Identity Criteria for Localities

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Abstract. The paper provides a tentative formulation of the diachronic identity criteria for localities based on a set of paradigmatic case studies of changes they may undergo.

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1. Introduction

Information systems store, retrieve and process information on certain entities. In order to reference these entities, it is common to define and maintain *unique identifiers*. If one wants to do this in a systematic and consistent way one should be able to identify the latter across different ontological situations in which they may occur. In this paper, we investigate the problem of determining the identity of localities (i.e., human settlements) in the context of the changes they undergo over time. This problem is of particular importance for the construction of *historical-geographic information systems (HGIS)*, which store and process data on history of the entities .The issues we discuss in this paper arose within an R&D project that aims to develop a computer system to collect and integrate historical information on localities and administrative units on the Polish lands until 1939 – see: `http://ontohgis.pl/`.

We recognise the need for theoretical foundations for such resolutions, in particular, for explicit identity criteria for localities so that domain experts may refer to the same principles when faced with identity puzzles. To this aim we will attempt to determine the essential aspects of localities and distinguish the types of changes that a locality may undergo without ceasing to exist from those that lead to the termination of its existence.

We probably should mention upfront that we are after *operational* criteria of identity, i.e., such criteria that may be applied given to the usual historic data. Therefore, even if it was true that locality *x* is identical to locality *y* iff *x* is spatio-temporally continuous with *y*, this criterion would not meet our needs because the historic sources hardly ever give enough evidence for such spatio-temporal continuity claims.[1]

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2. Related work

The importance of identity criteria in the development of information systems is well-known at least from the dawn of the OntoClean methodology by Guarino and Welty [1]. Still, it is also a well-known fact that providing a robust and non-trivial criterion of identity for a particular domain is usually a herculean task – as attested by Carrara and Giaretta [2]. In particular, criteria of identity for localities, in particular diachronic criteria of identity, are not well-researched. [3] is one, among several papers, that exemplify rather than solve the issues that may arise in this context.

Traditional approaches to model spatio-temporal changes are usually based on the relational database model [4]. Usually, either they keep the updated version of the state or they take snapshots at specific points of time [5] (the so-called *snapshot model*). The snapshot model includes changes only *implicitly* and their explicit detection requires comparison of many snapshots. This model is thus *not* centered around particular entities and their identity. [6] provides a theoretical foundation for this approach, in particular it classifies various types of state-based changes with respect to the identity of the objects being changed. [7] seems to continue this type of research, but with a more rigorous formal framework.

Object-oriented approaches are built using object-oriented databases [8,5]. They take into account the natural phenomena and artifacts of human work as highlighted objects characterized by thematic, topological and geometrical attributes. If the object is changed, a new version is created. The object's identifier is associated with its existence and determines the identity of the object during the changes that the object undergoes. However, this model does not answer the question when a new object identifier should be created.

Event-oriented approach, unlike the two approaches discussed so far, accepts the principle of storing the changes explicitly. In the simplest form, the event model consists of a base map showing the initial state and the subsequent changes, which are all saved in the transaction log [9]. This model makes it easier to formulate queries about change whose results could be used to reason about identity and paves the way to formulate event-based identity criteria.

Moving towards Semantic Web ontologies we should mention [10], where SAPO, an ontology-based model centered around so-called *spatio-temporal regions*, is developed. We also note [11], where SONADUS, a spatiotemporal ontology for the administrative units of Switzerland, is describe. This approach provides an identity of administrative units by specifying each period of life as being its temporal part, where the identity is created and lost as a result of a fundamental change: creation or end of a life.

Less related, but still relevant, research is discussed in [12], where the basic knowledge representation formal techniques to encode the spatial and temporal aspects of knowledge from geographical information science are surveyed. A fairly new area of KR research, which is not mentioned in that paper, focusses of the so-called qualitative trajectory calculi (see, for example, [13]). Finally, we should mention that the current problem was already addressed by us in [14] and [15].

3. Localities through time and change

Before we investigate how localities may change in time let us state some basic onto-logical facts about localities. We assume without further argument that localities are en-durants, i.e., they persist through time without having temporal parts at different times. Following [7] we assume that they do *not* enjoy intermittent existence, so they come into and go out of existence only once. The category of localities is rigid, i.e., if *x* is a locality at time *t*, then it is a locality at every time at which it exists. On the other hand, we will see that (at least) some subcategories of localities are not rigid, e.g., a locality may be a village at one point in time and a city at some other time. At each time when it exists every locality has a proper name and a geographic location. These two make it different from other localities, i.e., one cannot have two different localities with the same name and location at the same time. On the other hand, we will see that localities may change their names and locations in the course of time. Some localities may be parents (resp. children) to other localities, i.e., a locality may be a whole whose one part is another locality. We will see that a locality may change its parents and children over time. The category of localities is rather peculiar as far as its relation to time is considered. Local-ities like all kinds of spatio-temporal objects change in time: begin and cease to exist, gain and lose parts, etc. Still, the way localities keep (or lose) their identity through time sets them apart from most (if not all) other kinds. There is a number of changes that usu-ally do not affect the identity of localities. These include population fluctuations, spatial growth, infrastructural development, etc. On the other hand, there are changes that result in destruction of previously existing localities and/or creation of new ones. To set these cases apart we will first look at what is usually considered as the consitutive aspects of localities.

The standards for gathering and collecting data about localities (i.e. Gazetteer Ser-vice Profile of the Open Geospatial Consortium's Web Feature Service Standard and Gazetteer Content Standard of the Alexandria Digital Library) define three basic aspects of places: *placename*, *placetype*, and *footprint* (i.e., geographical location) [16,17]. Al-though, *prima facie*, neither of these may provide a simple criterion of identity for locali-ties, they will guide our quest for such, i.e. we will investigate whether and to what extent they may be taken as constitutive aspects of localities. In what follows we will present a number of examples, mini case studies, in which localities are shown as participating in certain processes maintaining or losing their identity. Discussing these cases we will look in particular at these three aspects of localities.

The simplest and often encountered situation is when a locality changes its name as a result of new political or social circumstances.In the Polish lands such cases were common and widespread in nature. This is particularly true in the areas of Silesia and Pomerania, which were under the sovereignty of Austria and Prussia for many centuries. Local names also fell the "victims" to the political situation. From 1953 to 1956 the Silesian city of Katowice was called Stalinogród.

Another type of change is translocation, when a particular locality changes its whole location while retaining its name [18,19]. Usually, such process means that the locality is moved over a short distance. For example, the town of Ryczywół located at the mouth of the river Radomka to the Vistula was transferred in the first half of the 19th century by 2 kilometres to the west. Another example of such translocation may be the town of Nieszawa. Addressing the economic conflicts between Nieszawa and Toruń, the Polish

king made in 1461 a decision to "disassemble" the town of Nieszawa located opposite to Toruń and move it about 30 km upstream of the Vistula river. This case is more complex than the previous one for two reasons. First, the official translocation document has designated the existing village called Roskydalino as a new place for Nieszawa. So after the town of Nieszawa had been moved, the village Roskydalino vanished. Secondly, after Nieszawa's translocation a new locality by the names of "Old Nieszawa", "Dybów" or "Podgórze" was established at the previous location of Nieszawa. [20]

Consider now locality merging, where (usually) smaller localities were grouped together to form a larger one. Sometimes two close-by localities of one type were also combined. These changes were mainly administrative in nature and did not have to be accompanied by any modification of infrastructure concerning individual components. However this type of merging may or may not involve changes in the proper names of the respective localities. An example of a change of the latter type may be the towns of Kleparz and Kazimierz that were attached in the second half of the eighteenth century to the city of Kraków (1792-1800). The former type of merging is usually more convoluted. On the maps from the first half of the 19th century three localities: Holonki (original record: Holonkÿ), Pauluk and Konstantyniuk were registered near the village of Hajnówka. In the same place several decades later there is one village called Pasieczniki. A name change may also be accompanied by the merging of localities of various types. In 2011 year the village of Załazek Tarnawski and sub-villages Załazek Piątkowski and Załazki were merged into the one village - Załazek.

Cases when a locality is moved apart (separated) from its "parent" locality are less common. At the beginning of 2018 sub-villages Burdze, Kołodzieje and Ruda were separated from the village of Przyszów and formed distinct villages. At the same time the sub-village Nieroda went from the village of Przyszów to the village of Ruda. In turn from the beginning of 2016 parts of the town of Pieszyce: Bratoszów, Kamionki, Piskorzów and Rościszów have been transformed into separate villages. All aforementioned localities have preserved their proper names.

The division of localities into two or more parts may be accompanied by changes in proper names. These changes could apply to all localities or only some of them. For example, the Podlasie village of Ostrowo, recorded on maps from the beginning of the 19th century, appeared in the cartography of the first half of the 20th century as already divided into two parts: Ostrów Północny and Ostrów Południowy. The phenomenon of dividing villages or towns continues today – the village of Chojno Nowe in 2011 was split into Chojno Nowe Pierwsze and Chojno Nowe Drugie. An instructive example of this type of change was the separation in 2014 of the new village Niedzica-Zamek from the village of Niedzica. This separation was accompanied by the change of the name of the place that was separated (Niedzica-Zamek) – previously it was a sub-village called Zamek. Interestingly enough, the inhabitants of the new village argued the necessity of the separation for historical reasons: before World War II Niedzica-Zamek constituted a separate locality.

There is also a separate, heterogeneous, group of changes that combine renaming, translocation, merging, etc., in sometimes startling combinations. This is true for many medieval urban foundations located on rural land. After setting up a new town or city a couple of scenarios could develop:

1. an old village is "replaced" by a new town, i.e., the village ceases to exist and the town is created in the same location where the village existed; usually, the town

gets a new name, but to complicate things, the name of the village and the name of the town may appear in historical sources written side by side or alternately (e.g., the village of Miechów replaced by the town of Kazanów);

2. an old village becomes part (e.g., a suburb) of a new town; again change may occur in two varieties:

   (a) the village retains its name;
   (b) the town adopts the village name and the village gets a new name.[21,22]

The last two scenarios deserve a more detailed discussion. The town of Łaskarzew was established on the land of the Gorczycew village by virtue of the royal document of 1418. The village of Gorczycew probably stretched on both sides of the Promnik River. The new town of Łaskarzew developed mainly on the right side of the river. The name of Gorczycew has not vanished completely and regularly appears on 19th and 20th century maps from as a toponym for the suburb or part of the town of Łaskarzew, which was localized on the left side of the river Promnik. A slightly different situation is the case of Łęczna. In 1467 in a part of the village Łęczna, through which the river Świnka flowed, a new town was founded with the same name as the existing village. A hill on the left bank of the river was chosen as the location for the town. After the town had been established, the remainder of the village formed a separate locality, which was initially called Stara Łęczna (Lanczna Antiqua), then after 1509 it adopted the name Stara Wieś.

We summarized the aforementioned examples in table 1 – skipping duplicates, e.g., the case of Nieszawa. Note that some changes involve multiple participating localities.

Begin Name	Begin Type	End Name	End Type	Transl.	L-Mereology	Identity Claims
Katowice	city	Stalinogród	city	No	None	Katowice = Stalinogród
Ryczywół	town	Ryczywół	town	Yes	None	Ryczywół = Ryczywół
Kleparz	town	Kleparz	quarter	No	Absorption	Kleparz = Kleparz
Holonki	village	Pasieczniki	village	No	Absorption	Holonki ≠ Pasieczniki
Pauluk	village					Pauluk ≠ Pasieczniki
Konstantyniuk	village					Konstantyniuk ≠ Pasieczniki
Burdze	sub-village	Burdze	village	No	Separation	Burdze = Burdze
Nieroda	sub-village	Nieroda	sub-village	No	Re-absorption	Nieroda = Nieroda
Zamek	sub-village	Niedzica-Zamek	village	No	Separation	Zamek ≠ Niedzica-Zamek
Ostrów	village	Ostrów Północny	village	No	Division	Ostrów ≠ Ostrów Północny
		Ostrów Południowy	village			Ostrów ≠ Ostrów Południowy
Miechów	village	Kazanów	town	No	None	Miechów ≠ Kazanów
Gorczycew	village	Gorczycew	suburb	No	Separation	Gorczycew = Gorczycew
-		Łaskarzew	town	No	None	Gorczycew ≠ Łaskarzew
Łęczna	village	Stara Wieś	village	No	Separation	Łęczna ≠ Stara Wieś
-		Łęczna	town	No	None	Łęczna ≠ Łęczna
Łuka	village	Nowa Łuka	village	Yes	None	Łuka ≠ Nowa Łuka

Table 1. Locality Change Paradigms Summary

Let us try to draw some general conclusions from these particular cases. Construing these examples as patterns we may notice that a locality changes its identity, i.e., is destroyed (or even supplanted), *only if* it changes its name and in addition it changes either its location or its l-mereology or its type. Otherwise, it keeps its identity. In addition identity of names seems to be sufficient for identity of localities, a certain locality persists through time as long as it keeps its proper name. Having these observations in place, we now aim for a fully-fledged, but local, criterion for localities, a criterion that provides both sufficient and necessary conditions for locality x to be identical to locality y. To this end we are going to resort to the idea of event-based criteria of identity for the so-called very weakly unstable objects, which was developed in [14].

4. Event-based identity criteria for localities

The informal idea exposed in this section focusses on perdurants (i.e., events or processes) in which localities participate. If a locality participates in a number of perdurants from within a certain period, then it keeps its identity within this period if this participation does not affect (i) *both* its proper name and location, (ii) *both* its proper name and type, (iii) *both* its proper name and l-mereology; otherwise, i.e., if (i) both its name and location are changed or (ii) both its name and type are changed or (iii) both its name and l-mereology are changed, then it is destroyed within this period (and is not identical to any locality that exists at the end of this period).

Let us first define the notion of qualitative transformation. Informally, a qualitative transformation of an object with respect to one of its qualities is a process whereby this quality is changed therein, i.e., the quality has different values at different stages in this process. This idea may be, of course, extended to multiple qualities. To put it in more formal terms, suppose that x and y are endurants (possibly $x = y$). Let $Q = \{q_1, q_2, \ldots, q_n\}$ be a set of qualities (which includes, among other member, all qualities of x and y). "$Q(x, q, v, t)$" will mean that quality q of object x has at t value v. Let then p be a process that starts at time t_1 and terminates at time t_2. y will be called a *p-transformant* of x at time t with respect to qualities from set $Q' \subseteq Q$ if all below conditions are met:

1. $t_1 < t \leq t_2$;
2. x participates at t_1 in p;
3. y participates at t_2 in p;
4. if $q \in Q'$, then q changes its value between t_1 and t_2, i.e.,

$$Q(x, q, v_1, t_1) \wedge Q(y, q, v_2, t_2) \rightarrow v_1 \neq v_2;$$

5. if $q \notin Q'$, then q does not change its value between t_1 and t_2, i.e.,

$$Q(x, q, v_1, t_1) \wedge Q(y, q, v_2, t_2) \rightarrow v_1 = v_2;$$

6. there is no other (than x and y) endurant z that satisfies conditions $1 - 5$.

If y is the *p*-transformant of x at t with respect to Q', then process p will be called a $Q'-transformation$ of x *into* y at t, but if Q' is a singleton $\{q\}$, then, for the sake of simplicity, we will write "$q-transformation$" instead.

This general idea can be now narrowed down to the case of localities by specifying the contents of set Q_{Loc} of qualities – given the previous analysis Q_{Loc} contains:

1. location quality q_{loc}– for each locality x and each time t at which x exists, q_{loc} yields x's geographical location at t;
2. proper name quality q_{name}– for each locality x and each time t at which x exists, q_{name} yields x's (main) proper name at t;
3. type quality q_{type}– for each locality x and each time t at which x exists, q_{type} yields x's type at t;
4. l-mereological quality for parents q_{parent}– for each locality x and each time t at which x exists, q_{parent} yields x's parent locality at t;
5. l-mereological quality for parents q_{child}– for each locality x and each time t at which x exists, q_{parent} yields x's child locality at t.

Suppose now that locality x start its existence at time t_0. Let us consider set P_0 of all processes in which x starts to participate at t_0 or, if this set is empty, the set of all processes at a later time when x starts to participate in any process. If there are two processes in P_0 such that one is a proper part of another, we remove the latter from P_0. Let "t_1" denote the time at which the first member of such P_0 ceases to exist, i.e., if $p \in P_0$ dies at time t, then $t_1 \leq t$. We will call P_0 and each such "subsequent" set of processes an *episode set* in x's history and t_0 and t_1 will be called, respectively, its *start* and *end boundary*. We will say that episode set P in x's history is *disruptive* for x if P has (at least) either a $\{q_{name}, q_{loc}\}$-transformation or $\{q_{name}, q_{type}\}$-transformation or $\{q_{name}, q_{child}\}$-transformation or $\{q_{name}, q_{parent}\}$-transformation of x at t_1. We posit that if P is disruptive for x, then x is not identical to any object that exists at the end boundary of P (i.e., x is destroyed at some time between P's boundaries). Otherwise, we claim that x exists throughout this episode and is identical to *all* its p-transformants (where $p \in P$).

Consequently, qualitative transformations provide a kind of local criterion of identity for localities, i.e., the above procedure establishes a principle that allows us to answer identity questions at the boundaries of the first epistode set in x's history.

If you want to get a less local criterion, then you need to "concatenate" adjacent x's episode sets. So if x survives its first episode set, you need to repeat the above procedure starting from its end boundary, i.e., you start with set P_1 of all processes in which x participates at t_1 and if there are two processes in P_1 such that one is a proper part of another, we remove the latter from P_1. Then we re-apply the above resolution. Etc. Combining these resolutions sequentially will result in a (global), but restricted, criterion of identity for localities. Namely, we will arrive at a set of times $\{t_0, t_1, \ldots, t_k\}$ such that we can say under which conditions locality x_1 is identical to locality x_2 even if x_1 exists at time t_i and x_2 exists at time t_j ($0 \leq i, j \leq k$).

5. Conclusions

We provide in this paper a conceptual framework to solve problems with identity of localities. We believe that the framework may be suitable for a historian who needs to process or provide data in some structured form as required by the contemporary computer systems. We looked into research practice in history to see how identity of localities is understood and conceptualised by collecting a number of mini case studies of how localities change. This survey led us to submit a certain notion of event-based criterion of identity.

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