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A harmonised GI model for urban governance

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Geographic information is a prerequisite for good governance. There are various urban geographic information system projects that have been produced by local governments all over the world. However, there are technical difficulties, a lack of spatial data standards and specific policies governing geographic information system projects. The result of the current situation is that the process of data collection is sometimes inefficient and the quality of the data may be inadequate. Furthermore, there are problems with managing projects and sharing data. The key to resolving these problems is to develop a harmonised geographic information model for the urban governance of Turkey. The model should fulfill the application-driven geographic data needs of local governments and support decision-making processes at regional and national levels. The domain model is an object-relational model and the starting point for creating sector models. The generic conceptual model components were defined to harmonise geographic data and to produce data specifications. In order to enable semantic interoperability unified modelling language has produced the application schemas for data themes such as administrative unit, address, cadastre/building, hydrographic, topography, geodesy, transportation, and land cover/use. The model has been tested and revised with local applications such as economic and demographic spatial analysis cases.

1. INTRODUCTION

Geographic information known as geo-information (GI) represents the location and characteristics of natural and constructed features on the earth. It has economic value as a major component of public sector information and it has value in terms of providing a basis on which to integrate policies, which in turn create tangible benefits for citizens, businesses and governments (Craglia, 2004; Longley *et al.*, 2001). One of the main tenets of good governance is the making of sound decisions at local, regional, national, international and global level (Molenaar, 2006). In order to do this, governments need quality data and information. The dynamics of the living environment are generally the result of interacting geo-data processes. Therefore, GI is a prerequisite for good governance.

Using GI effectively provides noteworthy benefits within the environmental, social and economic context for sustainable management of urban areas under the responsibility of local governments and municipalities (Ting, 2003). The demand for high-quality, up-to-date and interoperable geo-data has increased so that nations can cope with the outcome of natural disasters, maintain domestic security, combat environmental degradation and generally manage urban areas (Warnest, 2005). However, the lack of up-to-date exchange GI hampers cooperation among local governments and prevents consultative decision making at other levels (Annoni *et al.*, 2008; Kurvers, 2008). The availability of the data is restricted by issues such as copyright, funding and legality, and the sharing of data is limited by differences in data content such as data models and specifications (Annoni, 2002; European Statistics Institute, 2008; Loenen, 2006).

Geo-information systems (GIS) can provide a powerful means of supporting decision making and finding optimal solutions to complex problems in various application domains of GI (Yomralioglu, 2000). While GIS is largely designed to serve specific projects or user communities, the focus is now increasingly shifting to the challenges associated with integrating these systems into a broader society perspective (Hanseth, 2000; Georgiadau, 2003). Agenda 21 (UN, 1992) and the Aarhus declaration (UNECE, 2001) refer to the need to build appropriate databases and exchange of information in order to create the conditions necessary for sustainable development in all regions of the world.

Now it is necessary to move into the next stage of GIS, which is the GI or spatial data infrastructure (GII/SDI). This system encompasses policies, technologies and standards for the effective collection, management and access of geo-data to encourage better governance, and the fostering of environmental sustainability by reducing duplication and facilitating integration at different administrative levels (EC, 2007; LRCD, 2004; McLaughin, 1992; Nebert, 2004; NSDI, 1994). The integration of GI through interoperable systems is the central role of GII because it provides information from different sources for effective delivery of government services (Harrison *et al.*, 2006). GII also plays a crucial role in e-government, which supports the information flow between government, citizens and the private sector (Bruggemann and Riecken, 2005; Feeney *et al.*, 2001; Molen, 2005).

Most countries in the developing world are in the process of building GII systems at different administrative levels for effective geo-data management (Crompvoets *et al*., 2004). The GII concept takes its starting point as the local level and then proceeds through state, national, regional and global levels. A local GII supports access to GI for local governments or municipalities, but at the same time access to other inter-institutions should be provided. Most of the time, this is a complex task that requires a carefully planned data management design. National mapping and cadastre agencies (NMCAs) are generally not able to provide large-scale digital urban base maps. This realises investments in the development of digital geo-data sets to reduce costs and to increase benefits for municipalities where the data are maintained at the most effective level (Nebert, 2004; Turkstra *et al*., 2003).

There are technical and non-technical aspects to the realisation of GII and thus the facilitation of the fundamental interaction between people and the data. Among the non-technical aspects is the fact that the institutional framework is reliant on successful partnerships and communication between the geo-data producers and users (Warnest, 2005). Furthermore, there are legal issues such as copyright, pricing policy and access rights that need to be resolved in order for users to be able to reach the data. The technical issues include the development of access and distribution networks, the creation of a clearing house and other means for delivering the geo-data or datasets to the users (Rajabifard *et al*., 2002).

A central component of GII is the actual geo-data (ANZLIC, 1996; DHS, 2006). According to *The SDI Cookbook* of the Global Spatial Data Infrastructure Association (Nebert, 2004), the development of consistent reusable geo-data themes is recognised as a common ingredient and initial phase in the building of GII. The Open Geospatial Consortium (OGC) and the International Standardization Organization/Technical Committee (ISO/TC211) GI/geomatics have developed a variety of standards in this area. The infrastructure for spatial information in Europe (INSPIRE) directive was agreed to produce harmonised models of 34 different data themes such as administrative unit, address and topography to deliver to the 27 countries of the European Union (EU) (EC, 2007). The US Department of Homeland Security (DHS) geospatial data model covers a similar broad range of data themes (Scarponcini *et al*., 2008). Many countries are in the process of being able to manage geo-data, but because each country has its own administrative and institutional structure of development it is impossible to develop a standardised GI prototype that can be a model for local governments of different countries (Woodsfordi *et al*., 2006).

In the present study, the current GI use in Turkey was examined and an analysis undertaken of the requirements for building GII to develop a harmonised geo-database model of Turkey at province level. TURKVA: UVDM, a harmonised geo-database model with generic conceptual model components, was designed to manage the geo-data effectively. This model was tested for the Trabzon municipality in north eastern Turkey to support urban governance as a part of the e-government and GII initiative in various thematic areas.

2. BACKGROUND: GI USE IN TURKEY

Turkey covers a landmass of 780·580 km^2 that bridges Europe and Asia. The population is approximately 70 million as of the census in 2007 (Turkey Statistical Institute, 2008). The political system is a republican parliamentary democracy and some of the government's main priorities are to meet the accession criteria of the EU, to develop public administration and governance – including decentralisation – as well as infrastructure services, and to support environmental protection. There are three basic local administration systems: province, county and village. Figure 1 shows the location of Trabzon province and the other 81 provinces in Turkey. Each province with sub-counties has civil authorities. Each county and its

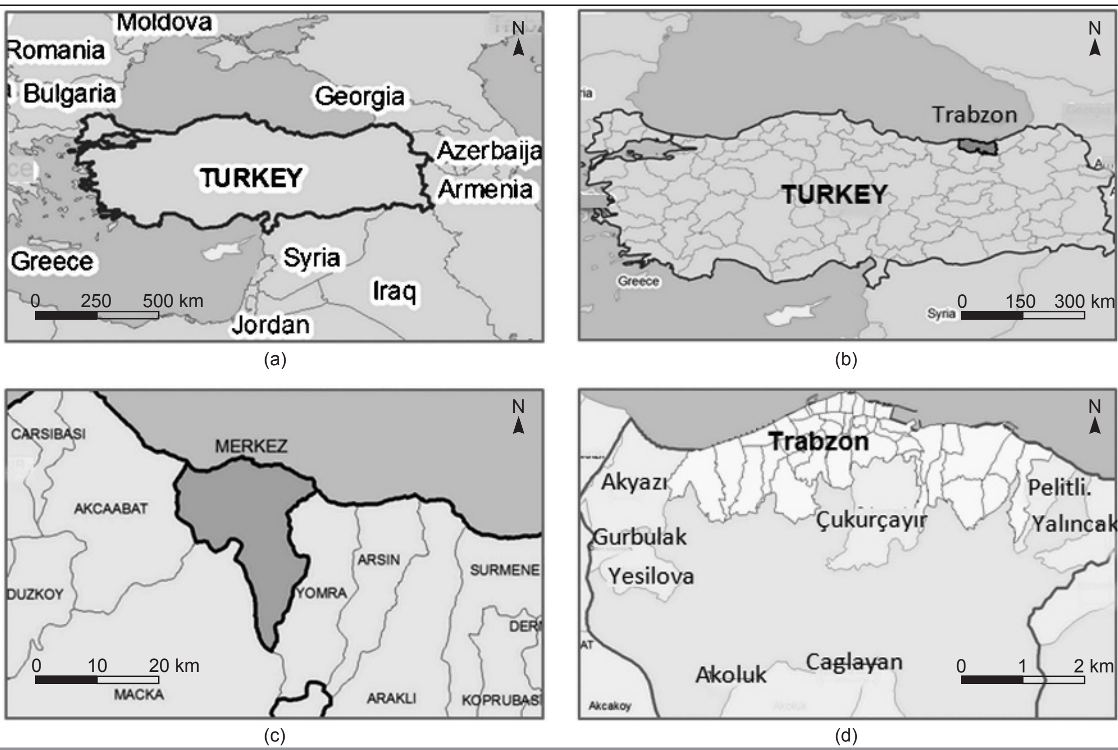

Figure 1. (a) Turkey, (b) Trabzon province and (c) the central county, Merkez, with (d) its municipalities

residential areas with population over 2000 have municipalities. The local infrastructure and services are provided by the provincial public administrations for the areas outside the municipalities (Prime Ministry of the Republic of Turkey, 2006).

2.1. The GI production process

In the 1990s, public institutions increased investment in information and communication technology and the importance of GIS has been recognised by a variety of public and private organisations within Turkey, in particular the General Command of Mapping (GCM) pioneered digital map production. At the beginning, analogue maps were converted to digital format and used as base maps in some specific projects (Yomralioglu, 2004). Standard topographic maps (STMs), smaller than 1:5000, are produced by GCM. Large-scale maps, 1:5000 and larger, are produced by the Land Registry and Cadastre Directorate (LRCD) and the State Provincial Bank. Other public institutions and municipalities have produced maps and developed GIS projects to serve their specific needs. According to the Turkey State Planning Organisation (SPO, 2006), there is a lack of coordination between the public institutions that produce and use geo-data. In addition, there are technical difficulties and a lack of data standards and specific policies governing GIS projects. These factors contribute to the inefficient collection of data, impact on the quality of the data and impede both the sharing of data and the management of the GIS projects.

2.2. National GIS actions

Turkey has hastened efforts to transform the country into an information society with the eTurkey initiative, which is almost identical to eEurope+. After 2003, these actions are combined in the e-Transformation Turkey Project that aims to foster the evolution and coordination of information society activities in a participatory manner. A sub-section of this project devoted to building a 'Turkish national GIS' was initiated and activities continue towards realising the national GII vision. In 2004 with the national action plan no. 47 the current situation in relation to building GII was examined. However, it has yet to be determined which institutions produce which data and to which standard or scale. In Turkey, it is found that 81% of public institutions have GIS software but there are no accepted international or de-facto standards in public institutions (Aydinoglu and Yomralioglu, 2006; LRCD, 2004). With the national action plan no. 36, the Turkish national GIS concept and implementation models were determined in 2005 and emphasis was placed on the need to build a national GII to share the geo-data efficiently in a different context and scale, with these geo-data being produced by participating public institutions, organisations, companies and universities (LRCD, 2006).

2.3. Urban GIS applications

According to the survey executed by the Turkish Statistical Institute (2007), in 3066 out of the 3228 municipalities in Turkey, 18% (i.e. 543) of the municipalities have a numbering unit and 4% (i.e. 126) work on the basis of an urban GIS. Most municipalities, especially in large provinces, are trying to build urban GIS and e-municipality applications. According to the municipality law (no. 5393) (Republic of Turkey, 2006) and the metropolitan municipality law (no. 5216) (Republic of Turkey, 2004), municipalities must build GIS and urban GIS applications. The interoperability circular (Republic of Turkey, 2005) published by the Prime Ministry of Turkey contains the general vision of the standards required to build information systems in all central and local public institutions; these GI standards should be defined on the scope of the Turkish Standards Institute (TSE), ISO/TC211 geographic information mirror committee.

2.4. Geo-information standards

The GCM STM data dictionary includes information for presenting the data on the maps, but does not include information for using in various thematic applications. Large-scale maps are produced in accordance with the large-scaled map production regulation (BÖHHBUY) that was revised and accompanied by a feature/attribute catalogue in 2006. However, the geo-data specifications are not defined in such a way as to support various GIS applications and decision-making processes (Aydinoglu *et al.*, 2010; Emem and Batuk, 2007). Local governments need high resolution and large-scale geo-data and maps for applications such as zoning plans, real property management and the development and maintenance of the infrastructure. The urban GIS applications of local governments were developed in accordance with the GIS software companies. Therefore, since public institutions use a different conceptual model and feature catalogues, the geo-data are not interoperable (LRCD, 2006). The Interior Ministry is in the process of combining the databases of the national address database (UAVT) and the national citizenship system (MERNIS). The Land Registry and Cadastre information systems (TAKBİS) were built in 2004 and are being activated in all cadastre directorates of Turkey. However, the GIS projects executed in local governments, the LRCD, municipalities and public institutions were not designed to enable data interoperability (Aydinoglu *et al.*, 2007; Cete *et al.*, 2009; Geymen *et al.*, 2008; LRCD, 2006).

According to the report by the Inter-Ministerial Map Progress Coordination and Planning Commission (2007), the features and attributes required by institutions and organisations should be determined by way of an application-driven approach. Data specifications should be defined to allow data themes to be used jointly and to harmonise geo-data from different sources. Furthermore, a common concept should be produced to generalise the geo-data from local to national level. In addition the report comments that the national data exchange format (UVDF) needs to be updated in order to comply with the geographic mark-up language (GML) 3.X.

3. DEVELOPING A HARMONISED GI MODEL

The preliminary work on building the GII, a harmonised GI model of Turkey, was designed to ensure that the data were enabled for multiple uses. The Turkish GII: geo-data exchange model (TURKVA:UVDM) is a new approach to GI management in Turkey. UVDM is a geo-database model that provides the means to consolidate the geo-data user requirements, defines specifications of geo-data themes and visualises what the database will be like, with documents and application schemas on a platform independent from any particular software or hardware.

3.1. General properties

UVDM complies with ISO/TC 211, the expectations of the INSPIRE data specifications that European countries follow in order to work towards building European SDI. UVDM includes the data that need to be shared among users and, because all sectors share this base, data exchange between the sectors is greatly enhanced. This base and the domain geo-database model form a starting point to create sector models in different thematic areas. Sector models including the land ownership and cadastre information system (TAKBIS), state hydro-information systems (DSICBS) and urban GIS applications (KBS) of municipalities, can produce their own geo-database model as an extension of UVDM, as shown in Figure 2.

UVDM is an object-relational data model that enables users to store objects and their associated attribute data in a single geo-database system (Yeung and Hall, 2007). In this way, the model can provide advantages such as indexing and transaction management. UVDM is a semantic model because a harmonised model provides a common domain of interaction and the related information. This interchangeable information in the model should be able to explain objects with properties and relations semantically. That is, a variety of different kinds of organisations can operate in the same GI base and exchange the data technically. UVDM is designed with unified modelling language (UML) class diagrams (ISO, 2005) that are a graphical modelling tool with well-defined semantics and an underlying computer model using a model-driven approach.

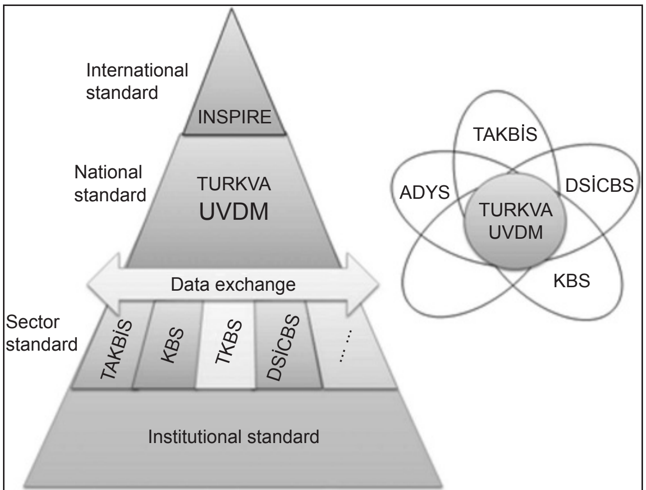

Figure 2. UVDM base and sector models

3.2. Generic conceptual model

The UVDM generic conceptual model specifies the components to determine the application schemas of geo-data themes and to harmonise geo-data. These components were defined and divided into two sections, scope/application area and technical components, as shown in Figure 3. The UVDM geo-data themes are administrative unit (IB), address (AD), land ownership/building (MB), hydrography (HI), topography (TO), geodesy (JD), transportation (UL) and land cover/use (AR). These data themes were selected because they were determined the most needed by geo-data users according to the field work and are also accepted as INSPIRE data themes, which include documentation, catalogues and UML application schemas.

3.2.1. Scale resolution and generalisation approach. Geo-data should be maintained at a level where the data are managed effectively. The only way to have consistent and current national datasets is to have transactional updates performed by local datasets. These data can be combined, transformed and integrated into the national datasets.

According to the field work carried out in public institutions that produce and use geo-data, municipalities and provincial administrations are determined to have high-level power/interest and geo-ICT/data requirements capacity and they are managing the data on scales larger than 1:5000, according to BÖHHBUY criteria. Thus, the UVDM is defined as being on the level of large-scale data use. The spatial hierarchy approach enables the collection of data at province level, larger than 1:5000 scale and 50 cm resolution, and then generalises to different levels such as region and country (Figure 4). Produced and combined geo-databases at this level can be used in the applications and information products with graphic and cartographic generalisation. The UVDM approach can be conceived at three different levels, from bottom to top. The bottom level, called UVDM-3, can be

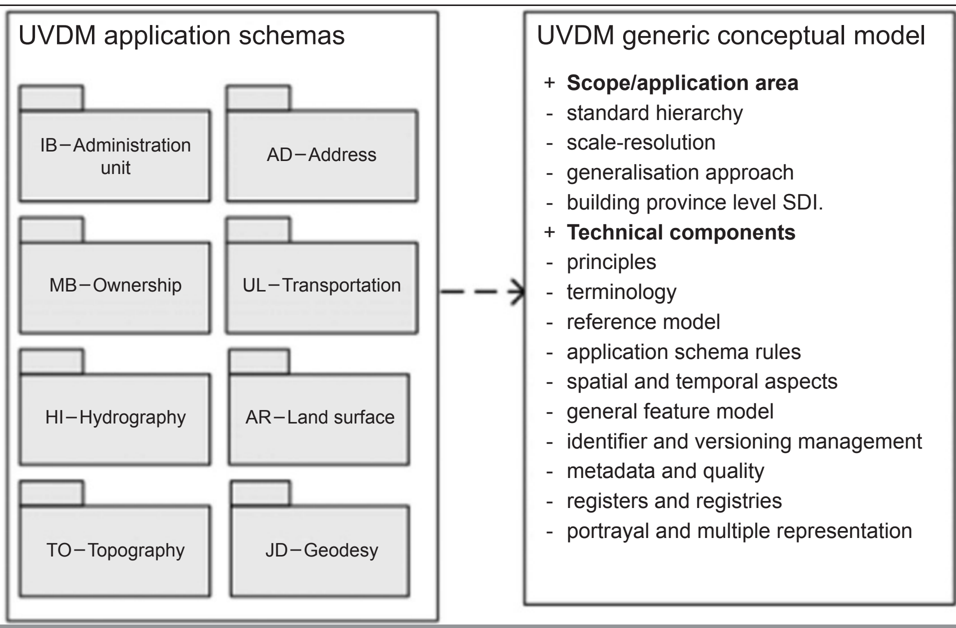

Figure 3. UVDM generic conceptual model components

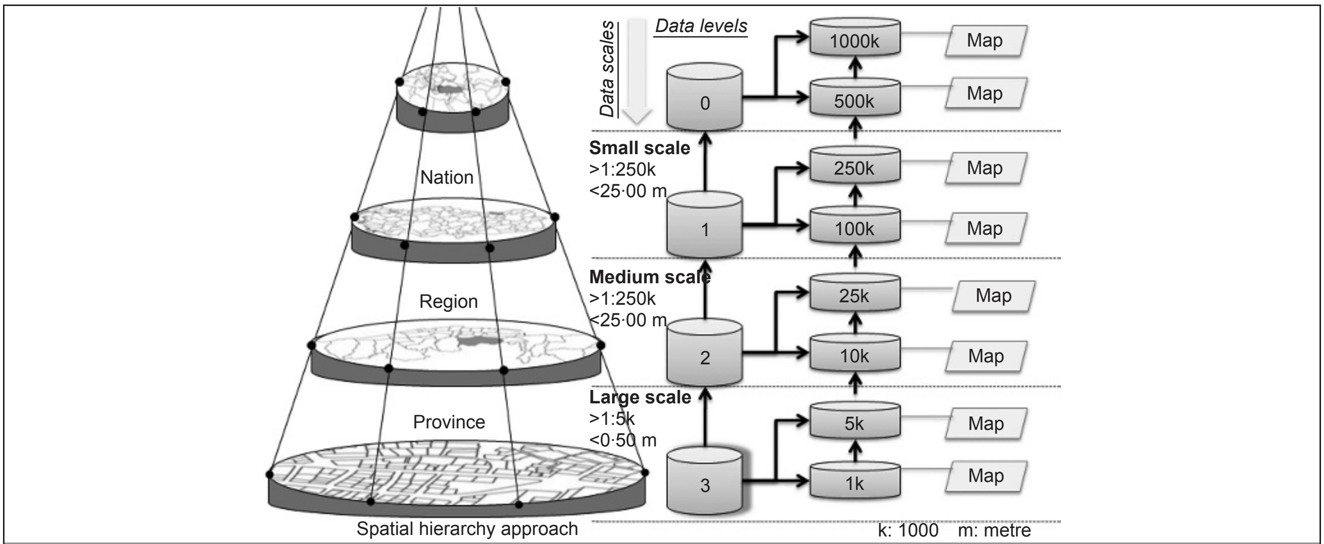

Figure 4. UVDM application level and generalisation approach

converted to the upper middle-scale level and to the top small-scale level with model generalisation. Satellite/aerial images can be used as base data with different applications, similar to facilities such as Google Earth. Geo-data sets of UVDM can be produced from the images, based on application and data-use level.

3.2.2. Base application schema rules. The key classes of UVDM application schemas are explained in Figure 5.

- The high-level and base class of UVDM is *UVDM_CografiNesne* accepted as a common and compulsory class.
- All geo-objects are defined in feature classes of data themes, they are sub-class and a specialisation of *UVDM_CografiNesne*.
- All geo-objects in feature classes have geometry and/or topology in a position.
- All geo-objects are referenced on the *CografiReferans* geography coordinate system.
- *NesneTanımlayıcı* defines all geo-objects with a unique identification.
- *NesneVersiyonu* defines and controls the changes of the objects through time with attributes.
- *KullanımHakkı* defines the data accession permission and sources with attributes.
- *Metaveri* defines the information about all the geo-objects at a dataset level of the feature classes.

3.2.3. Geo-object identification and versioning. A common framework is determined for the unique identification of geo-objects. This means that all geo-objects carry a unique identifier property called the geo-object identifier (CNTA). In order for a unique identifier to remain meaningful, it must persist throughout the life cycle of the object it refers to. These identifiers can be used to ensure interoperability among databases under national systems.

For example, public institutions such as TURKSTAT and the General Directorate of Local Governments use different definitions in relation to administrative units. Currently, there is no unique administrative unit code (IDBK) differentiating national to local level; therefore, the administrative unit definitions used

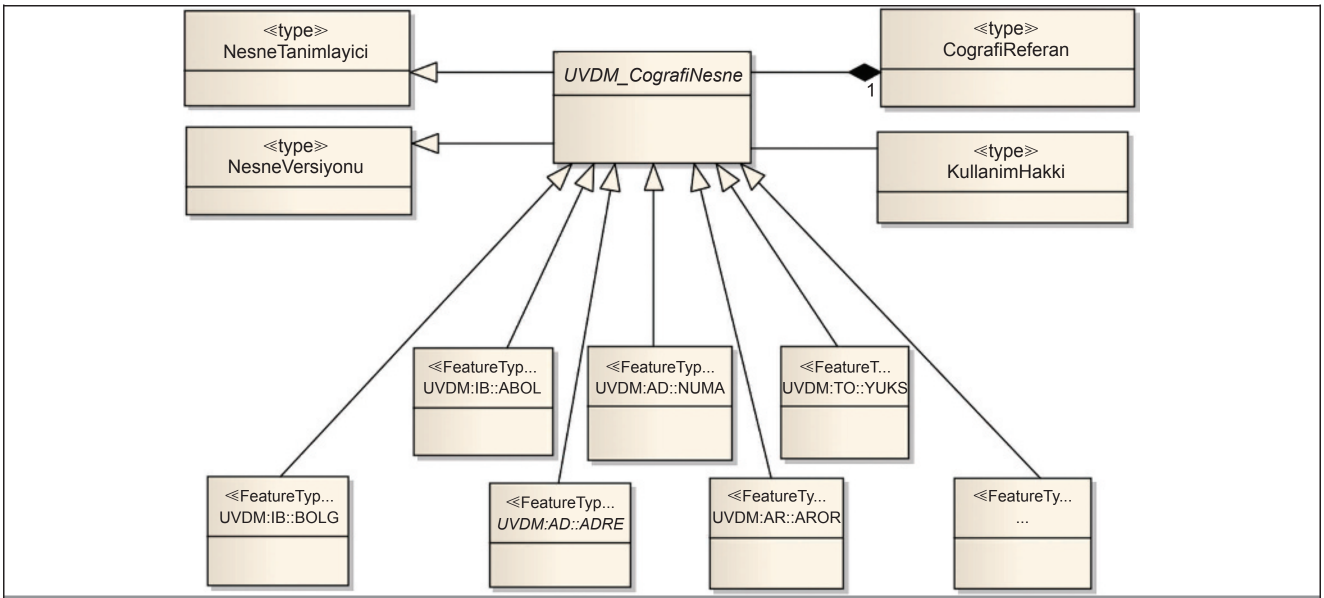

Figure 5. TURKVA: UVDM base application schema

in public institutions were combined in respect of Turkey's administrative hierarchy. In the administrative unit data theme (IB), an IDBK was created to access the databases of administrative units. An IDBK with 12 digits was produced to define the lowest level administrative units that are districts and villages. The feature types defined on different data themes support data sharing for applications, for example; as seen in Figure 6: geodata sets can be related to each other with CNTA attributes. The CNTAs for objects of UL, AD and MB data themes were determined hierarchically based on the lowest level administrative units of IB data themes, district/village (MAKO). This enables the use of the data as in a real-world interaction. The numbering data sets (NUMA) in the address data theme (AD) can be related to the building data sets (YAPI) in the land ownership/building data theme (MU) to describe the location of a building with its address. Similar combinations and data sharing possibilities provide opportunities to manage the data on various thematic applications.

A temporal feature class is produced for each feature class to manage the data through time temporally and to control changes. This class defines attributes such as CNTA, versioning number (VENU), version starting and finishing date (VEBA and VEBI). Old versions of an object can be obtained from temporal class, with the attribute CNTA explaining the same object. In addition to this, the life cycle of an object was defined with certain rules.

3.2.4. Application-driven geo-data modelling at province level. The design of the geo-database model follows the requirements of the application algorithms. This model is focused on the application and use of information, rather than a specific workflow for an organisation. Trabzon, one of 81 provinces of Turkey, was chosen as a pilot area in this study (Figure 1). The base principle is that if a geo-database is modelled for Trabzon province, it could then be a model from local to national level for all provinces in Turkey. As a result of this modelling process, a harmonized GI model could be built to meet the needs of local, provincial, regional and national levels. Data specification development for UVDM was based on the INSPIRE methodology (INSPIRE, 2007; ISO, 2006a) with sub-phases, as illustrated in Figure 7.

- *Step 1.* From the fieldwork, information products and applications that need relating to GI were determined for 37 of the public/private institutions and organisations situated in the Trabzon province in Turkey. These were summarised and combined in a list that included 85 functions, which explain GIS activities at local level. The user requirements of these functions were defined as the data content, the level of detail, relationships between objects, data consistency and updating, and the temporal dimension of the data.
- *Step 2.* An as-is analysis describes the current situation with respect to the existing specifications and data harmonisation components (INSPIRE, 2007). In this way, the use of GI was determined at the local level, including the GCM spatial data dictionary, BÖHHBUY feature/attribute catalogue, Turkish disaster information system spatial object catalogue (TABIS) and Istanbul metropolitan municipality urban GIS.
- *Step 3.* The gap analysis compares and evaluates the results of each as-is analysis to develop an application schema, if the identified source material is able to fulfil the user requirements. In this way, the geo-data needs based on the field work were combined with existing specifications to meet GI needs.
- *Step 4.* The data specifications of the data themes were formalised from the results of user requirements and the as-is analysis. A vital part of a data specification is the ISO 19109 (ISO, 2006a) application schema specified in UML, a conceptual schema for the data needed according to user requirements and applications. This schema defines feature

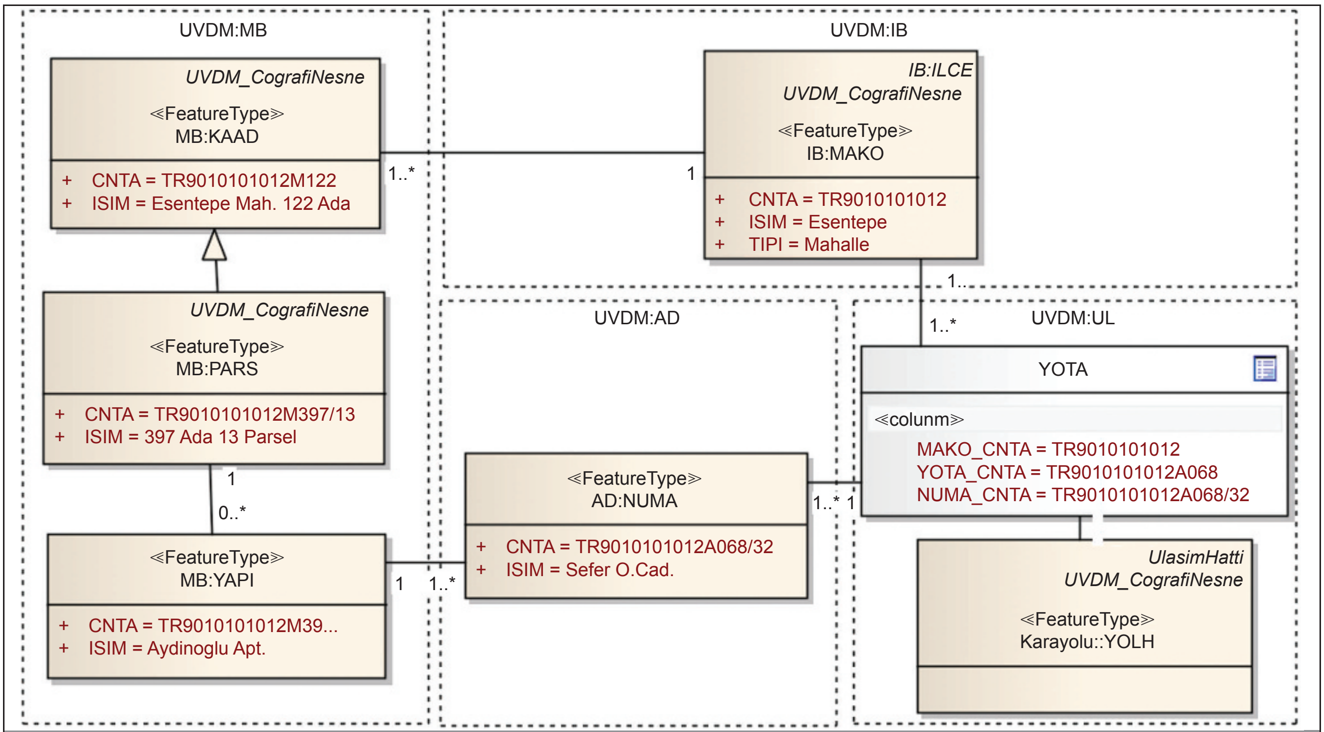

Figure 6. Managing geo-data in the sharable environment of IB, UL, AD and MB data themes

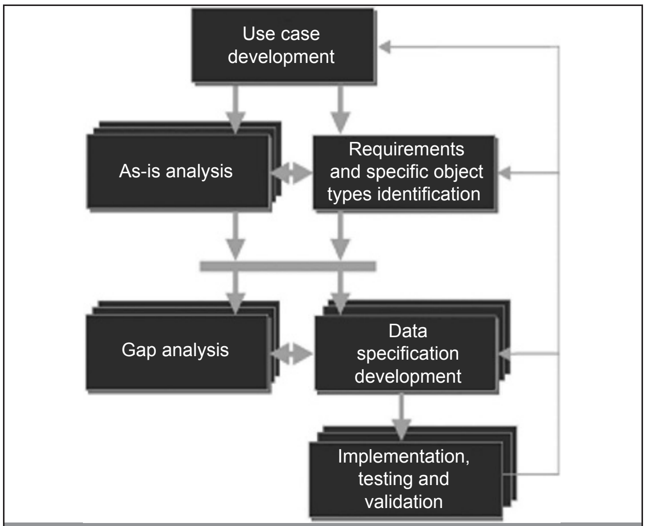

Figure 7. INSPIRE methodology for data specification development

types, geometry, attributes with multiplicity and domain values, associations and spatial rules in data catalogues, as defined in ISO 19110 (ISO, 2006b).

- *Step 5*. The data specifications developed are then tested and revised in a pilot case study under real-world conditions, as explained in Section 4.

3.3. An example of the application schema: address data theme (UVDM:AD)

Application schemas with UML and data catalogues were determined for all data themes such as address (AD) as shown in Figure 8. The data specification for addresses is required to facilitate the interoperability of address information from the whole country. Address reference data not only provides data in their own right, but also have the useful property to link information from other datasets. The general properties of these application schemas are as follows.

- On the AD data theme, the numbering (NUMA) feature class defines the fixed location of properties including plot of land, building, access ways and other construction. This is achieved by means of a structured composition of geographic names and identifiers. The attributes of the NUMA feature classes include position as point, origin, identifier as CNTA, status and object versions.
- Each NUMA object has an address defined with sub-address components, such as the administrative unit name, street name, numbering of door, postal region/area. These components are managed in an ADRS table that enables the get-point geometry of the address information with 'address locator mechanism'.
- Each NUMA object is defined in a postal area (POBI) and points out the location of landmarks (ILNO) defining urban functions such as shops, sport centres and tourist attractions.

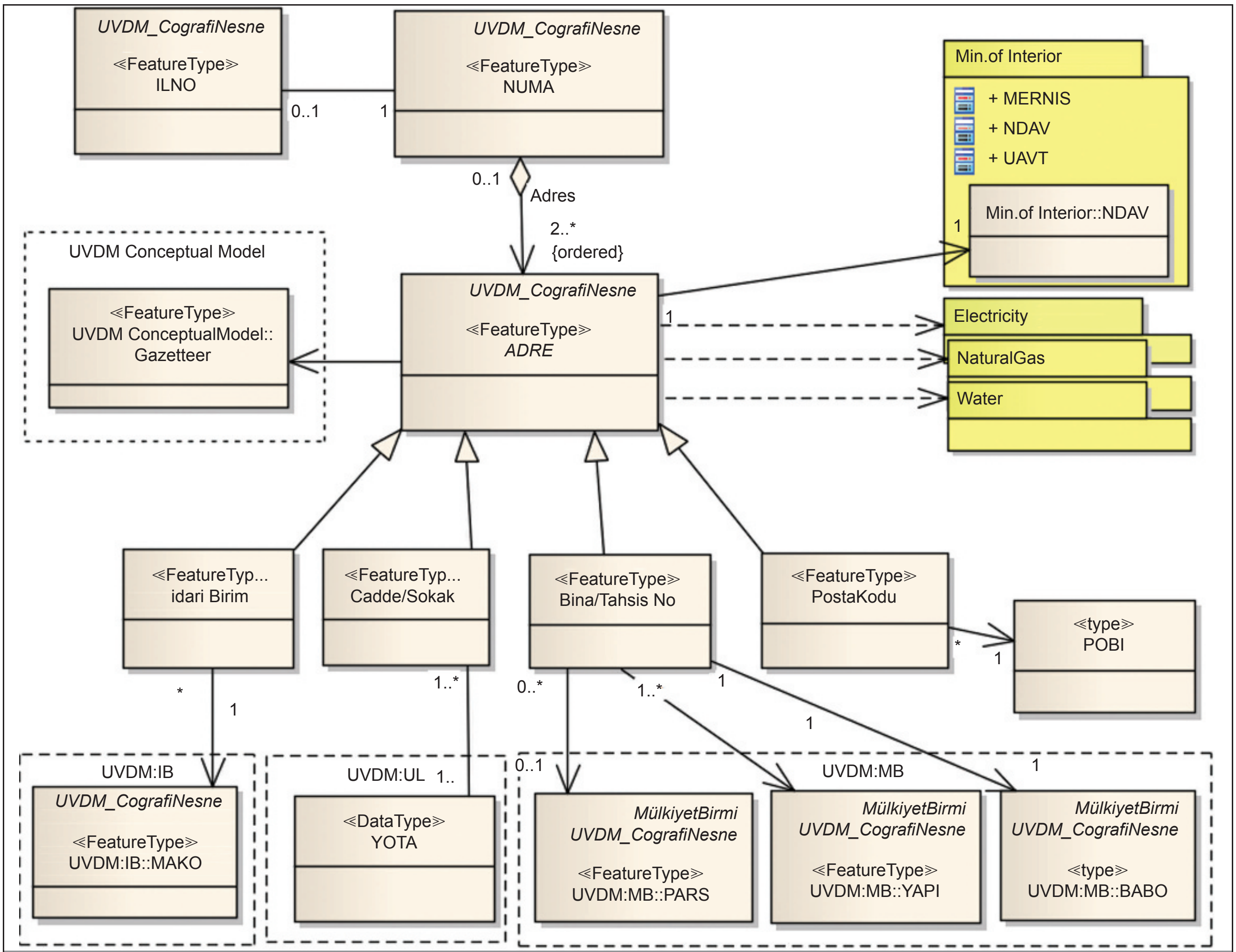

Figure 8. The application schema of the address data theme

- The properties of any building are defined in a BABO class with sub-address that is related to the NUMA object.

The relationships between the UVDM themes are modelled by associations, as follows.

- A numbering object with address is defined in a district/village object.
- A numbering object with address represents a building (YAPI) object or parcel (PARS) in the MB data theme.
- In order to be able to express that two sides of a road carry a different name, a class called road description (YOTA) is included in the AD data theme. This association defines which numbering object in the AD theme is related to which road in the UL data theme.

The relationships to other sector and institutional databases are modelled by associations.

- The national address code (UAKO) of the UVDM enables urban GIS applications to be combined with the databases belonging to the Ministry of the Interior.
- The BABO class can be associated with urban utility functions of municipalities and public institutions, such as electricity, water and gas.

4. CASE STUDY

4.1. Data collection

A geo-database named TR90101 was built within the scope of a project supported by Trabzon municipality and provincial administration. The data were collected from a range of sources which included: Trabzon provincial public administration (PPA), provincial directorate of public works, regional directorate of land ownership and cadastre, regional directorate of Turkish Statistical Institute, and the sub-sections of the Trabzon municipality, for example, the directorate of planning, numbering and mapping. The ArcGIS geo-database functionality was used to combine and manage geo-data, based on application schemas of the UVDM: IB, AD, UL, MB, TO, AR data themes.

4.2. Managing the geo-data in a networked environment

In 2007, under the auspices of the Turkish Ministry of the Interior, various geo-data management models were tested in a networked environment, taking into account the criteria of cost, ease of configuration and management, openness to competition and performance. According to the province–urban information management system (PUIMS) of the Ministry of the Interior (Interior Ministry of Turkey, 2007), the responsibilities are determined to build geo-databases at local level, as seen in Figure 9. In this way:

- municipalities should manage geo-databases of their own municipality areas
- PPA should manage geo-databases for the areas outside municipalities in a province
- to build the Turkey GII, geo-data are replicated from geo-databases of municipalities and PPA for each province, managed on a province portal and can then be combined into national geo-databases.

In this study, a municipality geo-database TR90101 was built for Trabzon municipality, based on the vision of the Ministry of the Interior. A server was built in the ICT department of Trabzon municipality to test the UVDM model. The data were managed on a centralised geo-database based on ArcSDE MS SQL server configuration of ArcServer architecture. Data producers and users such as the planning, mapping and strategy unit of the municipality were determined for real-time data management in a networked environment. For example, while one user is updating statistical data, another user can reach a demography website and see the current updated census distribution map. Figure 9 shows the possible users of the Trabzon municipality geo-database TR90101 and some feature classes of the themes of this geo-database.

4.3. Applications for the sustainable development of urban areas

Modelled feature classes in the themes were used and combined for a variety of applications. Various maps and information products were produced from local to national level for various user needs, from environment and land management to statistics and economic analysis. The examples given below are shown in Figure 9.

- The NUMA class in AD, YOLH class in UL and YAPI class in MB theme produce a 'street address map'.
- The MAKO class in IB theme and EPID statistics table produce a 'district/village cancer incidence map'.
- The ILCE classes in IB theme and literacy statistics table produce a 'county literacy map'.

The national address database (UAVT) and census and citizenship database (MERNIS) are in the process of being integrated under the responsibility of the Ministry of the Interior. This means that, if the national address code (UADK) of UVDM:AD model is used, data harmonisation and exchange on various databases will be possible. The address information for a person can easily be obtained from their identity number. When the urban GIS applications of municipalities are harmonised with the UAVT and MERNIS database, these data can be accumulated and summarised for the applications such as urban GIS, demography and regional development, from local to national level.

The urban GIS applications of Trabzon city were produced based on UVDM. Common identification and versioning management were enabled to manage numbering, building, block, parcel datasets of AD and MB data themes together, as explained in Section 3.3. For example, features can be obtained and mapped on specific data as a result of a temporal attributes query for Trabzon city-Esentepe district-397. The change, from 1 January 2007 (Figure 10(a)) to 1 June 2008 (Figure 10(b)), points out that parcels 2, 9, 10 and 12 of block 397 were merged into parcel 13 and buildings with numbering units have been demolished; block 397 was revised to have permission for construction. Two neighbouring buildings with numbering units were built on parcel 13.

The geo-database of the Trabzon urban atlas was generated from the TR90101 geo-database as a sector extension. Some features of the UVDM: IB, AD, UL and AR data themes were obtained from the main geo-database. A large-scale Trabzon urban atlas

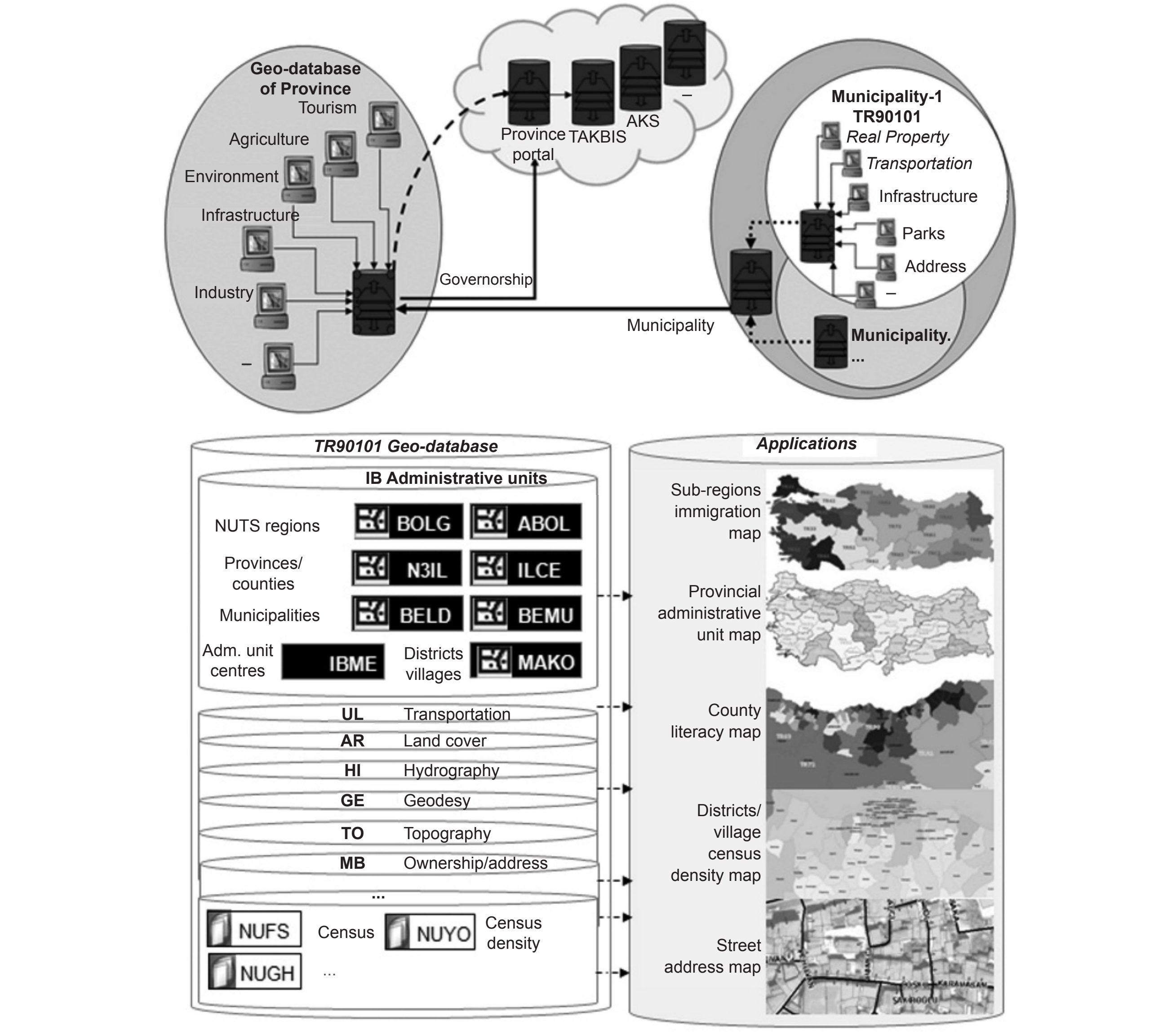

Figure 9. PUIMS (top) with Trabzon TR90101 geo-database and case (bottom)

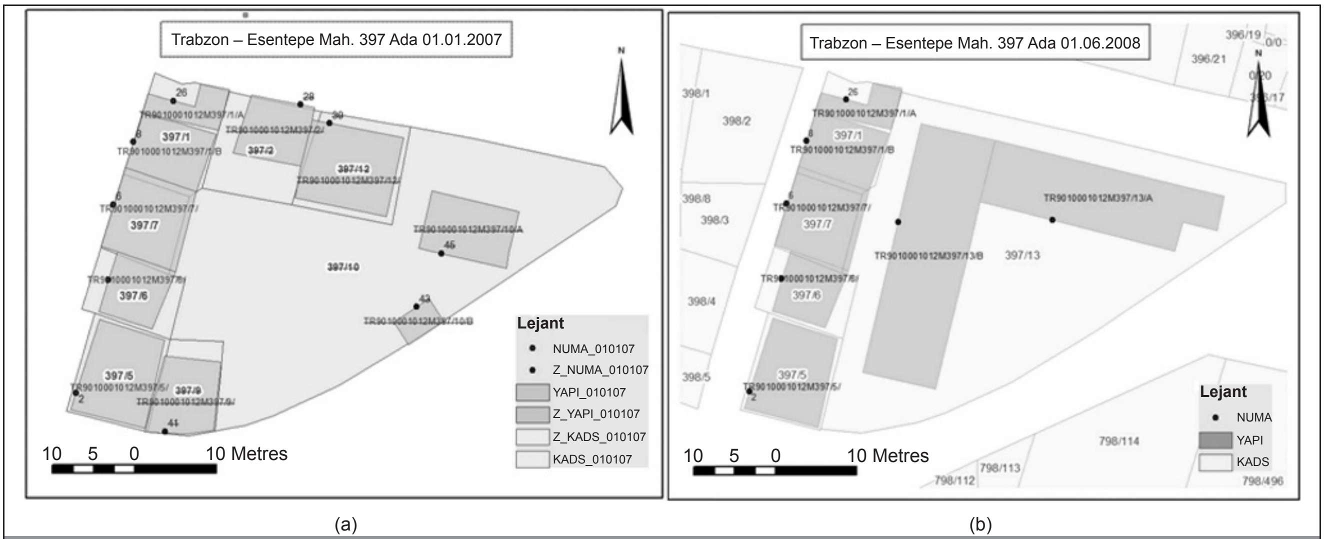

Figure 10. The versioning example for numbering, building, parcel and block feature classes

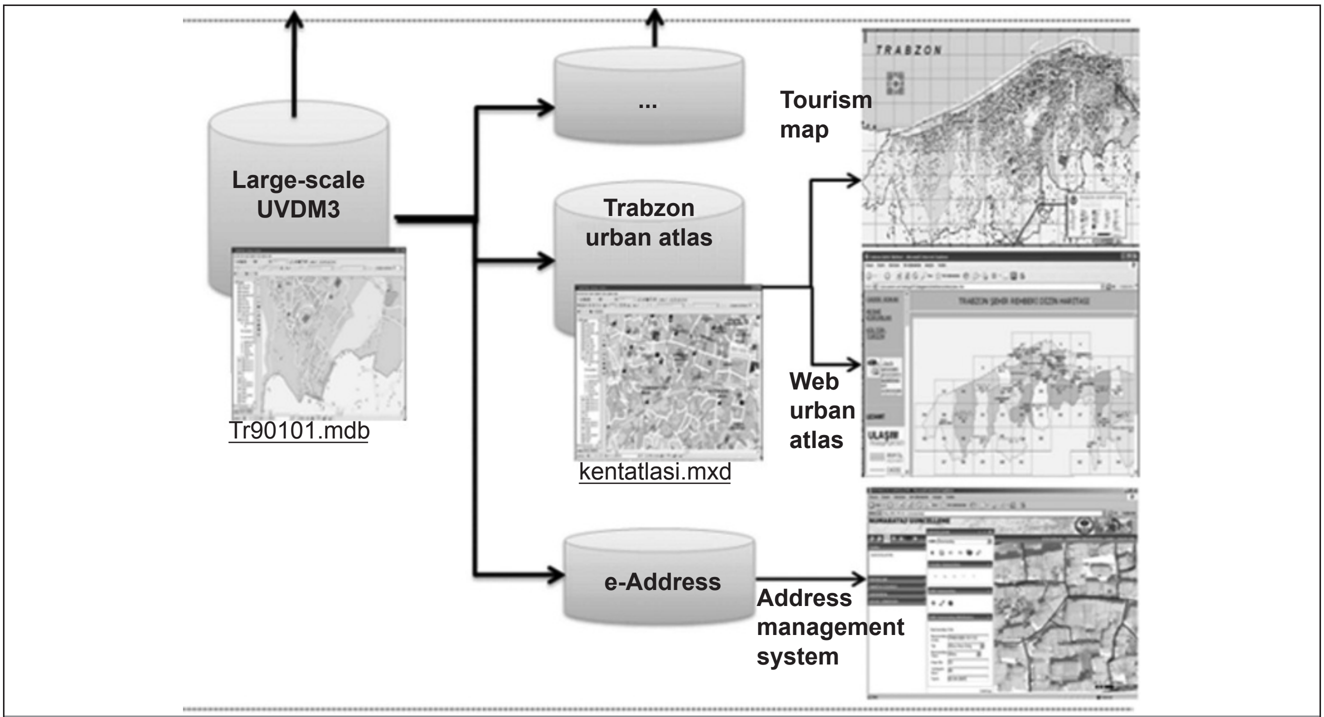

Figure 11. e-Trabzon applications based on UVDM

and an Internet web atlas were produced based on this geo-database, as shown in Figure 11. In addition the e-address, e-municipality applications were developed to test the TR90101 geo-database based on UVDM.

5. CONCLUSIONS

The geo-database model, also called the harmonized GI or feature/object model, can provide an effective approach to geo-data management. Conceptual components are enabled to manage the data in terms of linking, sharing and reusing with unique and persistent identifiers. UML data modelling supports object-oriented and relational data models, but it needs new tools to define spatial relations and constraints. In this way, this common approach enables the balance of heterogeneity in geo-data management towards the building of a national GII from a local GII that is managed by municipalities and local governments.

In Turkey, collecting geo-data and obtaining images from different sources poses some difficulties; because there is no standardised data structure, sharing data to produce different thematic applications is impossible. Thus, the harmonized GI model can enable various applications from local to national level. The data can be used for multiple representations in different implementations. Therefore, this approach can, through the sharing of geo-data, enable the effective management of a city and development of an e-municipality. Consequently, building the GII supports the development of good urban governance.

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