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4D cadastres: First analysis of legal, organizational, and technical impact—With a case study on utility networks

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ABSTRACT

The increasing complexity and flexibility of modern land use requires that cadastres need an improved capacity to manage the third dimension. As the world is per definition not static, there also will be needs in relation to the representation of the temporal (fourth) dimension either integrated with the spatial dimensions or as separate attribute(s). In this paper, registration of utility networks in cadastre are considered in this 3D + time (=4D) context. A number of countries in the world have developed methods to register utility networks complying with their legal, organizational, and technical structure. We researched the different approaches of three specific countries: Turkey, The Netherlands and Queensland, Australia. These are analysed to evaluate a solution that matches legal, organizational, and technical cadastral requirements in the most optimal way.

Introduction

The use of land is always related to a certain amount of (3D) space and spans a certain amount of time (3D + time, or 4D). The latter is well illustrated by leasehold and time-shares. However, traditionally cadastres are based on a representation of the division of land in 2D on a certain moment in time, obscuring the 3D and 4D aspects of land ownership in cadastral registers and maps (UN and FIG, 1999; Van der Molen, 2003; Stoter, 2004; Van Oosterom et al., 2006). Because of growing pressure on land, and rising land values, leading to more intensive and complex land use, we argue that there will be a growing need for 4D (including 3D) information in cadastral registers. Most cadastral data models are still based on 2D cadastral parcels. This has proved to be not suitable in all cases for organizing and modelling the information of complex commodities and interests in land (Kalantari et al., 2008; Bennett et al., 2008).

This observation is especially true for underground utilities. Insufficient and unclear information about location and depth of underground utilities is a major cause of damage to the utilities during excavation operations. The impact of this damage cannot be overestimated as this has been causing various problems and even resulted in tragic accidents. For example, the economic loss of the damage to gas pipelines in Bursa, Turkey was two hundred thousand US dollars in 2005 (Karatas, 2007). In Istanbul, with a population over 15 million, some accidents have occurred during excavation operations which resulted in damage to telecommunication networks and to a subway line, causing a significant direct and indirect economic loss (Doner et al., 2008). In China it has been estimated an economic loss of up to two hundred million US dollars per year during eighties and the beginning of nineties (Du et al., 2006). In the Netherlands, 40,000 damage reports to infrastructures are reported on a yearly basis causing about €40 million direct loss and €80 indirect loss million per year. Statistics in other countries (e.g. Roberts et al., 2002) reveals similar striking figures. Apart from the economic losses, damage inflicted to utilities even resulted in tragic accidents, such as the Ghislenghien disaster on 30 July 2004; the explosion of a high pressure gas pipeline in Belgium that killed 24 and injured 123 persons.

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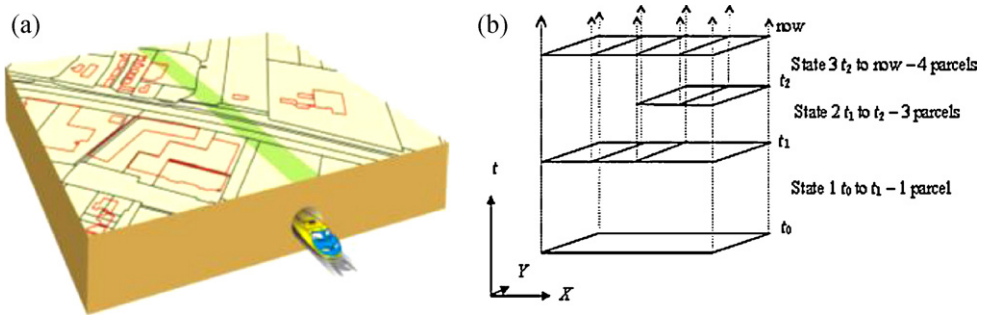

Fig. 1. (a) Illustration of 3D (railway tunnel crosses several land parcels) and (b) temporal concept (changes of state of a subdivision) in cadastral register.

Although the actual needs for 4D cadastre in relation to the costs should also be understood through market analysis, this paper explores the technical, organizational and legal implications of 3D and 4D cadastres. The representation of the third dimension has proved to be especially relevant for apartment units and for physical objects that cross above or below land parcels, such as tunnels (Fig. 1a), underground shopping malls and utility networks. In addition the time dimension is required to be able to record how the legal status of land is changing in time. In most cadastral registers, the time dimension is represented by a versioning of the objects (the state-based model) represented by time stamps that indicate the creation and deletion of represented objects in the cadastral system, see Fig. 1b (Van Oosterom, 1997).

Methodology

Establishing a 4D cadastre, which registers and provides access to all required 4D information of real estate, is not simple, since it comprises legal, organizational as well as technical issues. The aim of this research is to show how these three issues interact. First, the conceptual basis of a 4D cadastre has been studied based on the ISO Land Administration Domain Model (LADM, ISO/TC211, 2009) for utility networks to explain the specifics of physical and legal representations. Secondly, an empirical case study was carried out in three countries that are moving towards a 4D cadastre with different approaches fitting within their legal, organizational, and technical frameworks: in Turkey, in which the land parcel based system has been largely unchanged until now; in the Netherlands,

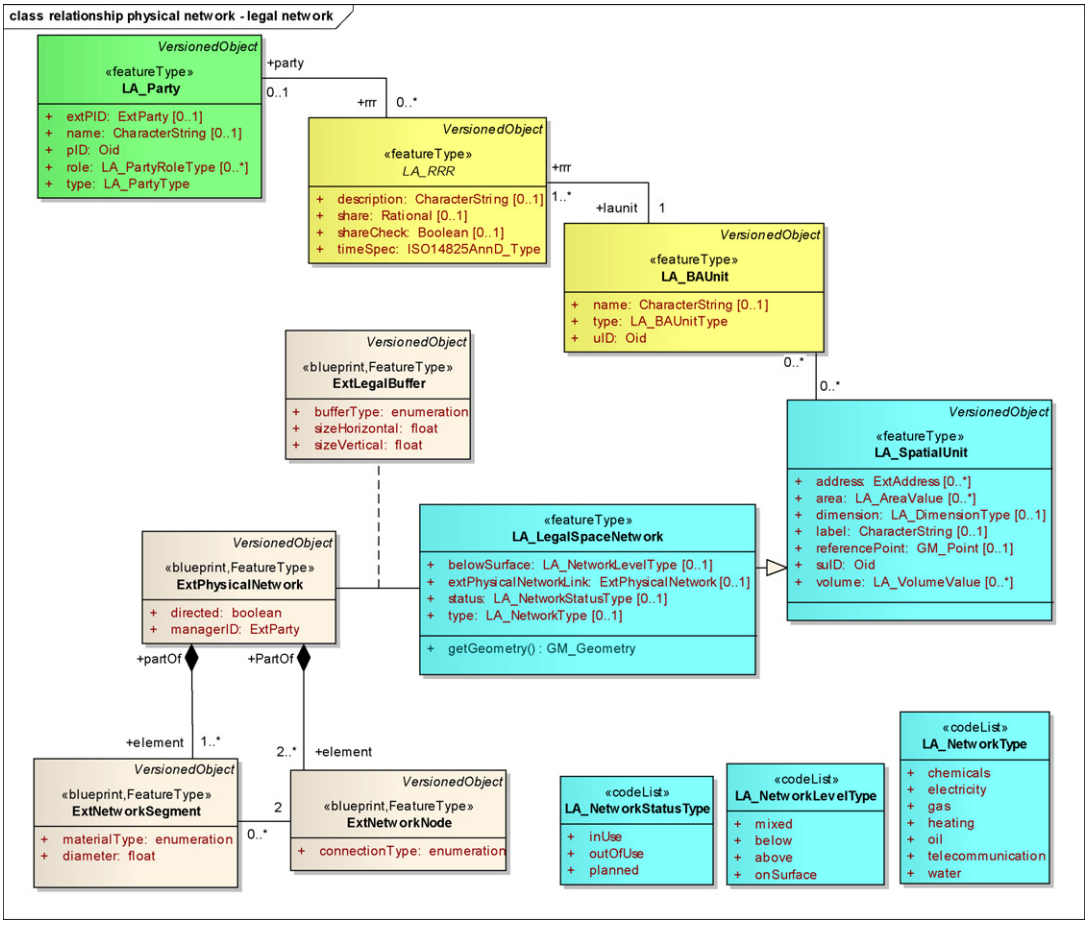

Fig. 2. The conceptual model for representing utility network (physical and legal network).