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Conceptual Data Modelling for Prehistoric Excavation Documentation

1 Introduction

Archaeological method and practice often deals with information that is tentative, liable to change and fuzzy. Data gathered in the field are usually fragmented posing the need to associate between pieces of relevant context. Drawing archaeological knowledge, which is by nature uncertain, from tentative and incomplete information and fragmented data is a formidable task which in itself would justify archaeology being a science (Richards/Ryan 1985; Ross *et al*. 1991).

Traditionally data is kept on paper (including photos and sketches), is organised in a single manner and all non-trivial processing takes place in the archaeologists head. This practice gives rise to problems in sorting and cross-referencing data with related information content. Informatics, or electronic data processing, promised, among others, to facilitate recording and association of excavation data by providing the means to organise and manipulate archaeological information efficiently. This promise has only partially been fulfilled. One reason is that some pieces of computer technology have until very recently been missing (integrating maps, images, text and attribute information in a single system). Another very important reason is the incorrect development of archaeological information systems (lack of methodology, indifference to issues of conceptual data modelling).

Conceptual data modelling of an application is the process of formally describing its static and dynamic properties for purposes of understanding the application's requirements and communication between the application developers and the system's users. This description of the application's properties is done independently of implementation issues and is carried out by use of a certain *conceptual data model*. The outcome of the conceptual data modelling of an application is called a *conceptual schema* and is an abstraction of reality as it is perceived by the intended users of the system, namely the archaeologists.

Computer users express their requirements in natural language — which includes diagrams, images, maps and processes — while computers execute machine code. Applications bridge this gap by executing programs that satisfy users' needs. The transition from user requirements to machine executable code is done by use of intermediate representations which facilitate the implementation of the desired system. One of these representations is produced at the stage of conceptual data modelling (Batini *et al*. 1992; Navathe 1992). Conceptual data modelling aims at the realistic representation of the information content of the application under research, therefore it should not be performed without the co-operation of its users, who are responsible for describing requirements and explaining the meaning of data. The conceptual schema that is produced is understandable to users, so mistakes can be detected at this very early stage. Moreover, the application converges towards the expected result. Furthermore, the designers' choices can be tested and the process of implementation is thus facilitated. Owing to the fact that the conceptual modelling process is independent of implementation details, the conceptual schema produced during the conceptual modelling process can still be used even if the software used at the stage of implementation changes. Lastly, maintenance and transformation of the system (e.g. in the case that application requirements change or are enhanced) are facilitated, because the existence of the conceptual schema of the application eases understanding of its structure and functions.

The *information system* for a specific project (e.g. an excavation documentation system) is a collection of activities that regulate the sharing and distribution of information and the storage of data that are relevant to the project. Information systems' development is a process which follows a series of steps, called the life-cycle of an information system. This life-cycle usually contains the following main stages: requirements analysis, design, implementation and maintenance. An application development methodology is a structured set of procedures, concepts, methods, models and tools covering the whole life-cycle of the system. For data-intensive applications the area of computing technology that leads from problem specification to system implementation is *database design*. Database design is a complex process and can be broken down into conceptual, logical and physical design. The purpose of conceptual database design is to organise data for effective processing by use of a model that is expressively rich and user understandable in order to facilitate implementation. There are several conceptual models that are used in conceptual design. One of them, namely the Entity-Relationship (E-R) model, has emerged as the leading formal structure for conceptual data representation, becoming an established standard. The E-R model is based on only a few modelling concepts and has a very effective and understandable graphic representation. The E-R model is described in detail in section 4 below.

This approach is not sufficient to cope with the special needs of archaeological applications since they deal with information which has three basic dimensions: the *spatial* dimension, which refers to the position of archaeological entities in space (for example the place where certain artefacts were found), the *a-spatial* or *descriptive* dimension (attributes that describe the form of archaeological information, for example the possible uses of artefacts), and also a *temporal* dimension, which refers to objects' location in time. The need for handling sufficient archaeological information as a whole demands a conceptual model enriched with spatio-temporal constructs. Moreover, prehistoric excavations have requirements that are not so evident in other types of excavations. These requirements stem from the fact that there is a vast number of scattered prehistoric excavation data that need to be correlated carefully in order to draw useful conclusions. Since interpretation is the most important task in a prehistoric excavation, the excavation documentation system should be able to provide the means of organising and manipulating archaeological data without eliminating individual observations and interpretative conclusions.

Archaeological information systems have only been developed in recent years (Allen *et al.* 1990; Lock/Stančič 1995), so there is little that can be said about previous work on the subject. While a lot has been accomplished towards the development of predictive modelling for site locations, little work has been done towards conceptual data modelling for excavation information systems. As a result, the excavation documentation systems that have already been developed are inadequate for manipulation of archaeological information and can usually not easily be adapted to satisfy the needs of other archaeological excavations or to handle changes in archaeologists' views and requirements.

The rest of the paper is organised as follows: Section 2 points out the special requirements posed by excavation documentation systems and presents a justification of why a special modelling approach is needed. Section 3 is a description of a prehistoric excavation scenery as viewed by a computer scientist. The archaeological information is analysed and presented, the primary objects are described and the relationships among them are identified. The main contribution of the paper is presented in section 4, which formally describes the conceptual model that is proposed and used and also explains the approach that was adopted by the authors. Section 5 contains a summary, an assessment of the paper as well as ideas on future research on the subject.

2 Why a specific modelling approach for archaeological applications?

Archaeological information can benefit from a special conceptual modelling approach on the following grounds:

Archaeological information is located in space. As mentioned above, an important aspect of archaeological information is its spatial dimension, the *position* of archaeological phenomena in space as well as their *shape*. The position of an archaeological object is a special attribute in the sense that any change on it affects other objects' positions. This does not usually happen in the case of properties like 'material' or 'use'. For example, a change in the position of a stratum may affect the position of the neighbouring strata. Additionally, the *shape* of an archaeological entity may relate to the shapes of other archaeological entities; consider a set of excavation units with specific shapes 'comprising' a stratum. The conceptual schema must be able to represent such cases.

Archaeological data need also to be 'located' in time. One of the most important features of archaeological data is their time dimension. An excavation documentation system should be able to record information about the dates when the archaeological data were discovered and the dates of their cultural affiliation and, also, to perform temporal queries. Temporal information about the archaeological entities can then be used to view the chronological history of particular phenomena, e.g. the construction phases of a wall. Interpretation itself poses the need for versioning. Consider the case of an artefact. At time A the archaeologist in charge thought that this was an arrow head, whereas at time B the same archaeologist decided that it was the blade of a knife.

Need to handle partially defined objects. Archaeological information about certain finds may sometimes be incomplete or uncertain due to constraints posed by factors such as short time due to lack of funds or construction projects in the area, and destruction of finds by later impositions which can make interpretation rather difficult.

Need to draw useful conclusions from data that do not follow patterns or follow patterns unknown at database design time. Archaeological data are characterised by a variety of form and lack of iteration. That is, archaeological method and practice involve objects that are usually unique and which an archaeologist attempts to classify. In most cases classification poses the need for unique descriptions. Classifying information that does not follow specific

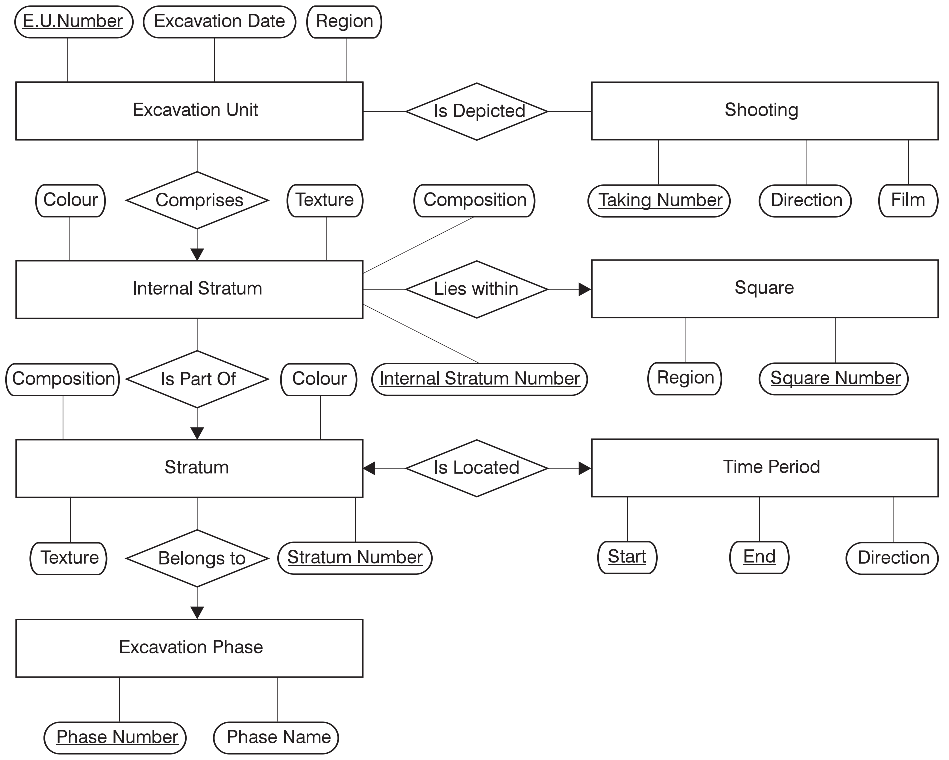

Figure 1. The Conceptual Schema.

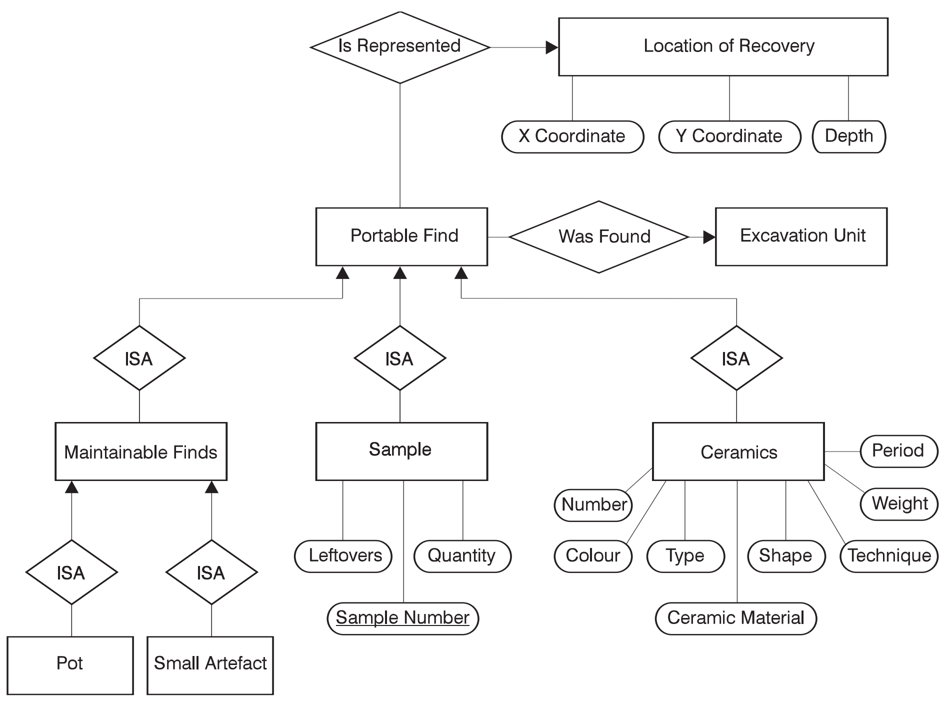

Figure 2. Portable finds.

patterns is a very special kind of decision making, on which interpretation is based. Drawing interpretation in an archaeological project where information does not follow specific patterns from attributes that are not repeated requires a special 'description' attribute in the archaeological database.

3 A layman's description of a prehistoric archaeological excavation

When compared to other kinds of archaeological excavations (e.g. classical or Roman), prehistoric excavations appear to have certain peculiarities that make the excavation practice and interpretation more difficult. Firstly, there is a vast number of prehistoric sites and finds which makes those that are under research only a small sample of the whole. Therefore, a prehistoric excavation cannot be representative of the context of others. An important aspect of a prehistoric excavation is that the information of interest is scattered. Therefore, it is very difficult to associate related pieces (for example finds, walls or hearths) as well as to visualise the excavation scenery as a whole. Moreover, prehistoric finds either have been destroyed by later impositions or are likely to be destroyed during the excavation itself, since excavating is by nature a destructive process. Many destructions are due to the errors and the inexperience of the archaeologists in charge. Therefore, the primary objective of a prehistoric excavation is the reproduction of a prehistoric scenery as well as the association between the elements of the archaeological information. This should be the objective of the excavation documentation system too.

Another important issue in archaeological excavation is *interpretation*. Interpretation is a decision-making process that depends very much on the cultural and scientific background of the archaeologist in charge. In prehistoric excavations, interpretation is very much limited by the findings.

Observation and experiment are very important parts of a prehistoric excavation method and practice. For example, it is possible to construct tools with the methods and techniques which are believed to have been used by prehistoric people. Then, these tools are tested upon use and are compared to finds. Prehistoric excavation itself can be thought of as an experiment, which unfortunately cannot be iterated. Therefore, errors in a prehistoric excavation may be very crucial to the conservation of finds.

Below follows a description of a prehistoric excavation scenery (Andreou/Kotsakis 1991; Andreou *et al.* 1995; Kotsakis *et al.* 1995). This paper presents a specific archaeological method for prehistoric excavations. However, the conceptual data modelling approach that is presented can be easily adapted to suit the needs of other prehistoric excavations.

The excavation site is divided into *squares* (or cuts). The square is the reference point for all archaeological activity that falls within its boundaries. Each find, each excavation unit and each stratum is identified within a certain square. Each square measures 4 × 4 m. The squares are separated from each other by lanes of earth that are not excavated and are called *witnesses*. Each witness is 1 m large. The witnesses are useful in order to study the stratigraphy of the ground in each square.

Most excavation methods use the *stratum* as the basic excavation entity that is located in time. The methods that are used for chronology can be either empirical or absolute (e.g. dendrochronology, chronology with C14). Determining the boundaries between consecutive strata is a very important archaeological decision which relies heavily on the experience of the archaeologist. Stratigraphy usually follows the rule of *overlaying*, which states that strata that are located closer to the surface are associated with more recent time periods than those that are deeper. However, this is not always the case. There are times when strata located in places with different elevations belong to the same chronological period. Since the square is the basic unit that controls the excavation process, strata are usually numbered with regard to the square in which they were identified. Aim of an excavation documentation application is to provide a unified stratigraphy and numbering for the whole of the excavation site. This numbering can take place after the end of the excavation. One must note that it is possible that strata belonging to different cuts are classified as contemporary in the final stratigraphy of the excavation site. Strata are characterised mainly by the colour, the composition and the texture of the soil that they contain.

Strata are usually divided into pieces of undetermined shape and size named *excavation units*. An excavation unit cannot go beyond the boundaries of a stratum and defines a constrained space where finds are distributed. Its fundamental use is to describe the progress of the excavation process.

Chronological period is the main historical product of a prehistoric excavation and provides a reference point for determining chronology for archaeological finds. Since chronological evaluation methods are applied directly to the stratum, the chronology of a certain period is determined by the strata that comprise it. Each period refers to a certain stage in a prehistoric settlement's life. For example, a fire that destroyed the settlement triggers the end of a period and the beginning of another, even if the new settlement is characterised by the same cultural and technological features as the previous one.

Until recently, excavation activities have been recorded on paper on a daily basis. The information that is kept refers to the square, the stratum and the current excavation unit; it describes the activities performed each day. It also contains the positions of artefacts. A large part of these paper manuscripts are in natural language and may also contain sketches, photographs, etc. However, there are some code expressions, for example those that refer to the colour of the ground. The use of code expressions aims at avoiding vagueness in descriptions and at facilitating interpretation. For example, ground samples with the same colour, which is expressed either by use of a code expression or by use of a standard colour set can be easily classified as belonging to the same stratum.

Prehistoric finds may be spatially fixed or not. Finds that are spatially fixed cannot be moved easily, such as walls or floors, hearths, post-holes and pits. All spatially fixed finds have a name or number that uniquely identifies them for the whole of the excavation site. For walls and floors it is interesting to note the material used to construct them (e.g. mud-bricks) and the depth of their foundations. Hearths, post-holes and pits are characterised by the number of their external phases, that is the number of times they were reconstructed or repaired. The phases of hearths, post-holes and pits are different from the phases of the prehistoric settlement.

Finds that are not spatially fixed may be pots, ground samples, seeds, shells and small artefacts that are usually classified with regard to the material used to construct them (stone, metal, bone or clay). Small artefacts, independent of classification, are described by information concerning their dimensions and shape, the material used to construct them, their colour, their type and possible use and are depicted in photographs and sketches. Some artefacts may require additional information recording, for instance concerning their decoration (type of decoration, technique and motif).

4 Modelling archaeological information

4.1 The Entity-Relationship Model

The *Entity-Relationship* model (E-R) described below is a conceptual data model that is entity-centred since its main objective is to represent entities (the primary objects, their attributes and the relationships in which they participate). The E-R model is a standard conceptual model which offers a very simple but abstractive means for structuring information. Due to its simplicity, it is widely used for the conceptual modelling of applications with very large information spaces. Certain variations and extensions of the model have occasionally been produced and used in order to satisfy the needs of certain applications.

Below follows a description of the fundamental constructs of the model. Each concept is further described by examples from the prehistoric excavation paradigm presented above. Examples are essential to aid understanding of concepts and to differentiate between similar concepts.

4.1.1 Entities

An entity is a thing or object of significance, whether real or imagined, about which information needs to be known or held. An entity represents a type or class of things — not an instance. For example, an entity named Stratum corresponds to the set of strata of a prehistoric excavation. This implies that each stratum identified in the field, for example stratum No 2, is an instance of the entity Stratum. Each entity must be uniquely identifiable. That is, each occurrence (instance) of an entity must be separate and distinctly identifiable from all other instances of that type of entity. In a conceptual schema entities are depicted by rectangles.

4.1.2 Attributes

An attribute is any description of an entity. Attributes serve to identify, qualify, classify, quantify or express the state of an entity. In a conceptual schema attributes are represented diagrammatically by circles which are linked to entities by undirected edges. The entity Stratum, discussed before, may have an attribute called Composition, which refers to the composition of the soil that each stratum in the excavation site contains. A combination of attributes usually serves to uniquely identify an entity. These attributes are then called the *key* for that entity. For example, the stratum number serves to uniquely identify a stratum (the assumption is made that the final stratigraphy of the excavation site consists of strata that are identified by different numbers), therefore an attribute named Stratum Number is the key for the entity Stratum. Attributes that are part of the key for an entity have their names underlined in the conceptual schema.

4.1.3 Relationships

A relationship is a significant association between entities. A relationship definition is one that represents a type of association between entities, to which all instances of relationships must conform. A relationship is represented by a diamond linked to their constituent entities by edges. As an example, consider the relationship which associates the portable artefacts with the excavation units in which they were found. Relationships have a functionality, which may be one of the following:

4.1.3.1 One-to-one

An example of a one-to-one relationship is the association between strata and chronological periods. Each stratum refers to one and only one chronological period. Furthermore, each chronological period is associated to one and only one stratum. (It is assumed that contemporaneous strata are merged in the final stratigraphy.) A one-to-one relationship is represented in the conceptual schema by directed edges that point to the entities forming the relationship.

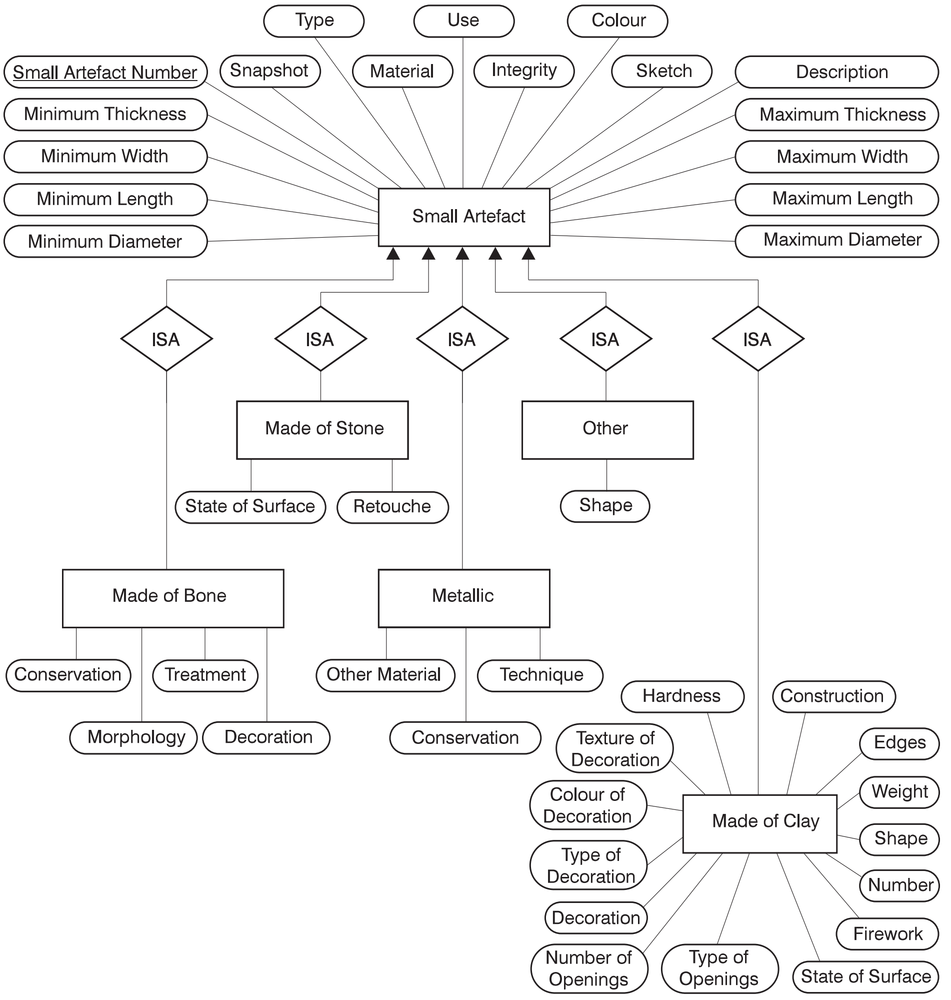

Figure 3. Small Artefacts.

4.1.3.2 Many-to-one
An example of a many-to-one relationship is the association between strata and excavation units. Each excavation unit belongs to one and only one stratum, whereas each stratum may consist of more than one excavation unit. A many-to-one relationship is represented in the conceptual schema by a directed edge that points to the entity which lies in the 'one' part of the relationship and undirected edges pointing to the rest of the entities participating in the relationship.

4.1.3.3 Many-to-many
An example of a many-to-many relationship is the association between spatially fixed finds and strata that surround them. Each spatially fixed find, a wall for instance, may be surrounded by more than one strata, whereas each stratum may surround more than one wall. A many-to-many relationship is represented in the conceptual schema by undirected edges pointing to the entities that participate in the relationship.

4.1.4 Isa Relationships
As we have seen, the Entity-Relationship modelling technique represents the world in terms of Entity Sets (e.g. Artefacts, Sites, Archaeologists) and Relationships among Entity Sets (e.g. 'found at' can be a relationship between Artefacts and Sites). 'Isa' is a special relationship indicating that one Entity Set is a ('Isa') subset of another. For example Archaeologists Isa Persons or Vases Isa Artefacts. The importance of this relationship is that the subset 'inherits' the properties of the superset. For example since Vases Isa Artefacts and Artefacts has the relationship 'found at' with Sites, then Vases also has the relationship 'found at' with Sites and we do not need to explicitly state this; thus when programs will be written we do not need to

write a special program to interrogate where a vase was found; the general program written for all artefacts will suffice. On the other hand, if Vases have an additional property, say 'type of clay' but not all artefacts have this property, we do not need to store a field 'type of clay' for all artefacts (and have it with value 'NON APPLICABLE' for all but vases): subsets (Vases in this example) can have additional properties to the ones they inherit from their supersets (Artefacts in this example).

Put another way, Isa relationships serve to declare special cases of entities. These entities implicitly inherit all the attributes and relationships of the entity at the higher level, but they can have attributes and relationships in their own right. For example, consider the case of the entity named Small Artefact. Since a metallic artefact is a special case of a small artefact, there is an Isa relationship between the entities Metallic Artefact and Small Artefact. This means that each occurrence of the entity Metallic Artefact (that is, each metallic artefact) is distinguishable by its identification number (as all small artefacts are) and is described by attributes like Type, Use or Colour. However, a small metallic artefact is further described by attributes of its own, such as Technique, Other Material and Preservation Status. The same holds for small artefacts made of stone, clay or bone.

4.1.5. Is-part-of and Is-member-of relationships

Is-part-of and Is-member-of relationships are special cases of the Isa relationship often present in some of the extensions of the E-R model. The is-part-of relationship refers to entities that form part of another entity and therefore share some of its properties, whereas the is-member-of relationship refers to an entity that is a member of a set of entities sharing common properties.

4.2 Modelling archaeological information for prehistoric excavations

Below follows a presentation of a conceptual schema for the prehistoric excavation presented above. In order to explain choices that were made during the conceptual modelling process, we present briefly the main entities and relationships they participate in. The basic entities of the conceptual schema are the following:

4.2.1. Excavation Unit[1]

Excavation units are described by their number (unique to the whole of the excavation site), the date they were excavated (it is assumed that an excavation unit corresponds to activities of one day) and the region where this excavation activity took place.

4.2.2. Square

Squares are identified by their number which is unique to the whole of the excavation site.

4.2.3. Stratum

The entity Stratum corresponds to strata that belong to the final stratification of the excavation site which is determined at the end of the excavation process. Since prehistoric excavations are usually performed in squares, during the excavation process information is kept for strata that belong to the certain square that is being excavated. Strata that are determined this way may be part of a stratum that expands to more than one square. At the end of the excavation, strata are classified and correlated and thus the stratification of the excavation site is determined. To satisfy the need for storing information about strata during the excavation the conceptual schema contains an entity named Excavation Stratum, which corresponds to the strata that are identified during the excavation of a certain square. Information stored about excavation strata can then be used to help the decision-making process of determining stratification by facilitating the association of strata from different squares that share the same properties. Strata as well as excavation strata are described by their numbers as well as other properties, such as the colour, texture and composition of the soil they contain.

4.2.4. Phase

A phase is identified by its name (or number) and its description.

4.2.5. Portable Find

Portable finds may be small artefacts, samples, pots or ceramics. Small artefacts are classified into one of the following categories: of bone, of clay, of stone, Metallic and Other.

4.2.6. Spatially fixed find

Spatially fixed finds may be walls or floors, hearths, pits or post-holes. All spatially fixed finds are uniquely identified by their name, for example Room A. Like in the case of strata, spatially fixed finds are recorded during the excavation of squares. Therefore, it is possible that parts of houses belong to different squares. Since post-excavation work requires that spatially fixed finds are viewed as a whole, the entity Part of Spatially fixed Find is used in the conceptual schema to suit the need for on-site recording of spatially fixed finds.

The basic relationships are:

1. An excavation unit *comprises* an excavation stratum. This is a many-to-one relationship, since more than one excavation unit comprises an internal stratum and each excavation unit may belong to only one stratum.

2. An excavation stratum *lies within* a square. A many-to-one relationship since each excavation stratum lies within one square exactly whereas each square contains more than one excavation stratum.

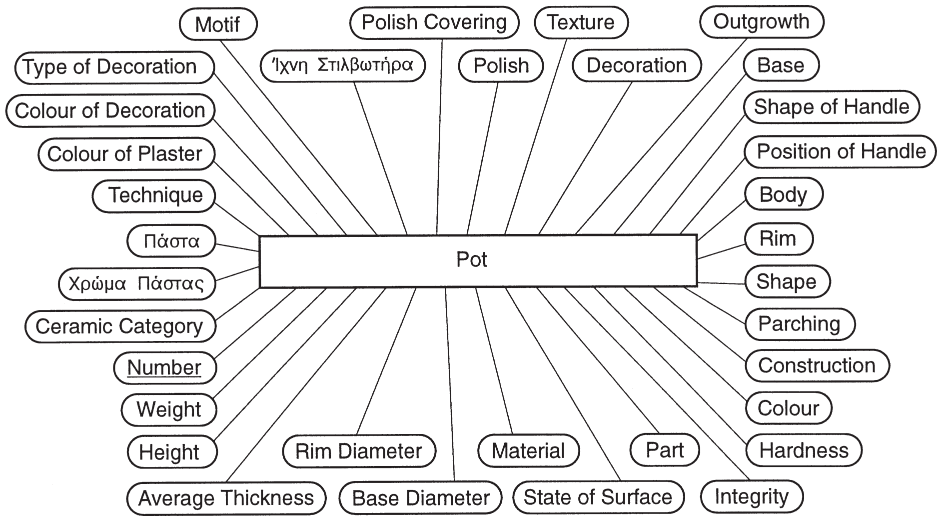

Figure 4. Pots.

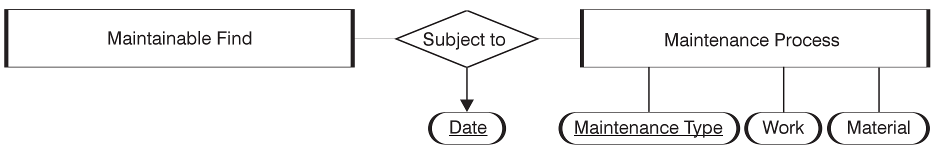

Figure 5. Maintenance of prehistoric finds.

3. An excavation stratum *is part of* a stratum. A many-to-one relationship since each stratum corresponds to more than one excavation stratum and each excavation stratum is part of exactly one stratum.

4. A stratum is *'located'* in a time period. This relationship is one-to-one. Each stratum is located to belong to exactly one time period and each time period corresponds to the chronology of exactly one stratum. It is assumed that strata that belong to the same time period are unified.

5. A stratum *belongs to* a phase. This relationship is many-to-one. Each stratum belongs to exactly one phase and each phase may contain more than one stratum.

6. An excavation unit *is depicted in* a shooting. This is a many-to-one relationship. Each excavation unit is depicted in more than one shooting, whereas each shooting depicts exactly one excavation unit.

7. A portable find *was found in* an excavation unit. This is a many-to-one relationship. Each portable find was found in exactly one excavation unit, whereas each excavation unit could contain more than one portable find.

8. Maintainable finds, samples and ceramics *are* (*Isa relationship*) portable finds.

9. Small artefacts and pots *are* (*Isa relationship*) maintainable finds.

10. Artefacts made of clay, stone, bone or metal *are* (*Isa relationship*) small artefacts.

11. Buildings, hearths, post-holes and pits *are* (*Isa relationship*) spatially fixed finds.

12. Walls (and floors) *are part of* buildings. A many-to-one relationship since each wall belongs to exactly one building and each building comprises more than one wall.

13. A spatially fixed find *is surrounded by* an excavation stratum. This is a many-to-many relationship. Each spatially fixed find may be surrounded by one or more excavation strata, whereas each excavation stratum may surround more than one spatially fixed find.

14. A spatially fixed find *is located in time* by a stratum. This is a many-to-one relationship. Each spatially fixed find is referenced in time by exactly one stratum, whereas each stratum may be used to chronologically reference more than one spatially fixed find.

15. A maintainable find *is subject to* a maintenance process. This is a many-to-many-to-one relationship. Given a specific date, a maintainable find may have been subject to one or more maintenance procedures. The other way round, given a specific date the same maintenance procedure may have been performed on one or more maintainable finds. What is more, there is only one day where a maintainable find has been subject to a specific maintenance procedure.

16. A portable find *is represented by* a point, the location where it was found. This is the graphical representation needed to map archaeological entities on the map of the excavation site. This relationship is many-to-one.

17. A spatially fixed find *is represented by* a set of solids. A one-to-many relationship. Solids are used to represent 3-dimensional entities in the excavation site and correspond both to the position of entities and to their shape.

18. An excavation unit *is represented by* a solid. A one-to-one relationship.

19. A square *is represented by* a solid. A one-to-one relationship.

20. A stratum *is represented by* one or more solids. A one-to-many relationship.

4.3 The Conceptual Schema of the archaeological database

This subsection presents the conceptual design of a database for a prehistoric excavation based on the previous description. The conceptual design, or schema, is presented in a diagrammatic form, known as E-R diagrams, using four symbols: rectangles denote entities; diamonds denote relationships between related entities; attribute names are encircled in oval shapes; underlined attributes are keys, i.e. unique identifiers, of the corresponding entities. Figure 1 is the E-R diagram of the overall excavation relating strata, excavation phases and excavation units. Figures 2, 3, 4, and 5 are the detailed diagrams of the four main types of archaeological finds: spatially fixed ones, portables, small artefacts and pots. Figure 6 is the design of that part of the database which deals with the maintenance of the finds, while figure 7 relates strata and excavation units to space, denoting that it is a 3-dimensional representation we are interested in.

5 Conclusions

Until recently, excavation documentation systems have not been much more than fast archiving systems. What is more, they often have not been correctly and efficiently designed. This paper presents the 'right' way to start developing an excavation documentation system by providing a modelling approach suitable to cope with the needs posed by the

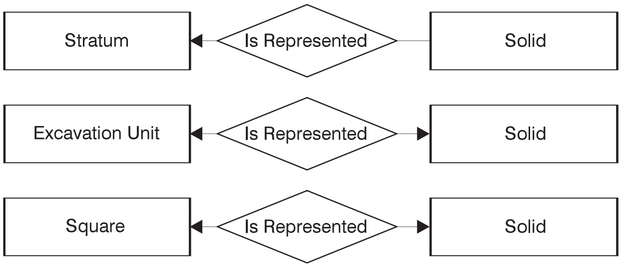

Figure 6. Position of excavation units, strata and squares.

majority of information systems (Hadzilacos/Stoumbou 1994; Hadzilacos/Tryfona 1995). This approach is able up to a limit to deal with a substantial amount of the requirements posed by prehistoric excavations. However, as mentioned above, prehistoric excavations do require special treatment as they present many peculiarities.

In the direction of providing a conceptual model suitable to deal with the special requirements often placed in the case of prehistoric excavation documentation systems, it would be interesting to search among the existing extensions of the E-R model in order to be able to chose the more suitable one for modelling prehistoric excavation information or even design a new extension that would provide the means to efficiently model data from prehistoric excavations.

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note

1 The excavation unit is an entity that is conceived by the archaeologist in charge of the excavation. Some archaeologists do not use excavation units in practice, while others that agree to the use of excavation units give different definitions to the term 'excavation unit'. The conceptual schema presented here can be easily adapted to cover such cases.

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