Listing of Currently Proposed, Unresolved Glossary Entries*

Christian S. Jensen, editor James Clifford Curtis Dyreson
Ramez Elmasri Shashi K. Gadia Fabio Grandi
Pat Hayes Sushil Jajodia Wolfgang Käfer Nick Kline Nikos Lorentzos
Yannis Mitsopoulos Angelo Montanari Daniel Nonen Elisa Peressi Barbara Pernici
John F. Roddick Nandlal L. Sarda Maria Rita Scalas Arie Segev
Richard T. Snodgrass Mike D. Soo Abdullah Tansel Paolo Tiberio Gio Wiederhold

Abstract

This document contains glossary entries that are candidates for inclusion into the next release of the glossary.

1 Introduction

2 Relevance and Evaluation Criteria for the Glossary

2.1 Relevance Criteria for Concepts

Only concepts that fulfill the following four requirements should be added to the glossary.

R1 The concept must be specific to temporal databases. Thus, concepts used more generally are excluded.

R2 The concept must be well-defined. Before attempting to name a concept, it is necessary to agree on the definition of the concept itself.

R3 The concept must be well understood. We have attempted to not name a concept if a clear understanding of the appropriateness, consequences, and implications of the concept is missing. Thus, we avoid concepts from research areas that are currently being explored.

R4 The concept must be widely used. We have avoided concepts used only sporadically within the field.

*Correspondence may be directed to the TSQL electronic mail distribution, `tsql@cs.arizona.edu`, or to the editor C. S. Jensen, at Aalborg University, Datalogi, Fr. Bajers Vej 7E, DK–9220 Aalborg Ø, Denmark, `csj@iesd.auc.dk`. This document was prepared by multiple contributors. The names, affiliations, and e-mail addresses of the contributors may be found in a separate section at the end of the document.

2.2 Evaluation Criteria for Naming Concepts

Below is a list of criteria for what is a good name. Contributors of glossary entries have been encouraged to reference these criteria when proposing glossary entries. As an example of this use, the occurrence of "+E1" in a glossary entry indicates that the name in question satisfies criterion E1. Reversely, "−E1" indicates that E1 is not satisfied. The criteria are sometimes conflicting, making the choice of names a difficult and challenging task. While this list is comprehensive, it is not complete.

E1 The naming of concepts should be orthogonal. Parallel concepts should have parallel names.

E2 Names should be easy to write, i.e., they should be short or possess a short acronym, should be easily pronounced (the name or its acronym), and should be appropriate for use in subscripts and superscripts.

E3 Already widely accepted names are preferred over new names.

E4 Names should be open-ended in the sense that the name of a concept should not prohibit the invention of a parallel name if a parallel concept is defined.

E5 The creation of homographs and homonyms should be avoided. Names with an already accepted meaning, e.g., an informal meaning, should not be given an additional meaning.

E6 The naming of concepts should be conservative. No name is better than a bad name.

E7 New names should be consistent with related and already existing and accepted names.

E8 Names should be intuitive.

E9 Names should be precise.

2.3 Structure of the Glossary

In the following, we will name concepts selected by applying the four above principles. For most of the concepts being named, we will employ the same template:

Name—the chosen name of the concept is used as the heading.

Definition—the definition of the concept.

Explanation—further exploration of the definition and its consequences, including exemplification; this section is optional.

Previously Used Names—list of previously used names.

Discussion of Naming—reasons for the particular choice of name (and concept) and reasons for not selecting previously used names (and concepts).

3 Proposed Glossary Entries

3.1 Temporal Rule

Definition

A database rule is a *temporal rule* if either the condition part or the action part involve time points or temporal elements.

Discussion of Naming

This definition is intended to distinguish between temporal and non-temporal rules in temporal active databases. A non-temporal rule can still cause changes over time in the case of retroactive or proactive (may change to predictive if term adopted) changes to temporal data. The concept has recently been used in many papers (+R4), it is well understood as defined above (+R3). There may be a problem with the preciseness (−E9).

3.2 Period of Indeterminacy

Definition

The *period of indeterminacy* is either an anchored duration associated with an indeterminate event or a duration associated with an indeterminate span, that delimits the range of possible times represented by the event or span.

Previously Used Names

Interval of indeterminacy, fuzzy interval.

Discussion of Naming

The period of indeterminacy associated with an indeterminate event is an anchored duration that delimits the range of possible times during which the event occurred. The event happened sometime during the period of indeterminacy but it is unknown exactly when. An anchored duration is usually referred to as an interval, however, in this context, we prefer to call it a period because the syntactic difference between an "indeterminate interval" and an "interval of indeterminacy" is slight, while the semantic difference is great. Hence, while using "interval of indeterminacy" might be more precise (+E9), it would also be more confusing (−E8). Using "fuzzy interval" would also be confusing due to the influence of fuzzy databases (+E5).

3.3 Admissibility Interval

Definition

Same as "period of indeterminacy."

Previously Used Names

Period of indeterminacy.

Discussion of Naming

The name "admissibility interval" is more intuitive than "period of indeterminacy" (+E8) and was used in the TSOS system (+E7).

3.4 Interval Relation

Definition

An *interval relation* is a (non-wholistic) fact with duration. An interval relation is said to hold over an interval I if it holds at all time instants belonging to the set of contiguous chronons representing I.

3.5 Interval Relation Holding Time

Definition

The *interval relation holding time* is the set of contiguous instants over which the interval relation holds in the real-world. The valid time interval associated with the interval relation is the pair consisting of the starting and the ending chronons.

Previously Used Names

Interval relation time.

Discussion of Naming

Interval relation holding time is more precise than interval relation time (+E9). Nevertheless, when the context is clear, the interval relation holding time may be shortened to the interval relation time.

3.6 Temporally Indeterminate

Definition

The modifier *temporally indeterminate* indicates that a fact or event it is known to have occurred, but it is unknown precisely when.

Explanation

There are (at least) two possible sources of indeterminacy: (i) a discrepancy between the granularities of the temporal qualification and the occurrence time; (ii) an underspecification of the occurrence time, when the granularities of the temporal qualification and the occurrence time coincide.

The proposed definition of *temporally-indeterminate* event is: "a *temporally-indeterminate* event is an event that is known to have occurred but precisely when is unknown". Reformulated in terms of statements it becomes: "a *temporally-indeterminate* statement is a statement that allows us to conclude that an event has occurred, but it does not tell us precisely when it has occurred."

Chronologically-indefinite statements are also temporally indeterminate, but not vice versa: temporally-indeterminate statements can be chronologically indefinite as well as chronologically definite.

The statements "Jack was killed on xx/xx/1990" and "Michelle was born yesterday" come within different categories with respect to the chronological definiteness/indefiniteness characterization, but they are both temporally indeterminate.

As a first approximation, we can say that a statement is *temporally indeterminate* if the granularity of its temporal qualification (in the examples, the granularity of days) is coarser than the granularity of the time at which the denoted events (instantaneously) occur. Notice that temporal indeterminacy as well as chronological indefiniteness are mainly qualifications of statements rather than of the events they denote (better, temporal indeterminacy characterizes the relation between the granularities of the statement temporal qualification and of the event occurrence time). Notice also that it does not depend on the time at which the statement is evaluated. The crucial, and critical, point is clearly the determination of the time granularity of the event occurrence time.

Some problems could be avoided by adopting the following weaker notion of temporally indeterminacy: a statement whose temporal qualification has granularity G (to say, days) is temporally determinate with respect to every coarser granularity (e.g., months) and temporally indeterminate with respect to every finer granularity (e.g., seconds).

However, we do not like this solution, because it does not take into account information about the denoted events. In particular, for each event there exists a limit time granularity such that its occurrence time can be specified at such a granularity and all coarser ones, but not at finer ones. With respect to each finer granularity, the event as a whole does not make sense at all and it must decomposed into a set of components (if possible).

Let us go back to the proposed definition of temporal indeterminacy to discuss the following issue: does temporal indeterminacy always involve a discrepancy between temporal qualification (expressed as a valid time) and occurrence time granularities? Consider the sentence: "The shop remained open on a Sunday in April 1990 all the day long". Clearly, the truth value of the statement does not depend on its utterance time, that is, the statement is chronologically defined. Furthermore, day is the granularity of both the temporal qualification and the occurrence time. Nevertheless, we believe that this statement is *temporally indeterminate*, because the precise day in which the shop remained open is unknown (we only know that it belong to the set of Sunday days in April 1990).

These sources of indeterminacy are not exclusive and they can jointly contribute to make a statement temporally indeterminate. This is the case, for instance, in the sentence: "Jack was killed on a Friday night in 1990".

Previously Used Names

Vague, imprecise.

3.7 Temporally Determinate

Definition

The modifier *temporally determinate* indicates that the occurrence time of an event or fact is known precisely.

Explanation

See the explanation for "temporally indeterminate."

Previously Used Names

Precise.

3.8 Temporally-indeterminate Event

Definition

A *temporally-indeterminate event* (or just *indeterminate event*, when the context is clear) is an event that is known to have occurred but precisely when is unknown. The times when the event might have occurred must be contiguous; non-contiguous times can be modeled by an exclusive-or disjunction of indeterminate events.

Explanation

"Michelle was born yesterday" is a typical indeterminate event. An indeterminate event is composed of an event (e.g., "Michelle was born") and some indeterminate temporal information (e.g., "yesterday").

Note that an event with noncontiguous temporally-indeterminate information, such as "Jack was killed on a Friday night in 1990," is not an indeterminate event since the times when the event might have occurred are non-contiguous. The incomplete temporal information could be more substantial. For instance, an indeterminate event could have an associated probability mass function which gives the probability that the event occurred during each chronon on a time-line.

Previously Used Names

Temporally-incomplete event, temporally-fuzzy event, temporally-imprecise event.

Discussion of Naming

Currently, there is no name used in the literature to describe the incomplete temporal information associated with an event. The modifier "incomplete" is too vague (-E9), while "fuzzy" has unwanted connotations (i.e., with fuzzy sets) (-E9). "Indeterminate" is more general than "imprecise;" imprecise commonly refers to measurements, but imprecise clock measurements are only one source of indeterminate events.

3.9 Temporally-indeterminate Interval

Definition

A *temporally-indeterminate interval* (or just *indeterminate interval* when the context is clear) is an interval bounded by at least one temporally-indeterminate event. Since an interval cannot end before it starts, the possible times associated with the bounding events can overlap on only a single chronon.

Previously Used Names

Temporally-incomplete interval, temporally-fuzzy interval, temporally-imprecise interval.

Discussion of Naming

Currently, there is no name used in the literature to describe the incomplete temporal information associated with an interval. The modifier "incomplete" is too vague (−E9), while "fuzzy" has unwanted connotations (i.e., with fuzzy sets) (−E9). "Indeterminate" is more general than "imprecise;" imprecise commonly refers to measurements, but imprecise clock measurements are only one source of indeterminate intervals.

3.10 Chronologically Definite

Definition

The modifier *chronologically definite* indicates that a fact or an event has associated a valid time at a given timestamp granularity.

Explanation

A chronologically definite event or fact has associated a time (see also the discussion about "temporally indeterminate"), and this time does not depend on the time of other events or facts. For instance: Mary's salary was raised on March 30, 1993.

Previously Used Names

Absolute time.

Discussion of Naming

The time associated with chronologically definite events has also been called absolute time in the literature.

3.11 Chronologically Indefinite

Definition

The modifier *chronologically indefinite* indicates that the time of a fact or an event is related to the occurrence of another event.

Explanation

Example are: Mary's salary was raised yesterday. (here it depends on the utterance time for the sentence). Mary's salary was raised before Lucy's.

Previously Used Names

Imprecise, relative.

Discussion of Naming

The time associated to chronologically indefinite events has also been called relative time in the literature.

3.12 Chronologically Definite Temporal Qualification

Definition

Chronologically definite temporal qualifications are specifications of absolute temporal positions.

Explanation

Examples are: June 15, 1993 (dates), 397 years after the discovering of America. The notion of chronologically definite temporal qualification is different from the notion of absolute time. Consider the case of temporal qualifications relating the occurrence time of an event to the occurrence time of another event rather than to the current (implicit) time *now*. Even if they can be considered relative times, they are chronologically definite. They specify an absolute temporal position which may possibly be unknown (it depends on common sense as well as context knowledge). Examples of statements including these kinds of chronologically definite temporal qualifications are: "the French revolution occurred 397 years after the discovering of America," "Mary's salary was raised before Lucy's."

3.13 Chronologically Indefinite Temporal Qualification

Definition

Chronologically indefinite temporal qualifications are specifications of temporal positions in terms of displacements with respect to the current time (*now*) which is left implicit.

Explanation

The notion of chronologically indefinite temporal qualification is different from the notion of relative time as shown in the related discussion about chronologically definite temporal qualifications. Examples are: tomorrow, three days ago, next month.

3.14 Chronologically Definite

Definition

Chronologically definite statements are statements whose truth value does not vary, because it does not depend on the time at which they are evaluated. Chronologically definite statements are characterized by chronologically stable temporal qualifications.

Explanation

Examples are: "Jack was killed on xx/xx/1990," it happened sometime in 1999," "the Jurassic is sometime after the Triassic," "the French revolution occurred 397 years after the discovering of America."

In particular, consider the statement "the French revolution occurred 397 years after the discovering of America", where the occurrence time of "the French revolution" is given with respect to the occurrence time of "the discovering of America" by means of the temporal qualifier "397 years after" (relative time). This statement is chronologically definite, because its truth value does not depend on the time at which it is evaluated.

3.15 Chronologically Indefinite

Definition

Chronologically indefinite statements are statements whose truth value may vary, because it depends on the time at which they are evaluated. Chronologically indefinite statements are characterized by chronologically unstable temporal qualifications or are devoid of any temporal qualification (a statement with no temporal qualification is equivalent to a statement characterized by a zero displacement with the respect to the implicit current time).

Explanation

Examples are: "Mary's salary was raised yesterday," "it happened sometime last week," "it happened on Easter," "it happened within 3 days of Easter."

3.16 Time Sequence

Definition

A *time sequence* (TS) is a sequence (ordered by time) of pairs $< v, t >$ where v is an arbitrary data object and t are chronons of a given granularity designating past and/or future instants. A TS is identified by a surrogate (possibly a time-invariant key). If each v is a single value, the TS is said to be *simple*, and if v is a complex value (e.g., a set, a sequence, etc.), the TS is *complex*. A TS may have properties and/or constraints attached to it.

Explanation

The above definition is model-independent and can have different representations in different models. For example in the relational model where a relation is attribute-value timestamped (chronons), each point in the sequence will be a tuple. For tuple timestamping, v will be a set of attribute values. Note that temporal elements are derivable from a time sequence.

Previously Used Names

History, time-series.

Discussion of Naming

The concept is specific to temporal databases (+R1) and is well defined and understood in the real world (+R2, +R3). It has been used and referred to in many works (+R4). The name is intuitive (+E8), it is not as widely used as "history" (−E3), but it describes the concept more accurately (+E9) than "history," i.e., the common use of history is in reference to the past, but a temporal database can have a time sequence that involves future times.

3.17 Temporal Value Integrity

Definition

A temporal DBMS is said to have *temporal value integrity* if:

1. The integrity of temporal values as first-class objects is inherent in the model, in the sense that the language provides a mechanism (generally, variables and quantification) for direct reference to *value histories* as objects of discourse, and

2. Temporal values are considered to be *value equivalent* only if they are equal for all points in time over which they are defined.

Explanation

The concept of *temporal value integrity* provides a term for the characteristic distinguishing those models which represent *time* as just another attribute or set of attributes, from those which represent temporal values directly. The former models do not have a primitive notion of a temporal value. Instead, they have the primitive notions of time values and ordinary values, and they can represent associations between these two types of values, for example, they can represent the (non-temporal) *value of a SALARY at time t*. Those models with *temporal value integrity* have built in the primitive notion of a temporal value. In these models one can refer to a primitive temporal value like a *SALARY history*, as well as referring to the (non-temporal) *value of a SALARY history at time t*.

Discussion of Naming

The orthogonality criterion (+E1) is satisfied, and there are no competing names in the literature (+E3), and the term does not appear to have other meanings (+E5). Further, the name is consistent with existing terminology (+E7) (and, indeed, clarifies the meaning of the term *value equivalence*), and does not violate other criteria.

3.18 History-oriented

Definition

A temporal DBMS is said to be *history-oriented* if:

1. It supports history-unique identification (e.g., via time-invariant keys, surrogates, or OIDs);

2. The integrity of histories is inherent in the model, in the sense that history-related integrity constraints might be enforced and the language provides a mechanism (history variables and quantification) for direct reference to histories;

3. The DML allows easy manipulation of histories, in the sense that the language provides for user-friendly history selection, history retrieval and history modification primitives.

Previously Used Names

With temporal value integrity, grouped, object-oriented.

Discussion of Naming

"History-oriented" is preferred over "with temporal value integrity" since its meaning seems to be more direct. Furthermore, in a more general perspective, integrity constraints can be introduced in a history-oriented model (e.g., history uniqueness, entity history integrity, referential history integrity).

"History-oriented" is also preferred over "grouped" (+E7) in order to avoid confusion with other kinds of grouping (e.g., dynamic and static valid time partitioning).

"History-oriented" is not a synonim for "object-oriented," even though a good temporal object-oriented model should also be history-oriented. In general, object-orientation requires more features that are inherited from snapshot O-O models (+E7). For instance, also (attribute/tuple—point/interval-stamped) relational models can be history-oriented, provided that suitable integrity constraints and algebraic operators are defined.

Once history has been defined, "history-oriented" is quite intuitive (+E8).

3.19 Temporal Qualification

Definition

The *temporal qualification* of a statement is the component of the statement that specifies the temporal localization of the denoted fact, namely, an associated instant, span, or interval.

Explanation

We assume one temporal qualification per statement. Moreover, we assume that implicit temporal qualifications (e.g. tense qualifications) are always made explicit. As an example, we assume that the statement "They went to Arlington" is rewritten as "Sometimes in the past is true that they *go* to Arlington". Finally, if the temporal qualification is absent or missing, the default qualification is the current time, *now*.

We distinguish between two different types of temporal qualifications, namely, chronologically definite and indefinite temporal qualifications.

3.20 Upper Support Chronon

Definition

In the discrete model of time, the *upper support chronon* is the latest chronon during which an indeterminate event might have occurred.

Previously Used Names

Upper bound.

Discussion of Naming

The upper support chronon is an upper bound on the possible times when an indeterminate event might have occurred. The noun "support" is preferred to "bound" because the use of the former term is consistent with probability theory (+E9). For an indeterminate event, a probability mass function gives the probability that the event occurred during each chronon. The probability that the event occurred sometime after the upper support chronon is zero.

3.21 Lower Support Chronon

Definition

In the discrete model of time, the *lower support chronon* is the earliest chronon during which an indeterminate event might have occurred.

Previously Used Names

Lower bound.

Discussion of Naming

The lower support chronon is a lower bound on the possible times when an indeterminate event might have occurred. The noun "support" is preferred to "bound" because the use of the former term is consistent with probability theory (+E9). For an indeterminate event, a probability mass function gives the probability that the event occurred during each chronon. The probability that the event occurred sometime before the lower support chronon is zero.

3.22 Snapshot Equivalent

Definition

Informally, two tuples are *snapshot equivalent* if the snapshots of the tuples at all times are identical.

Let temporal relation schema R have n time dimensions, D_i, $i = 1, \ldots, n$, and let τ^i, $i = 1, \ldots, n$ be corresponding timeslice operators, e.g., the valid timeslice and transaction timeslice operators. Then, formally, tuples x and y are snapshot equivalent if

$$\forall t_1 \in D_1 \ldots \forall t_n \in D_n (\\ \tau^n_{t_n}(\ldots(\tau^1_{t_1}(x))\ldots) = \tau^n_{t_n}(\ldots(\tau^1_{t_1}(y))\ldots)) \ .$$

Similarly, two relations are *snapshot equivalent* if at every instant their snapshots are equal. *Snapshot equivalence* is a binary relation that can be applied to tuples and to relations.

Previously Used Names

Weakly equal, temporally weakly equal, weak equivalence.

Discussion of Naming

Weak equivalence has been used by Ullman to relate two algebraic expressions (Ullman, Principles of Database Systems, Second Edition, page 309). Hence, "temporally weakly equal" is preferable to "weakly equal" (+E7).

In comparing "temporally weakly equal" with "snapshot equivalent," the former term is longer and more wordy, and is somewhat awkward, in that it contains two adverbs (−E2). "Temporally weak" is not intuitive—in what way is it weak? Snapshot equivalent explicitly identifies the source of the equivalence (+E8).

3.23 Snapshot-Equivalence Preserving Operator

Definition

A unary operator F is *snapshot-equivalence preserving* if relation r is snapshot equivalent to r' implies $F(r)$ is snapshot equivalent to $F(r')$. This definition may be extended to operators that accept two or more argument relation instances.

Previously Used Names

Weakly invariant operator, is invariant under weak binding of belongs to.

Discussion of Naming

This definition does not rely on the term "weak binding" (+E7).

3.24 Snapshot Equivalence Class

Definition

A *snapshot equivalence class* is a set of relation instances that are all snapshot equivalent to each other.

Previously Used Names

Weak relation.

Discussion of Naming

"Weak relation" is not intuitive, as the concept identifies a set of relation instances, not a single instance (−E8).

Contributors and Acknowledgements

An alphabethical listing of names, affiliations, and e-mail addresses of the contributors follows.

J. Clifford, Information Systems Dept., New York University, jcliffor@is-4.stern.nyu.edu; C. Dyreson, Computer Science Dept., University of Arizona, curtis@cs.arizona.edu; R. Elmasri, Computer Science Engineeering Dept., University of Texas at Arlington elmasri@cse.uta.edu; S. K. Gadia, Computer Science Dept., Iowa State University, gadia@cs.iastate.edu; F. Grandi, University of Bologna, Italy, fabio@deis64.cineca.it; P. Hayes, Beckman Institute, Phayes@cs.uiuc.edu; S. Jajodia, Dept. of Information & Software, George Mason University, jajodia@sitevax.gmu.edu; W. Käfer, IBM Almaden Research Center, kaefer@almaden.ibm.com N. Kline, Computer Science Dept., University of Arizona, kline@cs.arizona.edu; N. Lorentzos, Informatics Laboratory, Agicultural University of Athens, eliop@isosun.ariadne-t.gr; Y. Mitsopoulos, Informatics Laboratory, Agicultural University of Athens; A. Montanari, Dip. di Matematica e Informatica, Università di Udine, Italy, montanari@uduniv.cineca.it; D. Nonen, Computer Science Dept., Concordia University, Canada, daniel@cs.concordia.ca; E. Peressi, Dip. di Matematica e Informatica, Università di Udine, Italy, peressi@udmi5400.cineca.it; B. Pernici, Dip. di Matematica e Informatica, Università di Udine, Italy, pernici@ipmel2.polimi.it; J. F. Roddick, School of Computer and Information Science, University of South Australia roddick@unisa.edu.au; N. L. Sarda, Computer Science and Eng. Dept., Indian Institute of Technology, Bombay, India, nls@cse.iitb.ernet.in; M. R. Scalas, University of Bologna, Italy, rita@deis64.cineca.it; A. Segev, School of Business Adm. and Computer Science Research Dept., University of California, segev@csr.lbl.gov; R. T. Snodgrass, Computer Science Dept., University of Arizona, rts@cs.arizona.edu; M. D. Soo, Computer Science Dept., University of Arizona, soo@cs.arizona.edu; A. Tansel, Bernard M. Baruch College, City University of New York UZTBB@CUNYVM.CUNY.EDU; P. Tiberio, University of Bologna, Italy, tiberio@deis64.cineca.it; G. Wiederhold, ARPA/SISTO and Stanford University, gio@DARPA.MIL.