display menu options, thereby changing the appearance of the cells (paragraph 0073). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined Wilson with Felfernig, since it would have allowed a user to view a selectable data item from the displayed subset.

As per dependent claim 13, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig discloses values as

being non-explosively entailed, being non-explosively contradicted, or neither (page 3, left column- page 3, right column: Here, all values inherently fall into the category of being either non-explosively entailed or explosively entailed. Similarly, all values are either non-explosively contradicted or explosively contradicted). Felfernig fails to specifically disclose providing a menu associated with a cell, wherein the menu comprises a list of possible values. However, Wilson discloses a menu (paragraph 0073). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to combine Wilson with Felfernig, since it would have allowed a user to view a selectable data item from the displayed subset.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KYLE R. STORK whose telephone number is (571)272-4130. The examiner can normally be reached on Monday-Friday (8:00-4:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Hong can be reached on (571) 272-4124. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Kyle R Stork/

Kyle R Stork
Primary Examiner
Art Unit 2178

krs

Notice of References Cited	Application/Control No. 11/197,123	Applicant(s)/Patent Under Reexamination GENESERETH ET AL.	
	Examiner KYLE R. STORK	Art Unit 2178	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2005/0226505	10-2005	Wilson, Andrew D.	382/180
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Bibliographic data for Felfernig et al.
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US	4774

30869 7590 03/04/2009

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SECOND FLOOR
PALO ALTO, CA 94306

EXAMINER	
STORK, KYLE R	

ART UNIT	PAPER NUMBER
2178	

MAIL DATE	DELIVERY MODE
03/04/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/197,123	GENESERETH ET AL.	
	Examiner	Art Unit	
	KYLE R. STORK	2178	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

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- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *04 December 2008*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-4 and 6-18* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-4 and 6-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. This final office action is in response to the amendment filed 4 December 2008.

2. Claims 1-4 and 6-18 are pending. Claim 1 is an independent claim.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

4. Claims 1, 4, 7-11, and 14-18 remain rejected under 35 U.S.C. 102(b) as being anticipated by Felfernig et al. ("Developing constraint-based applications with spreadsheets," published 1 January 2003 by Sprinter Berlin/Heidelberg, pp. 1-6, hereafter Felfernig).

As per independent claim 1, Felfernig discloses a method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells (Figure 1; page 3, left column: Here, a user defines the variables with their domain, and the problem constraints to be applied to the values within the domain)

dynamically partitioning the set of cells into base cells and computed cells (page 3, left column- page 3, right column: Here, based upon the constraints, one set of cells inherently is a set of base cells, while a second set of cells is inherently a set of

computed cells. In the situation where an if-then-else constraint is used, the cell in which the "if" statement is applied is a base cell. Further, the cell or cells in which the "then" and "else" statements are applied to represent a set of computed cells, as these cells are based upon the computation of the base cell. Further, because the constraint values are dynamically added to the problem space (page 3, left column, final paragraph), these constraints are dynamic, thus the cells which the constraints apply to are similarly dynamic)

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints (page 3, left column- page 3, right column: Here, the user assigns inputs. Further, these inputs may not initially comply with the underlying rules. However, a new set of values is calculated for the remaining variables in order to maintain compliance)

computing non-explosive logical consequences of the user-specified values and the set of logical constraints to produce a complete set of entailed values for the set of computed cells (page 3, left column- page 3, right column: Here, if a base input is non-compliant with the constraints, the underlying constraint propagator dynamically infers a set of compliant values for the remaining computed cells)

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell (page 5, left column- page 5, right column: Here, one optimal solutions is calculated from multiple alternative solutions)

displaying a subset of the entailed values and a subset of the user-specified values (page 3, right column: If the constraint solver obtains a suitable result, the data is displayed)

wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values (page 3, left column- page 4, right column: Here, a subset of computed values is generated for each remaining computed cell based upon the input to the base cell. Each subset consists of computed cell values that meet the defined constraints).

As per dependent claim 4, Felfernig discloses wherein the cells are able to contain multiple values (page 3, left column- page 3, right column: Here, each computed cell is capable of having a plurality of possible values based upon the entered value of the base cell. These possible values are values which meet the defined constraints).

As per dependent claim 7, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to a cell (page 3, left column).

As per dependent claim 8, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises declassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell (page 3, left column- page 3, right column: Here, the *AllDifferent* constraint is taught. This constraint requires that all cells contain

different values. Based upon this constraint, the original cell, containing a user specified value, would be declassified as a base cell, and therefore become a computed cell).

As per dependent claim 9, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises declassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed (page 3, left column- page 3, right column).

As per dependent claim 10, Felfernig discloses wherein the logical constraints are formulated as relational constraints expressed in a logic language encompassing first-order logic (page 3, left column).

As per dependent claim 11, Felfernig discloses wherein the displaying comprises altering an appearance of cells containing inconsistent values (page 3, right column: Here, a user inputs values. These values may create conflicts with calculated cells. However, the calculated cells are recalculated based upon the inputted values, and the new calculated values are propagated to remove inconsistencies. Therefore, the appearance of the cells changes, as the old values are replaced with the new values).

As per dependent claim 14, Felfernig discloses wherein the displaying comprises providing an interactive user interface for an electronic document (page 3, right column).

As per dependent claim 15, Felfernig discloses wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document (page 3, right column: Here, the document is a spreadsheet document).

As per dependent claim 16, Felfernig discloses, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical constraints (page 3, left column- page 3, right column).

As per dependent claim 17, Felfernig discloses, responsive to a user instruction, automatically altering values of cells to reduce conflicts with logical constraints (page 3, right column).

As per dependent claim 18, Felfernig discloses wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed value matches an existing value contained in the cell (page 5, left column- page 5, right column).

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation

under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7. Claims 2-3 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Felfernig.

As per dependent claim 2, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the cells are named cells. However, the examiner takes official notice that it was notoriously well known in the art a the time of the applicant's invention that spreadsheet programs such as Microsoft(r) Excel(r) disclosed, at the time of the applicant's invention, spreadsheets containing named cells, where the name of a cell referred to the cells row and column. This naming convention allowed for the cells to be referenced via functions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known naming of cells with Felfernig, thereby allowing for cells to be referenced for computing functions.

As per dependent claim 3, Felfernig discloses the limitations similar to those in claim 2, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the named cells have structured names. However, the examiner takes official notice that programs such as Microsoft(r) Excel(r) disclosed, at the time of the applicant's invention, spreadsheets containing named cells, where the name of a cell

referred to the cells row and column. The naming convention of using rows and columns creates a structured naming convention. Further, this naming convention allowed for the cells to be referenced via functions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known naming of cells with Felfernig, thereby allowing for cells to be referenced for computing functions.

As per dependent claim 6, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig discloses determining an optimal solution (page 5, left column- page 5, right column: Here, one optimal solutions is calculated from multiple alternative solutions). Felfernig fails to specifically disclose that the union of multiple subsets is used to determine entailed values. However, it was notoriously well known in the art at the time of the applicant's invention that, mathematically, a union is the overlap of multiple subsets. Therefore, applying a union operation to the multiple subsets would determine the most commonly occurring values for a plurality of computed cells, thereby creating an optimal set of solutions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known with Felfernig, since it would have allowed for determination of a more optimal solution for calculated cells.

8. Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Felfernig, and further in view of Wilson (US 2005/0226505, filed 31 March 2004).

As per dependent claim 12, Felfernig discloses the limitations similar to those in claim 11, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the changing the appearance of cells occurs in response to a user pointer hovering over the subset of cells. However, Wilson discloses the use of a hover in order to display menu options, thereby changing the appearance of the cells (paragraph 0073). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined Wilson with Felfernig, since it would have allowed a user to view a selectable data item from the displayed subset.

As per dependent claim 13, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig discloses values as being non-explosively entailed, being non-explosively contradicted, or neither (page 3, left column- page 3, right column: Here, all values inherently fall into the category of being either non-explosively entailed or explosively entailed. Similarly, all values are either non-explosively contradicted or explosively contradicted). Felfernig fails to specifically disclose providing a menu associated with a cell, wherein the menu comprises a list of possible values. However, Wilson discloses a menu (paragraph 0073). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to combine Wilson with Felfernig, since it would have allowed a user to view a selectable data item from the displayed subset.

Response to Arguments

9. Applicant's arguments filed 4 December 2008 have been fully considered but they are not persuasive.

The applicant argues that the prior art fails to disclose wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values (pages 5-7). However, the examiner respectfully disagrees. Felfernig discloses wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values (page 3, left column- page 4, right column: Here, a subset of computed values is generated for each remaining computed cell based upon the input to the base cell. Each subset consists of computed cell values that meet the defined constraints).

The applicant points to the specification to define entailed values (page 6). Here, entailed values are defined as “the non-explosive consequences of the values in the base cells and the specified logical constraints (page 6).” It must be pointed out that Felfernig discloses base cells having applied logical constraints (page 3). Here, the cells may contain arithmetic and logical operators or constraints (page 3, left column). Additionally, cells may have Constraint Satisfaction problems applied. Therefore, Felfernig discloses the use of entailed values.

Conclusion

10. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KYLE R. STORK whose telephone number is (571)272-4130. The examiner can normally be reached on Monday-Friday (8:00-4:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Hong can be reached on (571) 272-4124. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Kyle Stork/

Kyle R Stork
Examiner
Art Unit 2178

/Stephen S. Hong/
Supervisory Patent Examiner, Art Unit 2178

krs

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US	4774

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EXAMINER	
STORK, KYLE R	

ART UNIT	PAPER NUMBER
2178	

MAIL DATE	DELIVERY MODE
08/12/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	11/197,123	GENESERETH ET AL.	
	Examiner	Art Unit	
	KYLE R. STORK	2178	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08 June 2009*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-4 and 6-18* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-4 and 6-18* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. This non-final office action is in response to the RCE and Remarks filed 8 June 2009.

2. Claims 1-4 and 6-18 are pending. Claim 1 is an independent claim.

The rejection of claims 1, 4, 7-11, and 14-18 under 35 USC 102 over Felfernig et al. ("Developing constraint-based applications with spreadsheets," published 1 January 2003 by Sprinter Berlin/Heidelberg, pp. 1-6, hereafter Felfernig) has been withdrawn in view of the applicant's remarks.

The rejection of claims 2-3 and 6 under 35 USC 103 over Felfernig has been withdrawn in view of the applicant's remarks.

The rejection of claims 12-13 under 35 USC 103 over Felfernig and further in view of Wilson (US 2005/0226505, filed 31 March 2004) has been withdrawn in view of the applicant's remarks.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of

the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 1-4, 6-11, and 14-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Felfernig et al. ("Developing constraint-based applications with spreadsheets," published 1 January 2003 by Sprinter Berlin/Heidelberg, pp. 1-6, hereafter Felfernig) and further in view of Breuer (US 2002/0055954, provisional filed 4 June 2001).

As per independent claim 1, Felfernig discloses a method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells (Figure 1; page 3, left column: Here, a user defines the variables with their domain, and the problem constraints to be applied to the values within the domain)

dynamically partitioning the set of cells into base cells and computed cells (page 3, left column- page 3, right column: Here, based upon the constraints, one set of cells

inherently is a set of base cells, while a second set of cells is inherently a set of computed cells. In the situation where an if-then-else constraint is used, the cell in which the "if" statement is applied is a base cell. Further, the cell or cells in which the "then" and "else" statements are applied to represent a set of computed cells, as these cells are based upon the computation of the base cell. Further, because the constraint values are dynamically added to the problem space (page 3, left column, final paragraph), these constraints are dynamic, thus the cells which the constraints apply to are similarly dynamic)

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints (page 3, left column- page 3, right column: Here, the user assigns inputs. Further, these inputs may not initially comply with the underlying rules. However, a new set of values is calculated for the remaining variables in order to maintain compliance)

computing non-explosive logical consistencies of the user-specified values and the set of logical consistencies to produce a complete set of values for the set of computed cells (page 3, left column- page 3, right column: Here, if a base input is non-compliant with the constraints, the underlying constraint propagator dynamically infers a set of compliant values for the remaining computed cells)

reducing the number of values for each computed cell whose number of values exceeds a predetermined number of allowed values for the computed cell (page 5, left column- page 5, right column: Here, one optimal solutions is calculated from multiple alternative solutions)

displaying a subset of the values and a subset of the user-specified values (page 3, right column: If the constraint solver obtains a suitable result, the data is displayed)

wherein computing the logical consistencies comprises computing logical consistencies of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of values, and combining the multiple subsets of the complete set of values (page 3, left column- page 4, right column: Here, a subset of computed values is generated for each remaining computed cell based upon the input to the base cell. Each subset consists of computed cell values that meet the defined consistencies).

Felfernig fails to disclose:

computing non-explosive logical constraints of the user-specified entailed values and the set of logical constraints to produce a complete set of values for the set of computed cells

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed entailed values for the computed cell

displaying a subset of the entailed values and a subset of the user-specified entailed values

wherein computing the logical constraints comprises computing logical constraints of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values

However, Breuer discloses:

computing non-explosive logical constraints of the user-specified entailed values and the set of logical constraints to produce a complete set of values for the set of computed cells (Figure 10; paragraphs 0015-0016 and 0062-0063

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed entailed values for the computed cell (Figure 10; paragraphs 0015-0016 and 0062-0063

displaying a subset of the entailed values and a subset of the user-specified entailed values (Figure 10; paragraphs 0015-0016 and 0062-0063

wherein computing the logical constraints comprises computing logical constraints of multiple consistent subsets of the user specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values (Figure 10; paragraphs 0015-0016 and 0062-0063: Here, a user may enter data into a spreadsheet having circular references. Entering such data may cause entailed values with are inconsistent with the logical constraints of the cell. For example, it is possible for cell A1 to display a value of “4” while cell B1 has a value of “A1-2=3" (paragraph 0063). The value of A1 is an entailed value that is not logically consistent with the value of B1. However, the user is able to select the option to “make row self-consistent” (paragraph 0063) or to close a circular reference (paragraph 0062). This reduces the number of entailed values and produces outputs which are logically consistent with the applied cell values).

It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined Breuer with Felfernig, since it would have allowed a user to derive consistency within a spreadsheet from logically constrained values.

As per dependent claim 2, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the cells are named cells. However, the examiner takes official notice that it was notoriously well known in the art a the time of the applicant's invention that spreadsheet programs such as Microsoft(r) Excel(r) disclosed, at the time of the applicant's invention, spreadsheets containing named cells, where the name of a cell referred to the cells row and column. This naming convention allowed for the cells to be referenced via functions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known naming of cells with Felfernig, thereby allowing for cells to be referenced for computing functions.

As per dependent claim 3, Felfernig discloses the limitations similar to those in claim 2, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the named cells have structured names. However, the examiner takes official notice that programs such as Microsoft(r) Excel(r) disclosed, at the time of the applicant's invention, spreadsheets containing named cells, where the name of a cell referred to the cells row and column. The naming convention of using rows and columns creates a structured naming convention. Further, this naming convention allowed for the cells to be referenced via functions. It would have been obvious to one

of ordinary skill in the art at the time of the applicant's invention to have combined the well known naming of cells with Felfernig, thereby allowing for cells to be referenced for computing functions.

As per dependent claim 4, Felfernig discloses wherein the cells are able to contain multiple values (page 3, left column- page 3, right column: Here, each computed cell is capable of having a plurality of possible values based upon the entered value of the base cell. These possible values are values which meet the defined constraints).

As per dependent claim 6, Felfernig discloses the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig discloses determining an optimal solution (page 5, left column- page 5, right column: Here, one optimal solutions is calculated from multiple alternative solutions). Felfernig fails to specifically disclose that the union of multiple subsets is used to determine entailed values. However, it was notoriously well known in the art at the time of the applicant's invention that, mathematically, a union is the overlap of multiple subsets. Therefore, applying a union operation to the multiple subsets would determine the most commonly occurring values for a plurality of computed cells, thereby creating an optimal set of solutions. It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined the well known with Felfernig, since it would have allowed for determination of a more optimal solution for calculated cells.

As per dependent claim 7, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to a cell (page 3, left column).

As per dependent claim 8, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises declassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell (page 3, left column- page 3, right column).

As per dependent claim 9, Felfernig discloses wherein dynamically partitioning the set of cells into base cells and computed cells comprises declassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed (page 3, left column- page 3, right column).

As per dependent claim 10, Felfernig discloses wherein the logical consistencies are formulated as relational consistencies expressed in a logic language encompassing first-order logic (page 3, left column). Felfernig fails to specifically disclose logical constraints. However, Breuer discloses the use of logical constraints (paragraphs 0062-0063). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined Breuer with Felfernig, since it would have allowed a user to derive consistency within a spreadsheet from logically constrained values.

As per dependent claim 11, Felfernig discloses wherein the displaying comprises altering an appearance of cells containing inconsistent values (page 3, right column: Here, a user inputs values. These values may create conflicts with calculated cells. However, the calculated cells are recalculated based upon the inputted values, and the new calculated values are propagated to remove inconsistencies. Therefore, the appearance of the cells changes, as the old values are replaced with the new values).

As per dependent claim 14, Felfernig discloses wherein the displaying comprises providing an interactive user interface for an electronic document (page 3, right column).

As per dependent claim 15, Felfernig discloses wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document (page 3, right column: Here, the document is a spreadsheet document).

As per dependent claim 16, Felfernig discloses, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical consistencies (page 3, left column- page 3, right column). Felfernig fails to specifically disclose logical constraints. However, Breuer discloses the use of logical constraints (paragraphs 0062-0063). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined Breuer with Felfernig, since it would have allowed a user to derive consistency within a spreadsheet from logically constrained values.

As per dependent claim 17, Felfernig discloses, responsive to a user instruction, automatically altering values of cells to reduce conflicts with logical constraints (page 3, right column).

As per dependent claim 18, Felfernig discloses wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed value matches an existing value contained in the cell (page 5, left column- page 5, right column).

6. Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Felfernig and Breuer, and further in view of Wilson (US 2005/0226505, filed 31 March 2004).

As per dependent claim 12, Felfernig and Breuer disclose the limitations similar to those in claim 11, and the same rejection is incorporated herein. Felfernig fails to specifically disclose wherein the changing the appearance of cells occurs in response to a user pointer hovering over the subset of cells. However, Wilson discloses the use of a hover in order to display menu options, thereby changing the appearance of the cells (paragraph 0073). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have combined Wilson with Felfernig, since it would have allowed a user to view a selectable data item from the displayed subset.

As per dependent claim 13, Felfernig and Breuer disclose the limitations similar to those in claim 1, and the same rejection is incorporated herein. Felfernig discloses values as being non-explosively entailed, being non-explosively contradicted, or neither (page 3, left column- page 3, right column: Here, all values inherently fall into the category of being either non-explosively entailed or explosively entailed. Similarly, all values are either non-explosively contradicted or explosively contradicted). Felfernig fails to specifically disclose providing a menu associated with a cell, wherein the menu comprises a list of possible values. However, Wilson discloses a menu (paragraph 0073). It would have been obvious to one of ordinary skill in the art at the time of the applicant's invention to combine Wilson with Felfernig, since it would have allowed a user to view a selectable data item from the displayed subset.

Response to Arguments

7. Applicant's arguments with respect to claims 1-4 and 6-18 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KYLE R. STORK whose telephone number is (571)272-4130. The examiner can normally be reached on Monday-Friday (8:00-4:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Stephen Hong can be reached on (571) 272-4124. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Kyle R Stork/
Primary Examiner, Art Unit 2178

Notice of References Cited	Application/Control No. 11/197,123	Applicant(s)/Patent Under Reexamination GENESERETH ET AL.	
	Examiner KYLE R. STORK	Art Unit 2178	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2002/0055954	05-2002	Breuer, Matthias	707/507
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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NOTICE OF ALLOWANCE AND FEE(S) DUE

30869 7590 02/19/2010

LUMEN PATENT FIRM
350 Cambridge Avenue
Suite 100
PALO ALTO, CA 94306

EXAMINER	
STORK, KYLE R	
ART UNIT	PAPER NUMBER
2178	

DATE MAILED: 02/19/2010

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US	4774

TITLE OF INVENTION: LOGICAL SPREADSHEETS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	05/19/2010

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 08/07) Approved for use through 08/31/2010.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

30869 7590 02/19/2010

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350 Cambridge Avenue
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PALO ALTO, CA 94306

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US	4774

TITLE OF INVENTION: LOGICAL SPREADSHEETS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	05/19/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
STORK, KYLE R	2178	715-500000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee

❑ Publication Fee (No small entity discount permitted)

❑ Advance Order - # of Copies _____

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❑ A check is enclosed.

❑ Payment by credit card. Form PTO-2038 is attached.

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	08/04/2005	Michael R. Genesereth	S04-076/US	4774

30869 7590 02/19/2010

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PALO ALTO, CA 94306

EXAMINER	
STORK, KYLE R	
ART UNIT	PAPER NUMBER
2178	

DATE MAILED: 02/19/2010

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 522 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 522 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice of Allowability	Application No.	Applicant(s)	
	11/197,123	GENESERETH ET AL.	
	Examiner	Art Unit	
	KYLE R. STORK	2178	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *amendment filed 14 December 2009*.

2. ☒ The allowed claim(s) is/are *1-4 and 6-18*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Kyle R Stork/
Primary Examiner, Art Unit 2178

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/197,123	04/27/2010	7707486	S04-076/US	4774

30869 7590 04/07/2010

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PALO ALTO, CA 94306

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 829 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Michael R. Genesereth, Palo Alto, CA;
Michael Kassoff, Mountain View, CA;
Nathaniel C. Love, San Francisco, CA;

US007707486B2

(12) **United States Patent**
Genesereth et al.

(10) **Patent No.: US 7,707,486 B2**
(45) **Date of Patent: Apr. 27, 2010**

(54) **LOGICAL SPREADSHEETS**

(75) Inventors: **Michael R. Genesereth**, Palo Alto, CA (US); **Michael Kassoff**, Mountain View, CA (US); **Nathaniel C. Love**, San Francisco, CA (US)

(73) Assignee: **The Board of Trustees of the Leland Stanford Junior University**, Palo Alto, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 829 days.

(21) Appl. No.: **11/197,123**

(22) Filed: **Aug. 4, 2005**

(65) **Prior Publication Data**

US 2006/0048044 A1 Mar. 2, 2006

Related U.S. Application Data

(60) Provisional application No. 60/599,644, filed on Aug. 6, 2004.

(51) **Int. Cl.**
G06N 3/00 (2006.01)

(52) **U.S. Cl.** **715/212**

(58) **Field of Classification Search** 715/212, 715/213, 214, 215, 216, 217, 218, 219, 220
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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2002/0055954	A1*	5/2002	Breuer	707/507
2005/0226505	A1*	10/2005	Wilson	382/180

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Bibliographic data for Felfernig et al.*

A. Felfernig et al., "Developing constraint-based applications with spreadsheets," Computer Science and Manufacturing, Universitat Klagenfurt, A-020 Klagenfurt, Austria.

Gopal Gupta et al., "Knowledgesheet: A Graphical Spreadsheet Interface for Interactively Developing a Class of Constraint Programs," Laboratory for Logic, Databases, and Advanced Programming, Department of Computer Science, New Mexico State University, Las Cruces, NM.

Michael Spenke et al., "A Spreadsheet Interface for Logic Programming," Chi '89 Proceedings, May 1989, German National Research Center for Computer Science, pp. 75-80.

Marc Stadelmann, "A Spreadsheet Based on Constraints," UIST'93, University of Victoria, Department of Computer Science, Nov. 3-5, 1993.

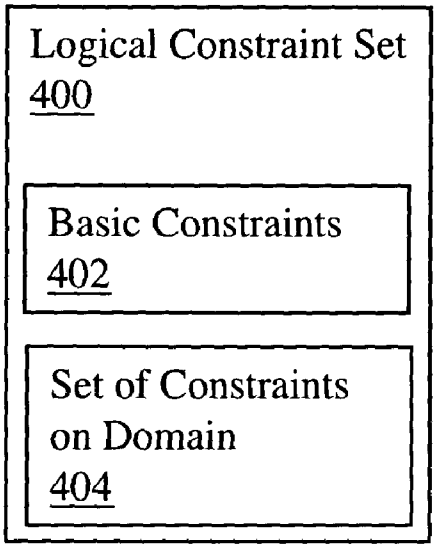
* cited by examiner

Primary Examiner—Kyle R Stork
(74) *Attorney, Agent, or Firm*—Lumen Patent Firm

(57) **ABSTRACT**

A computerized spreadsheet system includes a set of cells and a separate set of logical constraints on the values of cells. The constraints may be many-to-many relationships that permit omni-directional propagation of values between cells. The constraints may be expressed in a language encompassing first-order logic. Cells are dynamically reclassified as base cells or computed cells as a user specifies values for cells. Non-explosive consequences of the base cell values are computed and displayed in computed cells, even when the values in the base cells are inconsistent with the constraints. The spreadsheet system may also include an auto-complete feature that automatically fills in empty cells with values consistent with the logical constraints and an auto-deconflict feature that automatically changes values in cells to reduce conflicts with the logical constraints.

17 Claims, 4 Drawing Sheets



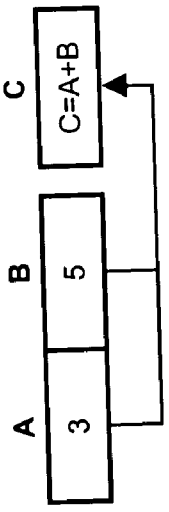


Fig. 1

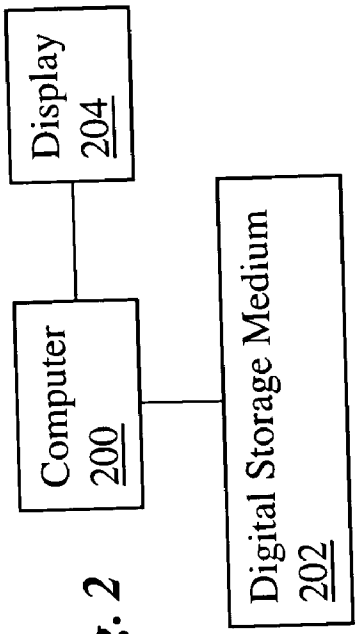


Fig. 2

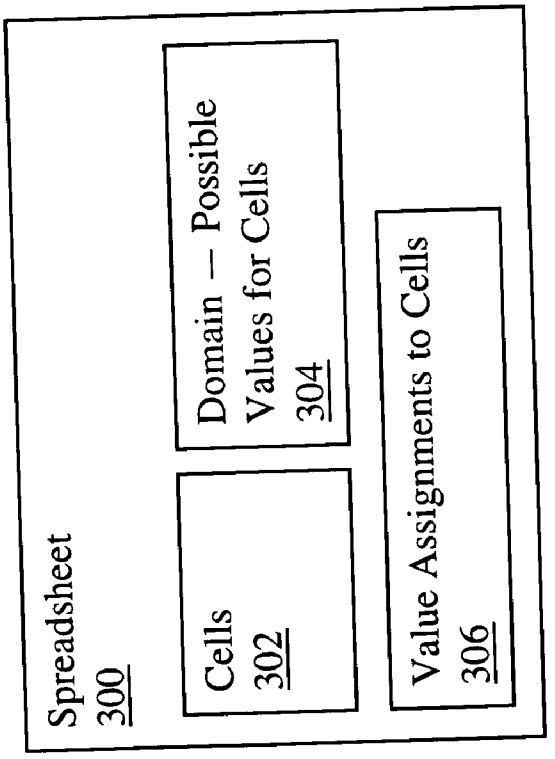


Fig. 3

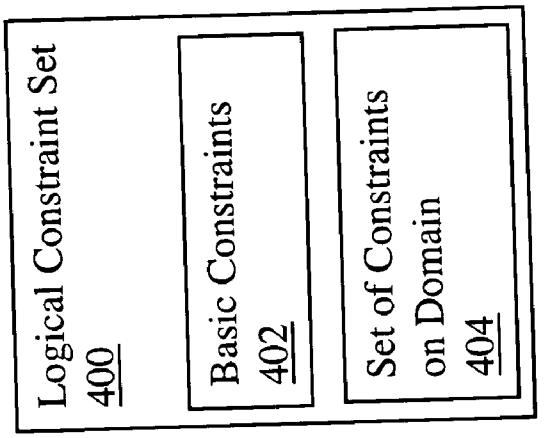


Fig. 4

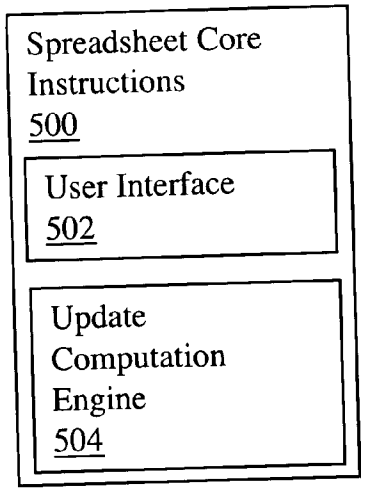


Fig. 5

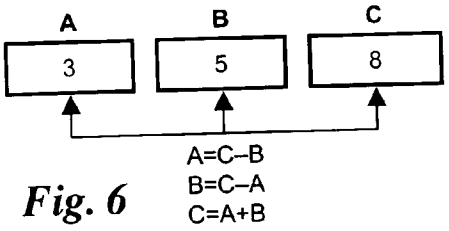


Fig. 6

Event	Owner	Projection	Room	Time
E1	Amy	No	G100	Morning
E2	Bob	Yes	G200	Afternoon
E3	Cal	No	G100	

Fig. 7A

Schedule	G100	G200	G300
Morning	E1		
Afternoon			
Evening			

Fig. 7B

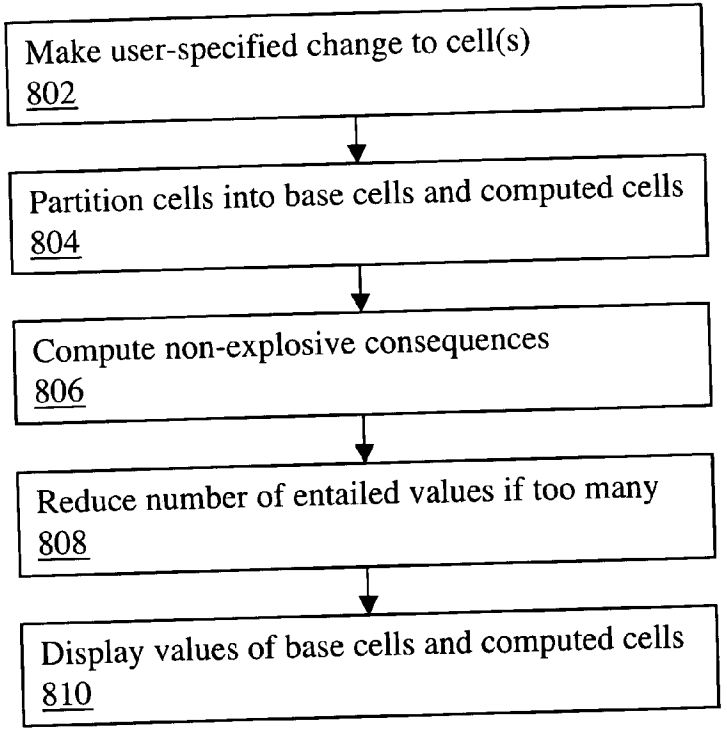
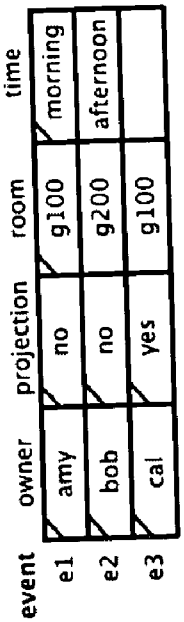
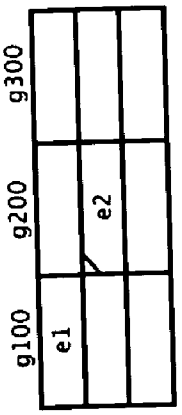


Fig. 8



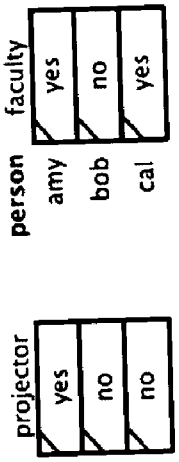
event	owner	projection	room	time
e1	amy	no	g100	morning
e2	bob	no	g200	afternoon
e3	cal	yes	g100	

Fig. 10A



schedule	g100	g200	g300
morning	e1		
afternoon		e2	
evening			

Fig. 10B

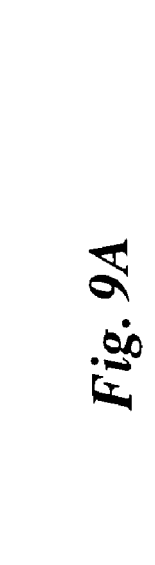


room	projector
g100	yes
g200	no
g300	no

Fig. 10C

person	faculty
amy	yes
bob	no
cal	yes

Fig. 10D

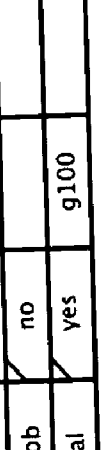


event	owner	projection	room	time
e1	amy	no		
e2	bob	no		
e3	cal	yes	g100	

Fig. 9A

schedule	g100	g200	g300
morning			
afternoon			
evening			

Fig. 9B



room	projector
g100	yes
g200	no
g300	no

Fig. 9C

person	faculty
amy	yes
bob	no
cal	yes

Fig. 9D

event	owner	projection	room	time
e1	amy	no	g100	evening
e2	bob	no	g200	afternoon
e3	cal	yes	g200	

Fig. 11A

schedule	g100	g200	g300
morning			
afternoon		e2	
evening	e1		

Fig. 11B

room	projector
g100	yes
g200	no
g300	no

Fig. 11C

person	faculty
amy	yes
bob	no
cal	yes

Fig. 11D

event	owner	projection	room	time
e1	amy	no	g100	evening
e2	bob	no	g200	afternoon
e3	cal	yes	g200	morning

Fig. 12A

schedule	g100	g200	g300
morning		e3	
afternoon		e2	
evening	e1		

Fig. 12B

room	projector
g100	yes
g200	no
g300	no

Fig. 12C

person	faculty
amy	yes
bob	no
cal	yes

Fig. 12D

LOGICAL SPREADSHEETS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. provisional patent application No. 60/599,644 filed Aug. 6, 2004, which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to computer-implemented methods and systems involving spreadsheets, specifically spreadsheets that use relational logic and handle inconsistencies.

BACKGROUND OF THE INVENTION

Traditional computerized spreadsheet systems have enjoyed great success, due primarily to their ability to automatically evaluate multiple mathematical formulas and display updated calculated values whenever user-entered data changes. Traditional spreadsheets employ a user interface for entering data and formulas into cells, combined with an underlying computation engine to support and perform operations on the data according to the formulas. A non-empty cell either contains a specific value entered by the user, or contains a computed value calculated using the formula in the cell. A formula in a cell is a single-valued function of other cells that assigns a unique value to the cell. The restriction to single-valued functions prevents ambiguities in calculated values. Circular references between formulas are not allowed, thus preventing inconsistencies from occurring. Thus, the propagation of values within the spreadsheet is one-way from cells containing specific user-entered data to computed cells containing formulas. For example, in the three-cell spreadsheet of FIG. **1**, cells labeled A and B contain user-entered data, while cell C contains the formula C=A+B. The value of cell C is updated automatically based on the values of cells A and B. The user is not permitted to directly change the calculated value for cell C, nor is the spreadsheet permitted to change values in cells A and B. The propagation is thus one-way from cells A and B to cell C, and the distinction between calculated cells and cells containing user-entered values is explicitly determined by the placement of the formula in cell C. One can also observe that the formula C=A+B is a single-valued function which generates a unique value for C given values for A and B. Although these properties of traditional spreadsheets provide simplicity and enforce consistency, they do so at the cost of flexibility.

Another limitation of traditional spreadsheets is that the formulas are typically restricted to algebraic operators (e.g., $+, -, \times, \div, \sqrt{}, \Sigma$) and logical connectives (e.g., $\wedge, \vee, \neg$). While these have sufficient expressive power for many applications, they are not powerful enough to express the formulas desired for other applications.

In view of the widespread use of spreadsheets for many applications, it would be an improvement in the art to overcome these limitations and other limitations.

SUMMARY OF THE INVENTION

The present invention provides a powerful computerized spreadsheet system with numerous advantages over existing systems. The many-to-one functions of traditional spreadsheets are generalized to many-to-many constraints. In contrast to traditional spreadsheets in which cells must have one value or one formula defining the cell value, cells in the present spreadsheet system can contain multiple values and be associated with multiple constraints. In addition, the constraints are separated from the cells. Because inconsistencies are not controlled by the restriction to unidirectional functions, the spreadsheet system provides an innovative technique for calculating non-explosive consequences for cells even in cases where the data is inconsistent with the constraints.

In contrast with traditional spreadsheets, the distinction between base cells and computed cells is not fixed but dynamic, and the restriction to unidirectional propagation that is found in traditional spreadsheets is relaxed to allow omni-directional propagation. In addition, the formula language is not limited to functions formed from logical connectives and/or algebraic operators, but can include general first-order logical relationships (e.g., allowing quantifiers $\forall$ and $\exists$). Moreover, the spreadsheet cells are structured, allowing rows and columns to be quantified over, providing the ability for the spreadsheet to be queried like a relational database.

In one aspect, the invention provides a computer-implemented method for displaying consequences in an electronic spreadsheet. A set of cells of the spreadsheet and a set of logical constraints on possible values of the cells is specified. At various times during interactive operation with a user, the set of cells may be dynamically partitioned into base cells and computed cells. A set of user-specified values is assigned to the base cells. Significantly, the user is allowed to specify values that may be inconsistent with the specified logical constraints. Non-explosive logical consequences of the user-specified values and the set of logical constraints are automatically computed to produce a complete set of entailed values for the set of computed cells. Some computed cells may have multiple entailed values. For each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell, a subset of the entailed values is selected, where the size of the subset is no more than the number of allowed values. Some of the entailed values and some of the user-specified values are displayed. (Although all cells and their values may be displayed, it is not necessary to display all cells and all values at once.)

Preferably, the cells are named cells, and may have structured names. The cells may also be able to contain multiple values. The logical constraints are preferably formulated as relational constraints expressed in a logical language encompassing first-order logic. The non-explosive logical consequences may be found by computing logical consequences of multiple consistent subsets of the user-specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values, e.g., by taking the union of the multiple subsets of the complete set of entailed values. If one of multiple entailed values for a cell matches an existing value contained in the cell, a subset of the entailed values for the cell may be taken by eliminating all but a single entailed value. If the cell was just explicitly emptied by the user, the entailed values for the cell may be replaced by the empty set, eliminating all the entailed values for that cell.

The dynamic partitioning of the set of cells into base cells and computed cells may include one or more of the following: classifying a cell as a base cell when a user-specified value is explicitly assigned to the cell, unclassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell, unclassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed.

In one embodiment, the appearance of cells containing inconsistent values may be altered when they are displayed. The alteration may include, for example, dynamically changing the appearance of a subset of cells containing related inconsistent values when a user pointer hovers over the subset of cells. The displaying may also include providing a menu associated with a cell, where the menu contains a list of possible values. Preferably, the possible values are classified, e.g., by labeling them as either being non-explosively entailed, being non-explosively contradicted, or neither.

An interactive user interface may be provided for an electronic document such as a spreadsheet document, an HTML document, a word processing document, and a PDF document, in order to display the values and receive input from a user. Responsive to a user instruction, values may be specified for cells, or existing values in cells may be cleared. In addition, in response to a user instruction, values may be automatically assigned to empty cells such that the automatically assigned values are consistent with the logical constraints. A user may also give an instruction to execute an automatic altering values of cells to reduce conflicts with the logical constraints.

In brief, the present invention provides spreadsheet systems which allow for general logical constraints and omnidirectional propagation. These spreadsheets provide greater benefits than traditional spreadsheets while preserving the key features of automatic calculation of values and ease of administration. They have applications in data management, design, and configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a traditional spreadsheet having two base cells and one computed cell.

FIG. **2** is a schematic diagram of a computer system which may be used to implement a spreadsheet system according to an embodiment of the invention.

FIG. **3** is a diagram illustrating the data structures contained within a spreadsheet.

FIG. **4** is a diagram illustrating a set of logical constraints that are used in a logical spreadsheet according to an embodiment of the invention.

FIG. **5** is a diagram illustrating a set of core instructions that are used in a spreadsheet.

FIG. **6** is a schematic diagram of a logical spreadsheet having three cells dynamically partitioned between base cells and computed cells according to an embodiment of the invention.

FIGS. **7**A and **7**B show two tables as they might be displayed to a user in a spreadsheet created using a spreadsheet system according to an embodiment of the invention.

FIG. **8** is a flowchart outlining steps performed by a spreadsheet system according to an embodiment of the invention.

FIGS. **9**A-D are schematic diagrams of four tables of an exemplary spreadsheet in an early stage of modification by a user in accordance with an embodiment of the invention.

FIGS. **10**A-D show the tables of the exemplary spreadsheet of FIGS. **9**A-D in an intermediate stage of modification by a user.

FIGS. **11**A-D show the tables of the exemplary spreadsheet of FIGS. **10**A-D in a later stage of modification by a user.

FIGS. **12**A-D show the tables of the exemplary spreadsheet of FIGS. **11**A-D in a still later stage of modification by a user.

DETAILED DESCRIPTION

A key feature of the logical spreadsheets of the present invention is that they allow for inconsistency between the value assignments and the constraints. This approach differs from the traditional consistency-maintaining techniques. In addition to allowing for inconsistencies, these spreadsheets actually show the consequences of the value assignments, even when the assignments are inconsistent with the constraints. Consequences under inconsistency are computed using a non-explosive consequence relation. As with traditional electronic spreadsheets, the spreadsheets of the present invention may be implemented on a single computer **200** having a digital storage medium **202** and display **204**, as shown in FIG. **2**. Alternatively, the spreadsheet may be implemented in a distributed computing environment, in separate computers over a computer network, or in various other hardware and network architectures and computing environments. Those skilled in the art will appreciate that many such implementations and realizations are possible and that the invention is not in principle limited to any specific one.

Definitions

The following definitions will be used for terms used in this description. In its most abstract sense, a spreadsheet **300** can be defined as a collection of n cells **302** together with a set of possible values for these cells **304**, as shown in FIG. **3**. The set of possible values for the cells is called the spreadsheet's domain. Cells can be associated with values in the domain. We represent these associations with sets of ground atomic sentences with a unary relation constant. The individual unary ground atomic sentences are called value assignments. A spreadsheet also includes a set of value assignments to the cells **306**. A value map is a set of value assignments in which each cell is assigned at most one value. For example, {p(a), q(b)} means that cell p has value a and cell q has value b. A value map is complete if and only if it provides a value for every cell; otherwise, it is partial. An update request is a value map together with a set of cells to be emptied.

A logical spreadsheet is a spreadsheet together with a set of logical constraints **400**, as shown in FIG. **4**. The vocabulary of the constraint language for logical spreadsheets consists of a finite set of unary relation constants, which serve as names for the cells of our spreadsheet, a set of interpreted n-ary relation constants including algebraic operators, along with a set of object constants, representing objects in the domains of the cells. Logical sentences are built up in the usual way from this vocabulary and the binary relation symbol = (equality), using the logical connectives $\neg$(negation), $\wedge$(conjunction), $\vee$(disjunction), $\Rightarrow$(implication) and $\Leftrightarrow$(equivalence) and the quantifiers $\forall$ (universal quantification) and $\exists$ (existential quantification). We use a standard model theory and proof theory. The constraints **400** typically include basic constraints **402** that are common to most spreadsheet documents in the spreadsheet system and domain constraints **404** that are customized by the user for each spreadsheet document.

Because spreadsheets are invariably realized on electronic computers as electronic spreadsheets, the term spreadsheet is often used interchangeably with electronic spreadsheet, and may also be used to include other associated features. For example, a spreadsheet typically has a set of core instructions **500** including instructions for a user interface **502** and a computation engine **504** for updating calculated cells, as shown in FIG. **5**. The update computation engine contains update semantics that specify the manner in which the values of cells automatically change after a user explicitly makes a modification to a cell. Update semantics include, for example, one or more notions of consequence that are used to compute the values in computed cells from user-specified values in base cells and the logical constraints. Spreadsheets of the present invention use a non-explosive or paraconsistent con-

sequence relation. In preferred embodiments, the non-explosive consequence relation is called existential Ω-entailment. A set of value assignments Λ existentially Ω-entails a value assignment ϕ if and only if there is some subset of value assignments $\lambda \subseteq \Lambda$ consistent with a set of constraints Ω such that $\lambda \cup \Omega$ logically entails ϕ.

Embodiments of the present invention will now be described in detail with reference to the drawing figures. It will be appreciated that the following description contains many examples for illustrative purposes only. Accordingly, the full scope of the invention should not be limited by the specific details used below.

ILLUSTRATIVE EXAMPLES

It is instructive to illustrate the innovative features of spreadsheets of the invention by first considering some simple examples of these spreadsheets in action. For example, the three-cell traditional spreadsheet of FIG. **1** may be contrasted with the three-cell logical spreadsheet of FIG. **6**. As already discussed above, the traditional spreadsheet has a one-way propagation from user-specified values in cells A and B to a calculated value determined by the function in cell C. That is, one can specify values for A and B and the spreadsheet will automatically calculate C, but one can not specify values for A and C and obtain the value for B. In contrast, the logical spreadsheet of FIG. **6** has three cells and a separate formula C=A+B that acts as a constraint on the values of the three cells that allows propagation of values to take place in any direction. For example, if a user enters values in cells B and C, then a value for cell A is computed as a consequence. Or, if a user enters values in cells A and C, then a value for cell B is computed. This example not only illustrates the omnidirectional propagation, but also shows how cells dynamically change between computed cells and base cells. This increased flexibility introduces the possibility that the user may enter values in all three cells that are inconsistent with the constraints on those cells. For example, a user may enter 1 in cell A, 1 in cell B, and 3 in cell C. Since $1+1 \neq 3$, these user-specified values are inconsistent with the relation A+B=C. Accordingly, logical spreadsheets of the present invention include various innovative techniques to handle the complexities that arise from this increase in flexibility, as will be described in more detail below.

Laying Out Cells and Tables

In a preferred embodiment, a user creating a new logical spreadsheet document is presented with a blank canvas, a textual constraint editor, and a domain editor. The user begins by placing cells and textual labels on the canvas. The user may also place static text onto the canvas, change the color scheme, etc. A cell may have any number of modalities, such as a drop-down list or a type-in field. In addition, cells may be arranged into tables, complete with row and column names. This arrangement of cells into tables serves not only to visually organize cells, but also allows cells to be given names based on their rows and columns. For example, FIGS. **7**A and **7**B show two tables as they might be displayed to a user in a spreadsheet created to implement a simple room management system. The Event table in FIG. **7**A has three rows (E**1**, E**2**, E**3**), representing events which need to be scheduled, and four columns (Owner, Projection, Room, Time), containing some properties of the events, namely their owner, whether a projector is required, their room, and their time. The Schedule table shown in FIG. **7**B represents the schedule for the rooms, where each cell contains the event scheduled in a given room at a given time. It has three rows (Morning, Afternoon, Evening) representing the available times and three columns (G**100**, G**200**, G**300**), representing the available rooms.

Defining Cell Domains

The user can also create domains for cells using a textual editor and associate each cell with a domain. These domains are used to populate cell drop-down lists. For example, the cells in the table of FIG. **7**B take values from a list of events (E**1**, E**2**, E**3**). In FIG. **7**A, the cells in the Owner column take values from a list of names (Amy, Bob, Cal), the Projection column takes values from a Yes/No list, the Room column takes values from a list of available rooms (G**100**, G**200**, G**300**), and the Time column takes values from a list of available times (Morning, Afternoon, Evening). In some embodiments, the number and rows and columns as well as the labels for the row and column heads are automatically updated as appropriate when the corresponding domains are redefined. With the row and column labels, the cells acquire structured names. For example, the structured name schedule [morning,g**100**] refers to the cell in the schedule table in the Morning row and the g**100** column. This structured name allows rows and columns to be quantified over. In addition to improving the user experience by reducing the replication typically required in a traditional spreadsheet, structured names allow tables to be queried in a manner similar to database tables. Indeed, since all rows in a table are named, one can either treat a row as a tuple with attributes named by the columns, or treat a column as a tuple with attributes named by the rows.

Formula Language and Constraints

Once the cells and tables are laid out, the user can create constraints that express relationships between cells. The constraints may be written as textual formulas using a variant of first order logic. Formulas can be built up from these structured names and the binary relation symbol = (equality), using the logical connectives ¬(negation), ∧conjunction), ∨(disjunction), ⇒(implication) and ⇔(equivalence) and the quantifiers ∀ (universal quantification) and ∃ (existential quantification). There are no restrictions on these formulas. For convenience, users may define new n-ary relations using ⇔and use these in an unrestricted manner. Decidability is preserved since these n-ary relations are reducible to unary ones. For example, Table 1 shows the set of constraints for the room manager spreadsheet shown in FIGS. **7**A and **7**B. Note that free variables are considered to be universally quantified.

TABLE 1

No.	Constraint
1	event[E,room](g100) or event[E,room](g200) or event[E,room](g300)
2	event[E,time](morning) or event[E,time](afternoon) or event[E,time](evening)
3	schedule[T,R](E) ⇔event[E,time](T) ∧ event[E,room](R)
4	event[E,projection](yes) ∧event[E,room](R)⇒ room[R,projector](yes)
5	event[E,owner](P) ∧person[P,faculty](no)⇒¬ event[E,room](g100)

The constraints **1** and **2** dictate that every event has a room and a time in the room and time domains, respectively. Constraint **3** relates the schedule table in FIG. **7**A to the event table in FIG. **7**B. Constraint **4** states that if an event requires a projector then it must be scheduled in a room with a projector. Constraint **5** states that only faculty members can reserve room g**100**.

Updates and Computing Consequences

Once the spreadsheet is set up, the user may proceed to use the newly created spreadsheet. As the user enters and deletes values from cells, the values in other cells may be changed automatically based on the logical constraints which have been defined. An overview of the process is shown in the flowchart of FIG. **8**. In step **802** a user makes an explicit change to a cell, e.g., if the cell has a value, either changing the value or clearing the cell; and if the cell is empty, entering a value in the cell. In step **804** the cells are automatically partitioned into base cells and computed cells. The non-explosive consequences of base cells are computed in step **806**, producing sets of entailed values for the computed cells. In some cases, the number of entailed values for a cell may be reduced in step **808**. Step **810** then displays values of the base cells and computed cells. The above steps will now be described in more detail.

In preferred embodiments, a user interface is provided to allow a user to make changes to the values in cells (step **802**). The user interface may include, for example, a display of some or all of the cells, with drop-down or pop-up menus to facilitate data entry. The menus may contain lists of values which may be organized or categorized to further facilitate interactivity with the user. A user can modify a cell in one of three ways: The user can assign a value to a previously empty cell, change a value currently assigned to a cell to another value, or empty a cell that currently has a value.

Once a user-specified change has been made to a cell, the cells are dynamically partitioned into "base cells" and "computed cells" (step **804**). In particular, if a cell has been directly modified by the user, the cell is classified automatically as a base cell. In addition, some other cells then lose their status as base cells and are reclassified as computed cells. Specifically, in the case of a new value assignment to a cell, any base cells with values that, together with the constraints, directly contradict the newly assigned value are reclassified as computed cells. In the case of a cell that is emptied of a value, any cells with values that, together with the constraints, directly entail a value in the emptied cell are reclassified as computed cells. In the case where two or more base cells have values that together contradict the newly assigned value but none does individually, these cells are left as is and do not lose their status as base cells. This leads to inconsistency. Similarly, if two or more cells have values that together entail a value in the newly emptied cell but none does individually, these cells are left as is and remain base cells. This leads to the newly empty base cell having an entailed value. Note that since the newly emptied cell is now a base cell, the cell does not contain a computed value and remains empty. This completes the dynamic partitioning of cells.

After the partitioning of base and computed cells, the set of entailed values is calculated (step **806**). The entailed values are the non-explosive consequences of the values in the base cells and the specified logical constraints. To calculate the non-explosive consequences, a paraconsistent consequence relation called existential Ω-entailment is preferably used. In other words, the non-explosive logical consequences may be found by 1) identifying subsets of the set of values in the base cells that are consistent with the logical constraints, using for example the resolution proof technique to determine consistency, 2) computing the logical consequences of the identified consistent subsets and the logical constraints to produce corresponding sets of entailed values for the computed cells, and 3) combining the computed sets of entailed values to form a complete set of entailed values, e.g., by taking their union or intersection. Which particular combination is used will depend on the application, though in the preferred embodiment, the union is taken.

The next step is to fill the computed cells with the existential Ω-consequences of the base values and the constraints. However, the complete set of entailed values does not necessarily provide one unique value for each computed cell, so in some cases the set of entailed values may be subsetted (step **808**). If a computed cell is allowed to contain just one value, but more than one entailed value is computed for the cell, then the number of entailed values may be reduced to one using inertia as a tie-breaker: if the cell contained a value before the update and the value is still existentially Ω-entailed, then that value remains in the cell. If there are multiple existentially Ω-entailed values for a computed cell but none of these was in the cell before the update, the cell is left empty. Similarly, if a cell can contain multiple values, but the number of entailed values exceeds the number of allowed values, then the number of entailed values may be reduced to the required number using inertia as a tie-breaker: if the cell contained a value before the update and that value is still existentially Ω-entailed, then that value remains in the cell. Again, if there are more than the maximum allowed existentially Ω-entailed values for a computed cell but none of these was in the cell before the update, the cell is left empty.

Finally, the values are displayed to the user via a user interface (step **810**). Some or all of the values for the base cells and computed cells may be displayed, depending on the particular layout in current use. In the case of a layout that contains all tables and cells, all the values might be displayed. Other layouts may display a subset of the base cells and computed cells, in which case a subset of the values is displayed. Spreadsheet systems of the present invention may be implemented with many different user interfaces. In a preferred embodiment, the user interface implements features such as drop-down menus to select values from domains and shaded cells to indicate inconsistent values. Shading, coloring, and various other types of markings or highlighting of cells can also be used to show which cells are base cells, computed cells, never-modified cells, recently modified cells, and newly modified cells. In addition, a mouse-over (i.e., placing a user-controllable pointer over a cell) can result in a highlight of a group of cells that are related (e.g., cells that are in conflict with a common constraint, or cells that are related by a common constraint). A group of cells in conflict with a particular constraint can be determined using standard database techniques to query for values that do not satisfy the constraint.

Update Illustration

The technique described above for updating cells will now be illustrated using the room management system discussed earlier in relation to FIGS. **7**A and **7**B. The room manager consists of four tables, named event, schedule, room, and person, shown schematically in FIGS. **9**A-D, respectively. The event table contains event requests, each of which has an owner, a specification of whether a projector is needed, a room, and a time. The schedule table contains a schedule of the events. The information is redundant with the first table but is useful because it offers a different view. The room table lists whether or not each room has a projector. The person table lists whether each person is a faculty member or not. The values in the person and room tables are entered by the user before scheduling specific events.

An administrator using the spreadsheet has the task of assigning to three new events a room and a time. The user begins by specifying values for cells in the owner and projec-

tion columns of the event table, as shown in FIG. **9**A. These values specify, for each event, the event owner's name and whether a projector is needed.

After entering a value in a cell, the spreadsheet system responds by automatically updating the spreadsheet. First, the system determines which cells are base cells and which are computed cells. As shown in the figures, base cells are marked with a triangle in the upper left-hand corner of the cell, while computed cells are not. These are the cells in which the user has explicitly specified values. The system then automatically computes the non-explosive consequences of the base cells. In this example, the system automatically computes the and displays a value g**100** for the room of event e**3** in the event table. This value is entailed by the logical constraints since the user specified that e**3** requires a projector, and g**100** is the only room with a projector.

As shown in FIGS. **10**A-D, the user then specifies additional properties for event e**1** in the event table. In particular, the user selects g**100** as the room for event e**1** and morning as its time. The system responds by classifying these cells as base cells and displaying them with a triangle, as shown in FIG. **10**A. The system also responds by automatically calculating entailed values. Specifically, the user's specification of a room and time for event e**1** in the event table causes e**1** to show up in the corresponding cell in the schedule table, as shown in FIG. **10**B. The user then directly modifies a cell in the schedule table by assigning the value e**2** to room g**200** in the afternoon. The system responds by automatically calculating the entailed values and displaying them in row e**2** of the event table, as shown in FIG. **10**A. This example illustrates the spreadsheet's ability to propagate values in multiple directions. That is, user modifications of values for cells in the event table result in entailed values appearing in cells of the schedule table, and vice versa.

Next, as shown in FIGS. **11**A-D, the user moves e**1** from morning to evening by clearing the g**100** morning cell and entering e**1** in the g**100** evening cell of the schedule table. The spreadsheet system responds by reclassifying the e**1** time cell of the event table from a base cell to a computed cell. It also computes and displays the entailed value evening for that cell, over-riding the previously specified morning value for the cell. This illustrates how the automatic update of the spreadsheet deals with a direct conflict between a value previously specified for a cell and a new entailed value for the cell that is a consequence of a newly specified value in another cell.

As illustrated in FIGS. **11**A-D, the user then changes the room assignment for e**3** from g**100** to g**200** by modifying the appropriate cell in the event table. The system responds by reclassifying the cell from a computed cell to a base cell. The system also responds by computing the entailed values. However, since e**3** requires a projector and g**200** lacks a projector, these user-specified values are inconsistent with the logical constraints. Nevertheless, the system allows the conflicting values to be entered. Since the inconsistency is caused by multiple cells, the system responds by coloring or shading the conflicting cells. Specifically, a cell is colored if it contains a value that is non-explosively contradicted by the values in the other cells. Note that if the conflict had been caused by a value in just one cell, the system would have modified the existing value in the cell to eliminate the conflict, as shown in the previous example. This example shows how the spreadsheet system deals with conflicts caused by values in multiple cells.

The user does not have to resolve the conflict immediately. For example, as shown in FIGS. **12**A-D, the user may instead proceed to set the time of event e**3** to the morning by modifying the appropriate cell of the event table. The modified cell is automatically marked as a base cell and event e**3** appears automatically in the appropriate cell of the schedule table. Thus, even though the specified values in the base cells remain inconsistent with the constraints, the system is still able to compute entailed values using existential Ω-entailment and display the consequences of the (inconsistent) base assignments. The administrator can remove the inconsistency and complete the event scheduling by moving the projector from g**100** into g**200** (not shown).

Variations

Although the example spreadsheet illustrated above shows many of the features enjoyed by most implementations of logical spreadsheets, there are some variations that are worthy of explicit mention. The domains for cells may include various types of numbers and logical values in addition to alphanumeric strings. Cells are not necessarily limited to containing just one value, but could contain multiple values (e.g., someone's three children). Cells could also store vectors, arrays, matrices, tables, or other structured values. In addition to constraints on the values of cells, logical constraints may also embody constraints on changes in the values of the cells. It should also be emphasized that the particular techniques for updating cells illustrated in the example above is just one specific approach. There are other reasonable interpretations of what it means to be a consequence of an inconsistent spreadsheet, and such alternate interpretations may be preferred in specific application areas. Moreover, alternate embodiments may include user-selectable preferences that control the automatic update behavior.

Spreadsheet systems of the present invention may also include other additional features such as an auto-complete feature and a deconfliction feature. In response to a user instruction to auto-complete a spreadsheet, the system will fill in empty spreadsheet cells with consistent values. The user can then alter or adjust the values to further customize the solution. If deconfliction is activated, the system will change existing values that are inconsistent to reduce or preferably eliminate inconsistencies. The user can then adjust the values of cells to arrive at a suitable solution. Auto-completion can be implemented, for example, by querying for empty cell values that satisfy the constraints given the current cell values, using standard database query techniques. Similarly, an implementation of deconfliction can query for conflicted cell values that satisfy the constraints given the non-conflicting cell values.

Applications

It will be evident to those skilled in the art that the spreadsheet systems of the present invention have many applications and uses. Here we mention just a few of the many possible types applications. First, logical spreadsheets have applications to data management. Logical spreadsheets facilitate the entry and editing of symbolic data governed by symbolic constraints. "Correct on capture" data entry systems and resource management systems, like the one illustrated in this description, are examples of this capability. Logical spreadsheets could also be used as a "data browser" for the Semantic Web. A Web-aware logical spreadsheet could be used to integrate data from different sources and the translate data from one schema to another. Logical spreadsheets also are useful in design applications. Configuration systems are good examples of the use of logical spreadsheets in design. Consider, for example, a configuration system to help users design their own cars or computer systems. Another application of logical spreadsheets is implementing smart forms. A spreadsheet with an HTML front end would allow users to fill out online forms in which data is checked for semantic well-formedness. Interactive documents are another application of

logical spreadsheets. Systems can return "interactive answers" to users, e.g. simulations, which allow a user to experiment by varying certain parameters while the system automatically propagates the consequences of those variations. Consider, for example, a student learning how lenses refract light by experimenting with different lens shapes. Spreadsheets could also support collaborative applications if they were linked, with automatic propagation of values and constraints among the connected spreadsheets. Linked spreadsheets of this sort would support a wide variety of applications in cooperative design and collaborative management. In addition, linking would allow the creation of a World Wide Spreadsheet.

The invention claimed is:

1. A method for displaying consequences in an electronic spreadsheet, the method comprising:

specifying a set of cells of the spreadsheet and a set of logical constraints on possible values of the cells;

dynamically partitioning the set of cells into base cells and computed cells;

assigning to the base cells a set of user-specified values, wherein the user-specified values are possibly inconsistent with the specified logical constraints;

computing non-explosive logical consequences of the user-specified values and the set of logical constraints using a paraconsistent consequence relation to produce a complete set of entailed values for the set of computed cells;

reducing the number of entailed values for each computed cell whose number of entailed values exceeds a predetermined number of allowed values for the computed cell; and

displaying a subset of the entailed values and a subset of the user-specified values;

wherein computing the non-explosive logical consequences comprises computing logical consequences of multiple consistent subsets of the user-specified values to produce multiple subsets of the complete set of entailed values, and combining the multiple subsets of the complete set of entailed values.

2. The method of claim **1** wherein the cells are named cells.

3. The method of claim **2** wherein the named cells have structured names.

4. The method of claim **1** wherein the cells are able to contain multiple values.

5. The method of claim **1** wherein the combining is done by taking the union of the multiple subsets of the complete set of entailed values.

6. The method of claim **1** wherein dynamically partitioning the set of cells into base cells and computed cells comprises classifying a cell as a base cell when a user-specified value is explicitly assigned to the cell.

7. The method of claim **1** wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell contains a value individually inconsistent with a user-specified value explicitly assigned to another cell.

8. The method of claim **1** wherein dynamically partitioning the set of cells into base cells and computed cells comprises unclassifying a cell as a base cell when the cell entails a value in another cell and the value is explicitly changed or removed.

9. The method of claim **1** wherein the logical constraints are formulated as relational constraints expressed in a logical language encompassing first-order logic.

10. The method of claim **1** wherein the displaying comprises altering an appearance of cells containing inconsistent values.

11. The method of claim **10** wherein the altering the appearance of cells containing inconsistent values comprises dynamically changing the appearance of a subset of cells containing related inconsistent values when a user pointer hovers over the subset of cells.

12. The method of claim **1** wherein the displaying comprises providing a menu associated with a cell, wherein the menu comprises a list of possible values classified as being non-explosively entailed, being non-explosively contradicted, or neither.

13. The method of claim **1** wherein the displaying comprises providing an interactive user interface for an electronic document.

14. The method of claim **13** wherein the electronic document is selected from the group consisting of a spreadsheet document, an HTML document, a word processing document, and a PDF document.

15. The method of claim **1** further comprising, responsive to a user instruction, automatically assigning values to empty cells such that the automatically assigned values are consistent with the logical constraints.

16. The method of claim **1** further comprising, responsive to a user instruction, automatically altering values of cells to reduce conflicts with the logical constraints.

17. The method of claim **1** wherein reducing the number of entailed values comprises eliminating all but a single entailed value if the single entailed value matches an existing value contained in the cell.

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