Which Period is it?
A Methodology to Create Thesauri of Historical Periods

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Abstract. In this paper we present a methodology to create multilingual thesauri of period names building on top of CIDOC specifications, archeological theory and results from Computer Science and Knowledge Representation. Periods are defined by different criteria based on the archaeological contexts (such as ceramics style, enabling technology etc.), rather than by time and place, which are regarded only as approximations of the spatiotemporal extent of a period. Identity criteria are distinguished from the general characteristics of a period. Terms and relations are structured by a specification in the form of an XML DTD for data exchange. A respective thesaurus is under development as proof of concept.

1. Introduction

The notion of an historical or archaeological period plays an essential role in archaeological documentation and data retrieval. Nonetheless, very little work exists to formally analyse the complexity of cultural period definition and the corresponding chronological reasoning. This paper presents an emerging methodology for creating multilingual thesauri of period names based on the specifications of CIDOC, archaeological theory and results from Computer Science and Knowledge Representation. The methodology is realised as a formal model (an XML DTD) and a proof of concept is shown of a thesaurus of period names from the Helladic period, which was developed at the University of Crete.

The design of such thesauri aims at a systematic approach to defining cultural periods and their interrelations, even when precise time, space and other properties are debatable or even unknown. The resulting thesauri should improve communication, and the resolution of disagreements, between scientific sub-communities concerning the definition of periods and more generally on relative chronology. It should bring clarity to the respective terminology and its use in the literature, so that comparative studies of literature and archaeological evidence may be effectively carried out and valid conclusions reached.

The presented methodology does not aim at the prescription of correct scientific opinion: rather, it aims at the overview and combination of established, alternative opinions using a methodical approach. A formal model has been developed as a proposal for standardization, taking up an initiative of the CIDOC Archaeological Working Group, a working group of the International Committee for Documentation of the International Council of Museums (CIDOC). This holds the view that thesauri are collections of terms with generally agreed-on semantics and not individual definitions or representations of a concept (Doerr and Kalomoirakis 2000). Well-designed thesauri of cultural periods should help to:

- define cultural periods and phases based on the distinct characteristics of the archaeological contexts that are used by the respective scientific community to identify their unity, rather than by time and place,
- organize the relevant archaeological information about periods in a consistent and comprehensible form in a computerized environment,
- classify museums objects with respect to chronology consistently, in particular between different geographical areas,
- identify finds and assess chronology in archaeological research and excavations.

This paper is organized as follows: Section 2 describes related work. Section 3 describes the theoretical background of the proposed method and justifies the design of the major elements of the formal model. Section 4 gives examples illustrating important features of the model. Finally we draw conclusions in Section 5 and present directions for future work.

2. Related Work

Related work can be divided into several areas: On one side, computer science concentrates on temporal reasoning in controlled industrial environments, typically using discrete events and time intervals, neglecting spatiotemporal dependencies (e.g. Allen 1983, Theodoulidis and Loucopoulos 1991, Ligozat and Vila 1998, Cowley and Plexousakis 2000). They evaluate systems of complex relationships, mostly to predict the behavior of engineering constructs or workflows. Similar work on spatial relationships has been done by (Cohn, Bennett, Gooday and Gotts 1997). In addition, there is considerable research and development into spatiotemporal databases (e.g. Koubarakis, Sellis. et al. 2003) to study the evolution of ecological, economical or other phenomena on earth. Systems for chronological reasoning in archeology typically concentrate on statistical approaches to

date archeological strata. These approaches normally regard the studied phenomena as simple, well-defined and associated with precise points in time. The Perseus Digital Library (Smith 2002) uses spatiotemporal maps and indexes to search for documents about events.

On another side, the archeological notion of cultural periods is based on cultural semantics. Chronological systems based on such periods are notoriously controversial, due to the complexity of the relationships between contextual phenomena and spatiotemporal values. Nevertheless, they play a key-role in archeological discussion. Several projects have attempted to define standard systems of periods for indexing databases, interpreting the spatiotemporal or stylistic inclusion as a "broader/narrower term" relationship based on ISO2788 (e.g. The J.Paul Getty Trust College Art Association 2000, AAT 2000). This approach is not expressive enough to capture the actual complexity, resulting in differences between chronological systems being able to be justified by the differences in the initial definition and subsequent (re)interpretation of observations. The British MIDAS (MIDAS 1999) standard and the ArchTerra Project (van Leusen 2000) define maximum/minimum dates in addition to broader/narrower relationships for periods. Intuitively, many systems regard points in time as a means to recognize events and the temporal end-points of periods, confusing definition with conclusion, and identity with non-unique properties (actually, the absolutely precise point in time when an event happens is not observable).

The final area of previous work is the CIDOC CRM (Doerr 2003, Crofts, Doerr, Gill, Stead and Stiff 2004.) which develops a general ontology (Guarino 1998) about cultural documentation. The CRM models periods as a generalization of events, which occur in space-time. It uses temporal and spatial relationships even for cases where absolute time and space are unknown. The notion of history is based on timelines of objects becoming manifest in events. It is the first widely accepted formal ontology that defines historical and archaeological periods and the fundamental relationships to events and things, a result of years of interdisciplinary work and analysis of documentation practice in museums and archaeology. As its primary role is to enable exchange and integration between sources of cultural heritage, it does not go into the details necessary to create and manage a thesaurus of periods. It does not propose a standard format nor does it analyze how to define a period.

This paper seems to provide the first specification of a document structure for thesauri of periods, which goes beyond general models for thesauri and is based on a scientific interpretation of archaeological theory and computer science.

3. Methodology

It is envisaged that the usual scenario will be a team of experts acting as a thesaurus editor, and a larger number of interested users sending proposals for concepts to be introduced or modified in the thesaurus (Doerr and Fundulaki 1998). The editor maintains the thesaurus on a suitable knowledge base,

and provides access to it either as a Webservice or via distribution of copies of the latest release. In order to promote a common approach to period definition for both the editor and the users, a standard schema for data acquisition and exchange is proposed. This will be accompanied by a user manual that clarifies the intended meaning of the schema elements and gives advice for its consistent use. The database will need additional management functions as described in Doerr and Fundulaki 1998, which are not discussed further in this paper.

The schema is expressed as an XML DTD (Fig.1, 2), which can be used directly by XML editors, native XML databases and can also be easily converted to other data-models or encoding schemes. The schema describes a single period concept as a single document (in the sequence called "period definition document") that may link to other period definition documents and auxiliary concepts, such as bibliography or gazetteer entries. A period thesaurus is built from a set of consistently linked period definitions.
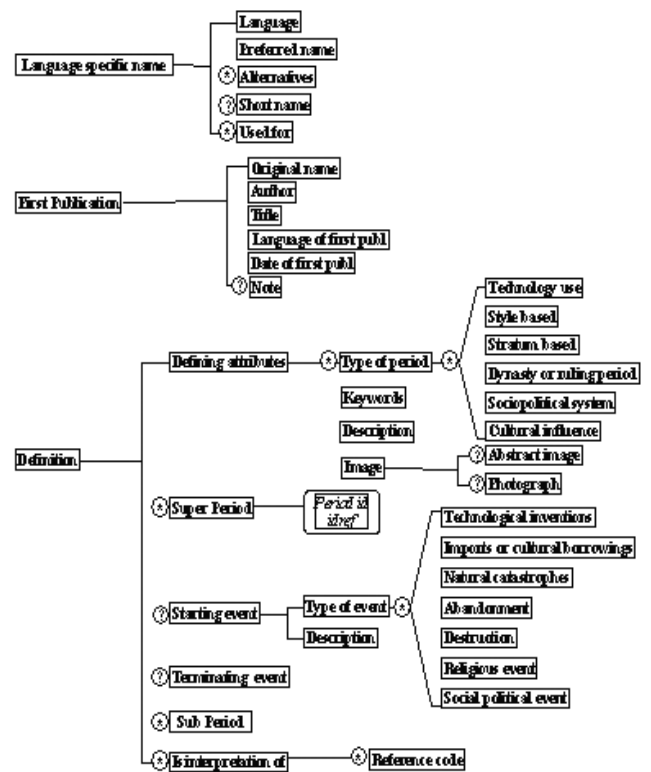

Fig. 1. Part of the Schema: Terminology and Definition.

The schema comprises multilingual terminology for the period, the period definition in the narrower sense, its analytical spatiotemporal extent and spatiotemporal relationships, characteristic attributes and cultural influences, metadata about the initial conception of the period and the document that first defines it (the definition document). The data that relate terminology and concept definition support the classical thesaurus functions (Soergel 1996, Doerr and Fundulaki 1998):

- Guidance for the user to find a concept in the thesaurus,
- clarification of its meaning,
- unique identifiers to be used for effective identification, indexing and classification of the (archaeological) material

The additional information is based on ontological analysis, which aims at supporting:

- reasoning about the relations between periods, and periods and finds. Actually this paper combines both ontological and terminological aspects. The following section justifies the proposed methodology and the choice of the major elements.

3.1 Terminology

Archaeologists create terminology about periods in order to classify finds by a schema of relative chronology (periods) and to relate sequences of settlements and cultures. The use of a certain terminology implies a number of ideas that may differ from researcher to researcher, so that there is a tendency to define cultural periods of even the same culture differently and to use different terminology for them (e.g questions about the definition or even existence of the Early Minoan III period caused disagreements between archaeologists in the past -see 1967, Warren 1984). Period names may represent the same or different concepts depending on the view or social group. Traditional names may be preserved, altered or redefined (Barber 1987) on the base of earlier literature. Even if an established terminology about periods exists, it sometimes operates against explanation and understanding. (see comments on tripartite system of Evans, made by Dickinson in Dickinson 1994) The nomenclature principles lead to ambiguity since a name may designate several concepts. The problem is similarly known from biological species definitions, and seems to be common to taxonomies that follow the evolution of science.

For that reason, we identify a period concept with the term plus a reference to the first known publication that actually defined it, just as it is good practice in biology (Berendsohn 1995). We propose to create unique preferred terms as in biology (e.g.: 'Fringilla coelebs Linnaeus, 1758'). If details of the original definition have undergone some evolution, we would refer to the most recent interpretation of it. This case is distinct from an actual redefinition, which would give raise to a new concept. In the case of diverging interpretations, we also propose to create two distinct definition documents. Any number of synonyms in any natural language may be added. Synonyms need not be unique. They guide the user to the concept and preferred term. A URI ("universal resource identifier") may serve as language-neutral, machine-processable identifier (see Fig. 1).

3.2 Definition

"Cultural period" is a multidimensional concept about complex interrelations between cultural phenomena. The CIDOC CRM defines the basic notion of a period as: "This class comprises sets of coherent phenomena or cultural manifestations bounded in time and space. It is the social or physical coherence of these phenomena that identify an E4 Period and not the associated spatio-temporal bounds. These bounds are a mere approximation of the actual process of growth, spread and retreat. Consequently, different periods can overlap and coexist in time and space, such as when a nomadic culture exists in the same area as a sedentary culture. …". (Crofts, Doerr, Gill, Stead and Stiff 2004). This definition is based on a notion of coherence, a "unity criterion" in the sense of (Guarino and Welty 2002), that relates phenomena such as people following a certain life-style, political decisions, an economy etc. The CRM definition goes actually beyond cultural periods in the narrower sense, but we shall adopt this definition here, intuitively restricting it to "cultural" periods.

As culture evolves gradually, respective characteristics increase and decrease in frequency and strength. This makes the definition of a period necessarily fuzzy with respect to space-time, but it makes the periods themselves not less real or objective. Rather, spatiotemporal bounds make no sense beyond a certain degree of precision. Further, culture evolves in many directions at the same time. The degree of synchronization between different kinds of phenomena, such as style and political system, may vary considerably. This gives raise to multiple points of view. Necessarily, such views differ objectively in their spatiotemporal bounds. Finally, archaeological observation is restricted to the products and traces of some of these phenomena. The degree, to which these are correlated to the non-observable phenomena, gives raise to subjective interpretations. Jean-Claude Gardin (Gardin 1990) analyzes this process in general terms. We try to make the distinction of Gardin's "M0" from the following sets Mi explicit.

We therefore propose to distinguish between the phenomena, that have left distinct traces and are taken as objective indicators for the coherence of the respective period (the identity criterion), and other characteristic phenomena, distinct or not, that are either product of interpretation or that are not directly associated with the coherence of the period as a whole. For instance, "Ming dynasty" is defined by the political system. Any change of our knowledge about the dates of rule of the Ming emperors will change the asserted temporal bounds of "Ming dynasty". In contrast, Ming porcelain is a good indicator for dating finds from the Ming dynasty. However, change in our knowledge of the dates of production of a certain Ming porcelain style will not affect the temporal bounds of Ming, but at most characterize this style as no more central to Ming etc. In this case, the political system provides the identity criterion, and the porcelain production just a distinct, characteristic phenomenon of this period.

Identity criteria are types of reported phenomena or the kinds of their observable traces that determine the unity and identify the cultural continuity of a period.

Archaeologists usually define and divide periods by stratigraphic and ceramic evidence – very easily especially when there are clear stratigraphic sequences. Particularly, Aegean archaeologists seem to see the passage of time in terms of ceramic typology (McNeal 1975). The recognition of a Style/Ware and its development may determine a period or a phase. Style can be used to sort and distinguish spatiotemporal cultural groups – culture includes style (Hodder 1987) – by specific characteristics; through a specific shape or decoration, style represents the specific society, which produced it (Renfrew and Bahn 2001). In such cases,

we regard the period to be defined by style. Hence the appearance of the respective style is the ultimate criterion for the associated spatiotemporal bounds, and not the assumed political system or whatever other phenomena a researcher may associate with the observation of this style.

We are still investigating the characteristic kinds of criteria to define a cultural period. In the sense of (Guarino and Welty 2002), we regard a notion like "style-period" as a "rigid" property bound to the whole existence of any of its instances. As such, it "carries an identity condition", such as "having the same style throughout its duration and spread". This approach allows us to objectify the discussion, if different opinions about a period are due to different definition or due to different stages of knowledge or interpretation. So far, we have identified the following classification of identity criteria: style, socio-political system, technological capabilities, strata, and cultural influence. This list will be refined and extended in the near future.

3.3 Events and Periods

Some events are closely related to the definition of a period. We mark them as "starting event" or "terminating event". A frequent intuition is, that some kind of distinct event should be responsible for the upcoming of a new cultural phase (as required by Biers 1992). The question is: can a single historical, religious, military, political or physical event have a definitive affect on a period? Did, for example, an earthquake or a volcano eruption as the one that happened in Santorini determine the specific period? We regard that an event may be one of the catalytic factors to social change and thus be loosely synchronized with the end points of a period. Only the rare cases of complete extinction actually terminate a period in the absolute sense. Generally however, we do not regard those events as causal to the properties of a period, and the change of a period may quite well happen without such an event. Therefore we use these events as chronological markers rather than as part of the definition.

3.4 Spatiotemporal Extent and Relationships

If we accept that the "substance" of a period is made of cultural phenomena, quite naturally these phenomena cover an irregular area in space-time. A period may slowly spread out from a kernel region, and still flourish at distant areas when it has vanished already at its origins. In other cases it may again "retreat" to its origins, or even separate spatially. The precise boundaries are naturally fuzzy, except may be for cases of modern political systems with precise geopolitical boundaries at any time and islands. Even then, the precise boundaries may be too complex for the utility of a general thesaurus. Therefore we foresee two kinds of approximation (Fig.2) of absolute bounds.

The first ("Max space time") serves rough orientation and narrowing down database searches for finds: The total of all places where the period flourished at any time is approximated by an outer (larger) spatial bound. This might be by the identifer of a geopolitical of geological unit, or by a geographical polygon, or both. The starting phase and the

Fig. 2. Part of the Schema: Spatiotemporal Extent.

terminating phase when the overall period flourished is approximated by outer temporal bounds, expressed by two date ranges. Note, that last date for the begin might be after the first date for the end.

The second ("Space time analysis") serves a more analytical description, in particular for cases where the dates differ significantly from place to place. (Fig.3) For this purpose, we foresee a break-down of the total area into individual subareas, which can be associated with individual data ranges, in the same way as for the overall approximation. In general not all individual places, where a culture flourished, may be known. Therefore the space time analysis is normally an incomplete list of individual centers of a culture. The given schema allows to capture the characteristic practice of chronology tables as shown in Fig. 3. It is however not our intension to compete with GIS systems or spatiotemporal

Fig. 3. Example of a spatiotemporal analysis from Korraq 1985.

databases, but to assist a reasonable recall and precision at general collection management systems or digital libraries.

Absolute bounds allow to calculate many spatiotemporal relationships, such as temporal succession, spatial separation etc. When these bounds change, the relationships can be recalculated. We therefore do not propose a documentation of such deductions from absolute places and times in the thesaurus. Archaeological evidence nevertheless allows to directly infer rich relative spatiotemporal relationships. In this case we foresee their documentation, providing a standard set of purely spatial, purely temporal (Allen 1983), and genuine spatiotemporal relationships taken from the CIDOC CRM. They comprise in particular relationships of succession and containment that are the result of an intellectual breakdown of larger periods into subperiods as part of their definition.

3.5 Characteristic Attributes

In contrast to the identity criteria, general characteristics of a period can be documented as part of their description, such as technological activities, social-political structures, economy and trading, history of war activities (and sequences/results), patterns of settlements and belief systems, generally different aspects of material culture. They do not define, but simply describe, and interpret a period. They are cultural activities that develop and vary during time- cultural phases, products of past human behaviors representing/describing progress in cultures and life. Some of these characteristics may be distinct, and be helpful to identify finds, such as the Ming porcelain, or the "index fossils" in geology. These are marked separately in the schema

4. Example

An example of Helladic (prehistoric) periods is developed in order to confirm the appropriate structure of the specific schema. A part of this example can be found on http://cidoc.ics.forth.gr/docs/period/xsl_output.html

Let us here regard only the definition of the period Late Cycladic I:

Period LCI, according to the interpretation of R.L.N Barber (Barber 1987), is defined by a combination of cultural phenomena (which are the identity criterion – the author examines how "definitive" they are), such as technology use (and by that, we mean the architectural changes in sites of Akrotiri on Thera, Ayia Irini on Kea and Phylakopi on Melos) and a strong cultural influence (specifically, the strong appearance of Minoan objects in Cyclades).

According to Barber, the dramatic event of the eruption of the volcano in Santorini is regarded as a "terminating event" (of type "natural catastrophe"), i.e. it ended the specific period and is used as a chronological mark of LCI period (and perhaps of others periods too; in that case there is a relationship of synchronism between periods). This does neither mean, that the eruption terminated immediately the culture, nor that we take any personal position. Rather, we render the chronological relation about the impact of the event that Barber claims.

The dates of absolute chronology of LCI are based on different evidence than the recent doubts about the date of the eruption (from polar ice analysis or tree rings). This demonstrates the utility to register both, widely accepted absolute chronology and distinct events that might help update the chronology or interpretation in the future. I.e., if the new dates for the eruption (Manning 1999) are confirmed, either the interpretation that it terminated LCI is wrong (there is also the opinion that the eruption occurred at the beginning of the period) or the absolute chonology. In the latter case, periods for which a synchronism with LCI has been established from independent evidence as described in 3.3 have to change absolute chronology etc.

It must be clear, that a thesaurus can never reflect absolute truth but only a historical stage of knowledge.

5. Conclusions, Future Work

We have developed a formal methodology to document the definition and description of cultural periods as found in literature, based on CIDOC specifications, archaeological reasoning and computer science. A fairly mature schema, in the form of XML DTD, is available to discuss standardization of period thesauri.

An initial thesaurus of Helladic (prehistoric) periods is under development.

More investigation will be devoted to the different kinds of period definition in archaeology, and refinement of the proposed DTD with respect to necessary and optional information. Finally, more examples and a technical manual will be provided and published at the CIDOC CRM Website (CRM).

References

AAT 2000. Art and Architecture Thesaurus User's Guide to the AAT Data Release, Version 4.0, The J. Paul Getty Trust, 2000 (www.getty.edu/research/conducting-research /vocabularies/aat/).

Allen, J. 1983. Maintaining knowledge about temporal intervals. *Communications of the ACM* 26: 832–843.

Barber, R.L.N. 1987. *The Cyclades in the Bronze age*. London.

Berendsohn, W. 1995. The concept of "potential taxa" in databases. *Taxon* 44: 207–212.

Biers, W.R. 1992. *Art, artifacts and chronology in classical archaeology*. London – New York, Routledge.

CIDOC. The International Committee for Documentation of the International Council of Museums (ICOM – CIDOC), http://www.cidoc.icom.org

Cohn, A., Bennett, B., Gooday, J. and Gotts, N., 1997. Qualitative Spatial Representation and Reasoning with the Region Connection Calculus. *Geoinformatica* 1(3), 1–44

Cowley, W. and Plexousakis, D., 2000. Temporal Integrity Constraints with Indeterminacy. *Proceedings of 26th VLDB Conference*: 441–450.

Crofts, N., Doerr, M., Gill, T., Stead, S. and Stiff, M., 2004. Definition of the CIDOC Conceptual Reference Model, April 2004 (version 4.0)

CRM. The CIDOC Conceptual Reference Model (ISO/CD 21127), http://cidoc.ics.forth.gr/.

Dickinson, O. 1994. *The Aegean Bronze Age*. Cambridge University Press.

Doerr, M. and Fundulaki, I., 1998 . SIS – TMS: A Thesaurus Management System for Distributed Digital Collections. *Proc. of the 2nd European Conference, ECDL'98*. 215–234.

Doerr, M. and Kalomoirakis, D., 2001. A Metastructure for Thesauri in Archaeology. In Stančič Z. and Veljanovski T. (eds), *Computer Archaeology for Understanding the Past CAA2000, Proceedings of the 28th Conference, Ljubljana, April 2000*. Oxford, ArchaeoPress (BAR International Series 931).

Doerr, M., 2003. The CIDOC CRM – An Ontological Approach to Semantic Interoperability of Metadata, *AI Magazine*. Volume 24, Number 3.

Gardin, J-Cl., 1990. The structure of archaeological theories. *Studies in Modern Archaeology Vol. 3: Mathematics and Information Science in Archaeology: A Flexible Framework*. Bonn, 7–25.

Guarino, N. 1998. Formal Ontology in Information Systems. In Guarino N. (ed.) *Formal Ontology in Information Systems. Proceedings of FOIS'98, Trento, Italy, 6–8 June 1998*. Amsterdam, IOS Press. 3–15.

Guarino, N. and Welty C. 2002. Identity and Subsumption. LADSEB CNR internal report.

Hodder, I., 1987. The contextual analysis of symbolic meaning. In *The archaeology of contextual meanings*. Cambridge University Press.

Korraq, G. 1985. *Kykladikøq Politismøq (Neoliuik¸ – Protokykladik¸ epox¸)*. Au¸na.

Koubarakis, M., Sellis, T. et al, 2003. *Spatio-Temporal Databases: The CHOROCHRONOS Approach*. Berlin, Springer.

Ligozat, G. and Vila, L. 1998. *Ontology and Theory of Time*.

Manning, S., 1999. *A test of time: the volcano of Thera and the chronology and history of the Aegean and east Mediterranean in the mid second millennium BC*. Oxford.

McNeal, R.A., 1975. Helladic Prehistory Through the Looking-Glass. *Historia* 24, 385–401.

Midas: A Manual and Data Standard for Monument Inventories. English Heritage. 1999.

Renfrew, C. and Bahn, P. 2001. *Arxaiolog°a: Uevr°eq, Meuodolog°a xai Praxtix™q efarmog™q*. Au¸na.

Smith, D.A., 2002. Detecting events with date and place information in unstructured text. In *Proceedings of the 2nd ACM+IEEE Joint Conference on Digital Libraries, Portland*. 191–196. www.perseus.tufts.edu/

Soergel, D., 1996. SemWeb: Proposal for an open, multi-functional, multilingual system for integrated access to knowledge about concepts and terminology. *Advances in Knowledge Organization* 5, 165–173.

The J. Paul Getty Trust College Art Association. 2000. Categories for the Description of works of Art – Styles /Periods/Groups/Movements www.getty.edu/research/ conducting_research/standards.

Theodoulidis, C. and Loucopoulos, P., 1991. The Time Dimension in Conceptual Modelling. *Information Systems* 16(3), 273–300.

van Leusen, Martijn. 2000. A Multilingual Thesaurus Application for Internet Archaeology. INCO Copernicus 977054 (ArchTerra) Technical Note # 2 – , 25/2/2000

Warren, P., 1984. Problems of chronology in Crete and the Aegean in the Third and Earlier Second Millennium B.C. *AJA* 84.

Zahq, A. 1967. Ypårxei PMIII epox¸. *Pepragmna B' Krhtogiko Synedry* 1: 141–156.