TOWARDS GOOD PRINCIPLES FOR THE DESIGN OF A NATIONAL ADDRESSING SCHEME

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Abstract
Traditionally, humans used an address as a direction to a building and its occupants. The advent of computers opened up a whole new range of possibilities, such as routing and vehicle navigation, automated processing of mail items, utility planning and maintenance, spatial demographic analysis and geo-marketing. *Addressing schemes* vary in different parts of the world, such as referencing to a road network or to a hierarchy of administrative areas; in informal settlements addresses can be informal, variable and creative. Addresses are used for a wide variety of *purposes*, often with conflicting needs, such as required geographical precision and accuracy. Various *stakeholders* are involved in both designing and maintaining an addressing scheme, including town planners, city managers, utility companies, postal operators and addressees. Some countries and international organizations have address *standards* and there is a process within the International Organization for Standardization (ISO) looking at bringing them together into a suite of international standards for addressing. In this paper we present a number of *issues* that have to be considered when designing an addressing scheme. Drawing on these, we show that there is a *trade-off* between people, the physical world and its digital representation when designing an addressing scheme. Based on these findings, we list a number of good *principles* for the design of a national addressing scheme.

1. Introduction

Traditionally, humans used an address as a direction to a building and its occupants. The notion of directing someone or something is evident in the origin of the word 'address', which is derived from the Latin *directus*, past participle of *dirigere*, to direct (Dictionary.com 2010). In Europe, street addresses were first assigned in the eighteenth century when cities started to expand and a need arose to identify individual buildings.

The advent of computers opened up a whole new range of possibilities, such as routing and vehicle navigation, automated processing of mail items, utility planning and maintenance, spatial demographic analysis and geo-marketing. For all of these, digital address databases are required to ensure efficient and effective processing. Therefore it is relevant to now take a new look at principles for the design of addressing schemes that support these new possibilities.

Addressing schemes vary in different parts of the world: in Euro-centric countries reference to a road network in the address is common; in eastern Asia a hierarchy of administrative areas without reference to a thoroughfare is used; and in informal settlements across the world the addresses are informal, variable and sometimes creative. This variety in schemes reflects the cultural connotation of addresses. Figure 1 shows some examples of addresses from different parts of the world.

Addresses are used for a wide variety of *purposes*, often with conflicting needs: postal delivery, emergency response, customer relationship management, land administration, utility planning and maintenance, etc. Sometimes a geographical overview of addresses is required for a large area, such as land administration and utility planning and maintenance. For mail delivery or emergency response planning, accurately identifying individual delivery points is priority. In other instances, delivery points are ignored and only the place name in the address is of relevance, for example, when aggregating household survey information (Coetzee and Cooper 2007b).

Figure 1. Address examples, from left to right: Quebec, Canada; Tsukuba, Japan; Mthatha, South Africa; Windhoek, Namibia.

Many *stakeholders* are involved in both designing and maintaining an addressing scheme, including: town planners who assign addresses when an area is first developed or formalized; authorities who install and maintain place and street name signs; local authorities and/or utility companies who use the address when providing services and billing for them; postal operators who deliver mail to an address; and addressees, who can correct errors in their addresses. In fact, any user of an address is a potential provider of address corrections and thus a stakeholder in the addressing scheme.

Some countries and international organizations have address standards and there is a process within the International Organization for Standardization (ISO) looking at bringing them together into a suite of international *standards* for addressing (Coetzee *et al* 2008, ISO/TC 211 2011). Standardizing addresses streamlines the service delivery process and Barr (2007), Coetzee and Cooper (2007a), Coetzee et al. (2008b), Lind (2007), Nicholson (2007) and Vivas and Lubenow (2009) describe the benefits of standardized addresses to the economy, society and governance.

Many African countries are confronted with addressing challenges. Streets and properties (in both rural and urban areas) in most African countries are characterized mainly by incomplete, inaccurate or missing names, numbers or other identifiers; inadequate or missing sign posting; and a duality of 'official' and 'popular' naming practices (UN ECA 2005).

An address empowers citizens by giving them an identity and enabling them to receive services without discrimination by race, status, gender, age, geographic location, etc. Farvacque-Vitkovic

et al. (2005) explore the links between street addressing and civic identity along with support for various services and economic development. An address has a user-friendly and local cultural quality to it, more so than identifiers commonly used in land administration systems, such as a property identifier or a land parcel number.

The daily lives of South Africa's people have improved tremendously since being allocated an address, which enables them to receive services. Due to Apartheid, many people, especially in rural areas, did not have an address until a decade or so ago. The South African Post Office (SAPO) rural addressing project allocates addresses in rural areas (Rossouw 2008) so that previously unaddressed and disadvantaged people can now use their address to open a bank account, subscribe to paid television services, obtain credit and generally become part of the formal economy. For people who have always had an address, it is difficult to appreciate what one has and can do as a result of having that address (Brown 2010).

In this paper we present a number of *issues* that have to be considered when designing an addressing scheme. Drawing on these, we show that there is a trade-off between people, the physical world and its digital representation when designing an addressing scheme. Based on these findings, we list a number of good *principles* for the design of a national addressing scheme. We hope that our paper will provide useful input for countries such as Botswana, where a location and postal addressing system is currently under development (Ditsela 2011).

2. Design issues for a national addressing scheme

Drawing from our experience with the South African address standard (SANS 1883:2009), the ongoing ISO addressing project (ISO 19160 2011) and other addressing initiatives, the following are issues that have to be considered when designing an addressing scheme.

Addresses are used to identify many different objects, such as people, buildings, landmarks, places or even an object in transit (e.g. a parcel track and trace). Conversely, an object can have several addresses. For example, a postal street address for mail delivery and a residential street address for directing someone to the house. 'Glenstantia' in the postal address below refers to the name of a post office, while 'Constantia Park' in the residential address refers to the name of the suburb, which appears on road signs, an they both refer to the same place:

> *42 Rover Street, Glenstantia, 0181, South Africa* (postal address)
> *42 Rover Street, Constantia Park, Pretoria, South Africa* (residential address)

Another example is one address for a front entrance (for receiving visitors) and another address for the back entrance (for connecting utilities). In both examples, the different addresses are used to identify an object for different purposes.

An address can be absolute or relative. In the latter case the location is specified relative to something else, e.g. relative to a carrier (for something or someone in transit) or relative to a geographical feature. An example of the latter is a landmark or informal address:

> *House with the red door opposite the butcher shop, Tsamaya Street, Mamelodi*

Some addresses have a third dimension for the level above or below the ground. For example, flats in a multi-storey block of flats, offices in a multi-storey office block, or underground utility connections.

How precise does the address need to be? Humans can adapt to find the address once in the general area (or ask someone!). Consider for example, a small village comprising a few houses. An address with only the village name (along with the higher level address components) is sufficient to visit a friend in the village. In contrast, a utility company requires more information to identify and bill individual dwellings. The purpose for which the address is needed determines how precise the address has to be.

An address consists of a number of components forming a hierarchy of names and/or numbers, each with an increasing level of precision. For example, a European city-style address usually consists of one or more place names, a street name and a number; a Japanese address consists of a prefecture name, a municipality name, one or more place names, and a parcel or house number. Sometimes the country name is included as the highest-level component of the hierarchy.

There are a large variety of rules according to which the address numbers at the lowest level of the hierarchy can be assigned. Two examples are independent address numbering along a thoroughfare with an origin and numbers proceeding according to a numbering rule from that point to the end of the thoroughfare; and address numbering that is organized around axes that extend from a common point of origin (the local "zero" point for address numbers), with all numbers increasing with distance from the point of origin. There are many more examples, such as the Saudi Arabian addressing scheme that makes use of geographic coordinates when calculating the number and the Australian/New Zealand and SAPO rural addressing schemes (ISO 19160 2011).

Often it is not a single authority that is responsible for assigning names to the individual components of an address. For example, in South Africa the Municipal Demarcation Board assigns municipality names, while municipalities themselves assign street names. There is also a naming process that has to be followed, including consultation with the community and maintenance of a register or database of names. In addition, the SAPO assigns postcodes to addresses for the sorting and delivery of mail items. If multiple authorities are involved, coordination among them is important. For the actual naming of the higher-level components of an address, such as towns and streets, typical issues from toponomy (the scientific study of place names) come into play:
- Uniqueness of names.
- Official recognition of names vs colloquial names.
- Endonyms (e.g. Köln) and exonyms (name that differs from the endonym, e.g. Cologne).
- Political, cultural and religious divides, legacies and sensitivities.
- Community preferences, aversions and differences.
- Cultural and linguistic adaptability, such as power relationships (e.g. dominant and marginalised languages).
- Translatability into other languages vs one name across languages.
- Alternative (local) meanings of words, slang, code words, etc.
- Symbolic perceptions of bias in using certain objects and names (e.g. association of a particular animal with a particular political party).

- Deprecated language, words and concepts.
- Using the names of people: should one use only the names of those who have been dead for some years, and hence whose likely legacy and image won't change?
- Name changes cause confusion and antagonism.

Apart from the stakeholders involved in creating and maintaining addresses, it is important that addresses are usable in multiple systems, ranging from postal operations, utility maintenance and Censuses to land administration (cadastre) and financial systems. The Addressing Botswana Project illustrates this. It is a combination of two projects: firstly, the national system for unique referencing of land parcels and location addresses by the Land Administration, Procedures, Capacity and Systems (LAPCAS); secondly, a postcode and addressing system analysis by Botswana Post. The key stakeholders in the project are the Councils, Land Boards, Botswana Post, the Department of Surveys and Mapping (DSM) and the Ministry of Agriculture. The proposed flow of address data is shown in Figure 2: district, town and city councils provide uniquely referenced land parcels and location addresses for a central database. Botswana Post continuously updates the database with postcodes and postal delivery addresses (Makhuoe 2010).
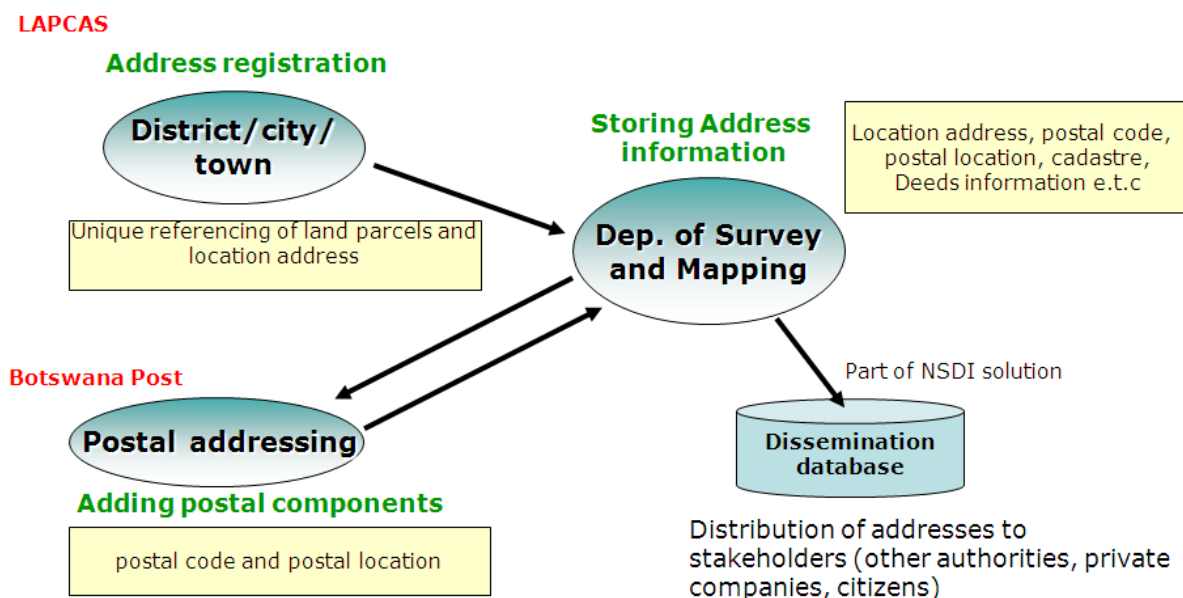

Figure 2. Proposed address flow, Addressing Botswana project (Adopted from Makhupe 2010)

Addresses can be for people to read and write, machines to read and write, or both. However, humans do not like purely numeric or alphanumeric codes; they prefer names (geographical identifiers) for geographic features. Often there is a cultural or historic non-systematic connotation to names which humans are quite capable of dealing with. Computers, on the other hand, work efficiently when addresses are assigned systematically so that they can be processed algorithmically.

For example, NAC Geographic Products Inc developed the Global Postal Code (GPC) system as an application of the Natural Area Coding (NAC) system. A standard GPC is an eight-character, two-dimensional NAC representing an area of about 25 by 50 meters anywhere on the surface of the Earth. In this way, a GPC should accurately locate an individual house or apartment. Mail

sorting equipment can read and use the GPC, if it is displayed on the mail item as in the example below (NAC Geographic Products 2006):

> Mr Xhianhang Shen
> 1608-45 Huntingdale Blvd
> Toronto, ON M1N 2ND
> Canada
> *NAC*: 8CNK Q8XM

A letter with a GPC can be processed efficiently by a computerized system but the negative aspect is that people do not remember GPCs easily and signposts with place and street names are in no way related to the GPC. It also seems that the GPC has to be mapped to a postcode from the local postal operator who is responsible for delivery of the mail item. Finally, GPCs are not practical in developing countries with limited technology availability.

While it might be ideal to have a single addressing scheme that is applied throughout a country, there might be political, cultural, historic and financial reasons for retaining the status quo. The trade-offs between the short-term costs of implementing a single efficient addressing scheme vs. the long-term financial benefits of such an addressing scheme have to be evaluated carefully.

Various countries and international organizations have developed address standards. Standardized addresses streamline the delivery process but also facilitate the development of databases and tools for creating and maintaining address data. On an international level, address standards facilitate cross-border trade and commerce. Standards also facilitate the use of addresses in areas where there are no addresses, e.g. the informal address type in SANS 1883-1:2009, *Geographic information – Addresses Part 1: Data format of addresses*, caters for addresses in informal settlements. Standards that specify an address assignment scheme can be used as guidelines for countries that still have to assign addresses.

The project, ISO 19160, *Addressing*, is bringing together experts involved in the various address standards to develop a suite of international standards for addressing. The purpose of the project is not to design a 'new' standard but rather to recommend the development of standards that facilitate not only the interoperability of addresses but also the interpretation of addresses. As part of the review of existing address standards, it was found that address standards typically include specifications for one or more of the following (ISO 19160 2011):

- An *address assignment scheme*, i.e. how addresses are assigned in the physical world.
- *Terminology* that is used to describe the addressing scheme and/or concepts in the conceptual model.
- A *conceptual model* that describes addresses, i.e. the meaning of concepts and relationships between them. The conceptual model reflects the addressing scheme in the physical world.
- Address-specific *metadata* provides information about the address data, such as the custodian, lifespan, status, etc. Metadata augments the conceptual model.
- An *encoding* of the conceptual data model.
- Specifications for address data *maintenance*, such as quality management, life cycles and aliases.
- Specifications for the *rendering* of addresses for display on mail items, forms, maps, etc.

Finally, it is also important to consider the costs of the infrastructure required to support the addressing scheme. It can be expensive to provide a comprehensive addressing system in a country: signs for place names, street names and house numbers have to be maintained in the physical world; similarly, a digital representation of addresses in databases is required for digital mapping, in-car navigation, address verification, etc. Thus, it is important that the political will to provide addresses according to the addressing scheme exists.

3. Good principles for the design of a national addressing scheme
Drawing on the issues discussed in the previous section, we now show that there is a trade-off between people, the physical world and its digital representation when designing an addressing scheme. Refer to Figure 3.
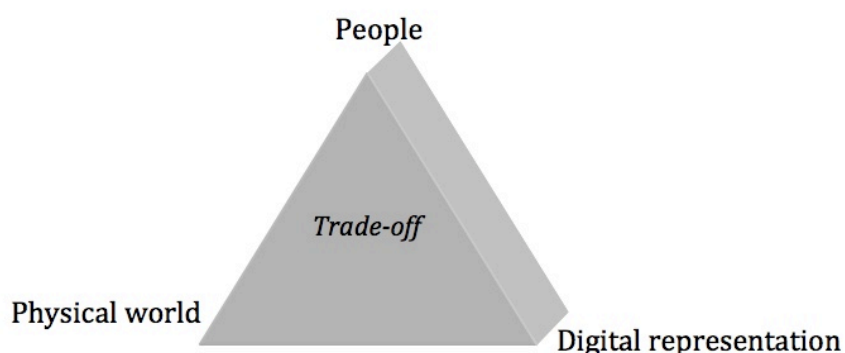

Figure 3. Trade-off in the design of an addressing scheme

People refers to all the 'human' requirements of an addressing scheme, i.e. humans should be able to read, understand and remember addresses (e.g. one should intuitively know what the next address down the road is); the scheme should reflect the local culture and be in harmony with political objectives; and it should support the social and civic identity of people living at the address.

The *physical world* refers to the actual location of the address and how it is used: sign posts for the address on the object itself but also signposts for the other components (e.g. street and place names) of the address; elevation level of an address (i.e. above, on or below ground); entrance(s) to the object in relation to where the address is allocated or signposted; multiple addresses for a single object; and multiple objects that share an address.

Finally, the *digital representation* of an addressing scheme relates to the efficiency of the representation for storage and processing by computers: systematic address assignment; algorithmic processing of addresses; character recognition of addresses (e.g. for mail sorting); maintenance in databases; non-ambiguity or uniqueness of addresses (humans can deal with ambiguity but computers 'prefer' unique identifiers); a data model with or without coordinates for each address; integration with other systems, such as land administration.

If one wants to accommodate people, for example, by changing street names to reflect a change in the political system, the physical world and its representation (e.g. a database of address data)

has to change. The potential cost of replacing signposts is huge, but the cost of the ripple effect in the digital processing of addresses is also significant: people will continue to use the 'old' address for quite some time and computer systems will have to accommodate this.

If one wants to have an efficient digital representation, for example, by introducing a single unique numeric identifier as an address (as opposed to place and street names), people have to compromise to remember these numbers (without the aid of signposts). As a last example, if one wants to optimize costs in the physical world by putting up street names at every second intersection only, it becomes difficult for people to find addresses.

Based on this trade-off and the issues discussed in the previous section, we list a number of good *principles* for the design of a national addressing scheme.

An addressing scheme should
- define *what* objects are being addressed;
- define the *components* that make up an address;
- define how *values* are assigned to these components;
- define *how* addresses are assigned to objects (including provision for possible future expansion);
- define the *purpose(s)* for which the addresses are assigned;
- define the intended *precision* of the addresses;
- state who is responsible for the assignment and maintenance of addresses by *people* (e.g. naming);
- state who is responsible for the assignment and maintenance of addresses in the *physical world* (e.g. signposts);
- state who is responsible for the assignment and maintenance of the *digital representation* of addresses (e.g. data model, databases, etc.); and
- state how its addresses are used together with *other systems*, such as land administration.

While a single addressing scheme per country is more efficient, there are several reasons, such as local cultural relevance or cost implications, for a country to support more than one addressing scheme. However, for efficient use of any addressing scheme it is important that such a scheme is described. The principles above describe the aspects of an addressing scheme that should be included in the description. We plan to refine these principles through future work, e.g. by describing existing addressing schemes and evaluating them.

4. Conclusion and future plans
In this paper we discussed a number of issues that have to be considered when designing an addressing scheme. For this, we drew from our experience with the South African address standard (SANS 1883:2009), the ongoing ISO addressing project (ISO 19160 2011) and other addressing initiatives.

We showed that there is a trade-off between people, the physical world and its digital representation when designing an addressing scheme. This trade-off should also be considered when introducing changes into an existing addressing scheme. Finally, we listed a number of good principles for the design of an addressing scheme. We plan to refine these principles through future work, e.g. by developing a formal method of describing an addressing scheme

(e.g. with a conceptual model of the addressing scheme) and then using this method to describe existing addressing schemes and evaluating them. An international standard for describing different addressing schemes in a uniform way will improve the understanding of different addressing schemes.

For a country that does not yet have an addressing scheme, it is important to design an efficient addressing scheme that fits its particular purpose(s) right from the start. Other countries that already use one or more addressing schemes should be aware of the many challenges that influence each other and cannot necessarily all be addressed at the same time. The trade-offs between the short-term costs of implementing a single efficient addressing scheme vs. the long-term financial benefits of such an addressing scheme have to be evaluated carefully.

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