Formalizing Fact and Fiction in Four Dimensions: A Relational Description of Temporal Structures in Settlements

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Abstract

Long lasting settlements with physically overlapping structures often contain a vast amount of observations, which can be taken to indicate specific relative chronological relations between different structures. Our concept of the temporal significance of the observations can be translated into a formal logical expression. This allows the construction of a detailed graph of the temporal structures of the settlement. The procedure will be demonstrated on a section of a Danish Iron Age settlement. Compared to the traditional handling of temporal structures the suggested formalized approach gives a more detailed picture of the development of the settlement with the potential of conducting formal analysis on the relational structures. Furthermore, it presupposes the explicit formulation of the preconditions on which the temporal sorting is based, revealing a problematic mix of fact and fiction in the traditional analysis of Danish Iron Age and early Medieval settlements.

Key words: relational description, networks, Harris matrix, relative chronology, settlement analysis

1. Introduction

When settlements occupy the same area for several centuries traces of buildings and activities may accumulate to such an extent that original distinct patterns and structures become totally obscured.

Northern European Iron Age and Early Medieval villages may be taken as an example from this kind of settlement. The buildings were constructed of posts dug into the subsoil, leaving durable and archaeologically easily recognizable traces. The buildings themselves, on the other hand, had a relatively short life span of one or two generations leading to frequent changes in the layout of the settlement over several centuries. Consequently the excavation plans are often characterized by an overwhelming confusion of postholes and other structures (Hvass 1979, 1980).

Normally, it is possible to identify the individual buildings, first and foremost the longhouses but also the smaller out-houses as well as the fences surrounding the buildings. Furthermore, different types of physical connections between the buildings point to specific relative chronological relations. Buildings may, for instance, cut each other indicating that the cutting structure was constructed after the demolition of the structure being cut. Another example could be that one fence had been added to another. Here the added fence must have been erected after the construction but before the demolition of the other fence. A final example is structures which overlap although without a clear stratigraphy we only know that the involved buildings did not exist at the same time.

When the connections between the different structures form a closely interwoven net, it should, in principle, be possible to generate a detailed relative chronological model of the development of the settlement. Temporal sorting of a number of Iron Age and Medieval settlements have also resulted in seemingly clear and unambiguous phases of contemporary structures, but the analyses are informal and often seem somewhat intuitive. The combination of complex data and the lack of an explicit, formalized approach to the sorting makes it very difficult to test the results and evaluate what preconditions they are based upon.

2. Relational description of the temporal structures

A formalized method for the interpretation of temporal structures of settlements must take its starting point in the character of the data. We can consider settlements to be a relational system consisting of a number of entities, i.e. the buildings, which are related to each other by physical connections with temporal implications (figure 1) (Dallas 1992, Holst 1999).

The connections refer to the construction and demolition of the structures and to the life span of the entities, which can be understood as the time between construction and demolition. If we define demolition as the time where physically the building no longer influences subsequent structures, we may consider both construction and demolition as points in time, notwithstanding that abandonment of the building might have been a gradual process. In a relational description each structural entity in this way has two nodes: A starting point and an end point. If, based on this, we explicitly formulate the life span as the open interval between the two extreme points, we can furthermore distinguish between continuity, where the end point of one structure is contemporary with the start point of another structure, and discontinuity where the end point of one structure is earlier than start point of another structure. The temporal sorting is purely a relative chronology, and as we are dealing with points in time, in principle only three types of relations are possible: Contemporary with, earlier than and later than.

In this way the relational network is rather similar to the one found at stratified excavations, where a formal, graph based representation of the relations has long been used in the form of the Harris Matrix (Harris 1975).

However, it should be stressed that the analysis of temporal structures in settlements differs from the handling of stratigraphy for a number of important reasons. First and foremost, stratigraphical observations are relatively objective, whereas it is quite evident that attempts to uncover the temporal structures of the settlements deal with interpretative constructs and are based upon our subjec-

tive evaluation of the significance of connections between different constructs.

Another difference is that in settlement analysis the structural entities consists of two nodes, and the connection between two entities might consequently be a set of relations rather than just one relation as in stratigraphical analysis, making it possible to describe the temporal consequences of the connection very specifically. This level of detail is necessary, because settlements contain a wide range of different types of connections with different temporal implications, whereas stratigraphical analysis principally only operate with two connections i.e. above and below.

A final characteristic that distinguishes settlement analysis from stratigraphical analysis are the ambiguities and uncertainties of the temporal connections. As the data are a fragmented and partial reflection of the past, we are often left with several possible relations. An example is the overlapping structures without cuttings. Here we know that either the start of structure X is later than or contemporary with the end of structure Y, or the end of structure X is earlier than or contemporary with the start of structure Y. To describe this kind of ambiguity it is necessary to introduce an either-or-connective.

We may now describe the temporal relationship between structures in a settlement by relating the start and end points of the individual structures with the relations: earlier than, later than and contemporary with and by combining these relations with the logical operators *and* and *either-or* (Holst 1999). The relations can be represented formally using the symbols:

=	for the relation	*contemporary with*
<	for the relation	*earlier than*
>	for the relation	*later than*
≤	for the relation	*either earlier than or contemporary with*
≥	for the relation	*either later than or contemporary with*
AND	for the connective	*and*
XOR	for the connective	*either or*

The example of the overlapping structures without cuttings would formally be expressed as:

X(start) ≥ Y(end) XOR X(end) ≤ Y(start)

3. The procedure in practice

Having established the general principles of description, attention can now be directed towards the practical use of the formalized handling of the temporal structures.

The first step is to identify the different types of connections between structures of a settlement. Secondly, our interpretation of the temporal significance of the connection types must be formulated, and thirdly, this interpretation has then to be expressed formally according to the principles outlined above.

The types of connections can be classified into 13 classes each with their specific temporal implications as seen in figure 2.

Having defined the connections and expressed their temporal implications formally the next step is the actual recording of the temporal structures in the settlement. This process can be demonstrated on a small part of the 3rd to 7th century AD Nørre Snede settlement situated in Mid Jutland (figure 3) (Hansen 1988). The

	Time	Entities	Links	Interpretation
Data level	Span of time	Structures	Connections	Temporal implication
Formal representation	Points in time	Nodes	Relations	Formal expression

Figure 1: The basic concepts in the analysis of temporal structures related to a distinction between a data level and a formal representation.

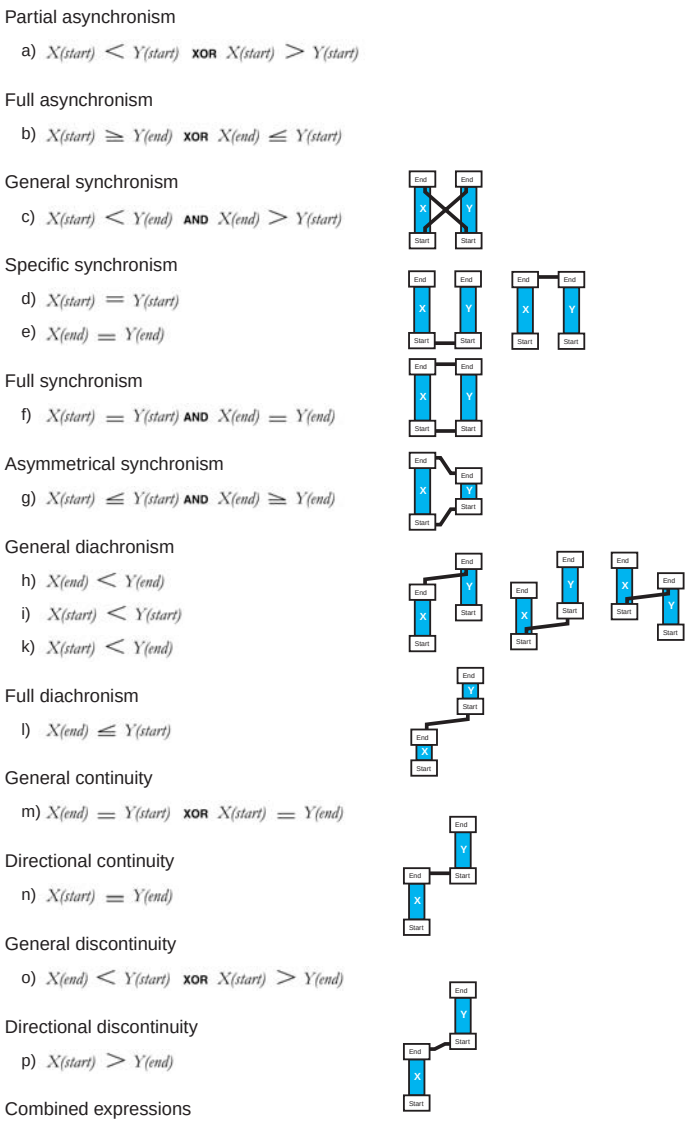

Figure 2: Classification of the temporal implications with graphical representation, where the implication is unambiguous.

area shown consists of two farms, which can be divided into a number of minor structural entities, i.e. fences, longhouses, minor houses and barns. The defined structures are listed in an m x m matrix, figure 4, where the temporally significant connections between the structures are shown. If the individual connections are substituted with their formal relations between start and end-nodes of the structural entities, a relational network representing the temporal structure of the settlement is achieved.

Figure 3: The analysed area of the Nørre Snede excavation showing the identified structures in the settlement (scale 1:500).

4. The ambiguities of the relational network

The relational network of the Nørre Snede settlement can be represented graphically as shown in figure 5. It offers a very detailed picture of the temporal structure, where we can distinguish between contemporary replacements of buildings and fences in one of the farmsteads and gradual changes in the other. The level of detail makes it possible to give a very precise description of the character of changes in the settlement.

However, the network is also a highly flexible structure and very much open to interpretation. The partial character of the archaeological record means that only a few elements are related to each other and hence there are a limited number of constraints on the relative positions of the elements. They are seldom locked, but can be moved relative to each other, making it difficult to point out exactly which elements existed simultaneously. Furthermore, due to the either-or relations several different ways of sorting the elements will often be logically consistent and thus equally probable. Consequently, it is not possible to identify unambiguously which structures existed simultaneously.

What then is the basis for the often very detailed segregation of phases of contemporary structures seen in the publications of the North European Iron Age and Medieval settlements? Apparently the chronological sorting is based on the same types of connections as in the network analysis presented here, but there seems to be important differences in the concept of their temporal implications. In the construction of the network at least 13 classes of different temporal implications were used, whereas the more traditional analyses only seems to distinguish between full synchronism, full diachronism and full asynchronism, even though it is rarely expressed explicitly.

This is a generalization, which to a wide extent ignores the ambiguities of the archaeological data, and makes the temporal sorting appear more certain than it actually is. Furthermore, it may have far reaching consequences for the interpretation of the organisation and social structure of the settlement, as it can impose false structures on our picture of the development of the settlement. For instance, the exclusive use of the three mentioned types of temporal implication, will make changes in the settlement appear contemporary even if they occurred gradually, and these apparently contemporary changes have been used to argue that the settlements were strongly regulated. Again this influences our concept of power structures and the character of the power in the Iron Age and Medieval society.

Another reason why traditional chronological sorting results in a relatively inflexible picture of the temporal structure of the settlement can be found in the introduction of a number of implicit

	Longhouse I	Longhouse II	Longhouse II	Longhouse IV	Longhouse V	Longhouse VIa	Longhouse VIb	Longhouse VII	Fence 1	Fence 2	Fence 3	Fence 4	Fence 5	Fence 6	Fence 7	Fence 8	Fence 9	Fence 10	Fence 11	Fence 12	Fence 13	Fence 14	Fence 15	Fence 16	Fence 17	Other 1	Other 2	Other 3	Other 4	Mindre 1	Farm 1	Farm 2
Farm 2	.	.	.	g	g	g	g	g	.	.	.	.	.	c	g	g	g	g	g	g	g	g	g	g	.	.	.	g	g	.	..
Farm 1	g	g	g	.	.	.	.	.	g	g	g	g	g	c	.	.	.	.	.	.	.	.	.	.	g	g	g	.	.	..	
Mindre 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..		
Other 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..			
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Other 2	.	.	.	.	.	.	.	.	.	.	g	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..					
Other 1	.	.	.	.	.	.	.	.	.	g	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..						
Fence 17	.	.	.	.	.	.	.	.	.	.	.	.	.	b	bb	.	c?	.	.	.	.	.	.	..							
Fence 16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	c	.	.	i	..							
Fence 15	.	.	.	.	.	.	.	d	.	.	.	.	.	.	.	.	.	b	b	b	b	b	..								
Fence 14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b	b	b	bn	..									
Fence 13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b	b	bn	..										
Fence 12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b	bn	..											
Fence 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b?n	..												
Fence 10	.	.	.	.	.	c?	.	c?	.	.	.	.	.	c?	.	.	.	..													
Fence 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	b	biln	..														
Fence 8	.	.	.	c	.	.	.	.	.	.	.	.	.	.	bim	..															
Fence 7	.	.	.	.	.	.	.	.	.	.	.	.	.	bln	..																
Fence 6	.	.	ci	.	e	.	.	.	.	.	.	c	c	..																	
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Fence 4	.	.	g	.	.	.	.	.	.	m	.	..																			
Fence 3	.	.	g	.	.	.	.	.	.	.	..																				
Fence 2	l	f	.	.	.	.	.	.	m	..																					
Fence 1	cf	.	.	.	.	.	.	.	..																						
Longhouse VII	.	.	.	bin	bi	bi	bi	..																							
Longhouse VIb	.	.	.	b	bl	bln	..																								
Longhouse VIa	.	.	.	b	bln	..																									
Longhouse V	.	.	.	bin	..																										
Longhouse IV	.	.	.	..																											
Longhouse III	b	bln	..																												
Longhouse II	bbn	..																													
Longhouse I	..																														

Figure 4: Matrix representing the connections between the structures of the analysed area of the Nørre Snede settlement. The letters in the matrix refer to the codes used in figure 2.

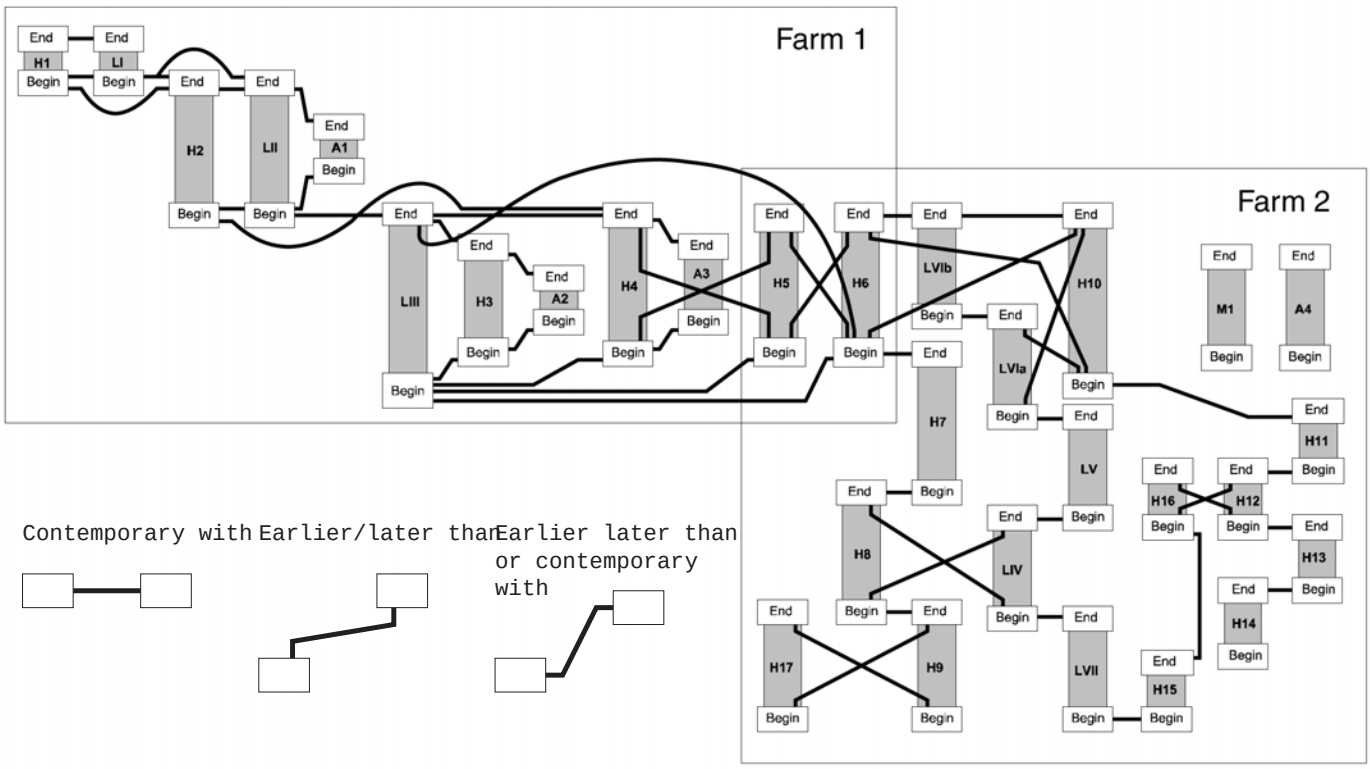

Figure 5: Graphical representation of the temporal structure within the analysed area of the Nørre Snede settlement.

preconditions. For instance, it is often more or less consciously assumed that all the structures of the settlement have approximately the same life span. Furthermore, continuity is often supposed, where it is not directly opposed by dating finds. These preconditions may be useful and often also reasonable, but they are not directly supported by the data, and should be treated carefully and explicitly as they may introduce false structures, as do the generalizations of the temporal implications.

Both the generalizations and the implicit preconditions are obviously a product of a non-formalized, non-computer-aided approach. The vast amount of data necessitates a reduction of the complexity and the ambiguities, if they are to be handled purely intellectually, but the by-product is an unfortunate mixture of fact and fiction, where it is often the fiction which creates those structures in the data upon which we build our interpretation of Iron Age and Medieval society.

5. The use of the relational network

Even though the relational network may not result in an immediate, unambiguous, relative chronological sorting of the structures of the settlement, it must be stressed that it does produce a very detailed picture of the temporal structure of the settlement. Consequently it ought to be possible to obtain valuable information through studies and analysis of the network. The question is simply how.

One way may be to introduce the implicit preconditions of the traditional sorting of the settlements as explicit parameters in the formal analysis of the temporal structures. In this way we reduce the number of possible solutions by introducing structuring principles, which might seem reasonable, but which are not directly supported by archaeological observations. For example, the principle that the structures of the settlement have had approximately the same life span. By making the preconditions explicit and only allowing formal operations, it should be possible to estimate the consequences preventing circular arguments and allow for appropriate modifications of the conclusions.

Another approach is to accept that due to the partial nature of the data, there will not be one definite answer, but several equally probable solutions. We can then formulate queries examining the possibilities of specific temporal structures existing within the temporal network. For instance we can examine whether the introduction of relations representing simultaneous changes in the settlement cause logical inconsistencies, and so get closer to answering the question if the movements of the villages were the result of organized restructuring of the whole settlement or a gradual translocation of individual farms. Other examples could be a query of the possible maximum and minimum number of contemporary farms within a given area, or a study of the possibility of strongly structured layouts of settlement.

6. Conclusions

The work with the relative chronological structure of Iron Age and Medieval settlements is very much a work of interpretation. It is based upon ideas of the temporal consequences of a wide range of connections, and it presupposes a specific syntax for the layout of the farms and a specific syntax for their changes. This relative chronological sorting involves both fact and fiction.

However, the prominent subjective element of the work does not prevent a formal approach. On the contrary the need almost becomes even more pressing. It is necessary to clearly state the premises of the temporal sorting, so that they can be openly discussed and their effect can be studied. Thereby we can evaluate

the conclusions on their premises, and we can choose to discard those which are based upon premises we cannot accept, and adopt those conclusions which are based upon what we conceive as reasonable premises. Furthermore as the interpretation often involves very complex structures, a formalized approach will enable us to achieve a much higher level of detail in our analysis.

If the potential of the detailed description of the temporal structures is to be satisfactorily exploited and a better understanding of Iron Age and Medieval settlements is to be achieved, it requires further development of computer applications. In this work, two areas are of special importance.

Firstly, a database system, where the complex data structures can be recorded and retrieved, has to be developed. This is a precondition for analysis of the temporal structures and some of the suggested questions concerning structures in settlements could in principle be easily answered through querying in a database. The GARD-system seems to be an ideal solution (Madsen 1999, this volume).

Secondly, tools for the sorting and analysis of the network structures have to be developed. The ability to handle the complicated logical structures with the possibility of describing ambiguities is essential. A graph theoretical approach seems the obvious solution to this problem, and this area will consequently take a central role in the future development of the analytical methods.

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