Investigation of Data Models and Related Requirements affecting the implementation of a Multipurpose Cadastre System in Malaysia

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Abstract

One aim of this study was to investigate the state of development of multipurpose cadastre systems (MPCs) internationally, and, based on the findings to design a multipurpose cadastre data model enhancing the current cadastre system in Malaysia. A second aim was to determine the organizational and legal requirements for implementing a multipurpose cadastre system, within the current Malaysian context. As a final aim, the service oriented architecture (SOA) concept was examined to investigate how it might support the storage, maintenance and delivery of the different layers of data found in an MPC.

The data model and service oriented architecture were developed using Oracle Spatial technologies and the SQL language. Sample data from the national digital cadastre database, utility data and topographic mapping data from Malaysia were used in the case study. The investigation enabled data from various agencies to be integrated into a single multipurpose cadastre database in the Oracle Spatial database environment, and a case study of an easement as a legal land object was executed. It was discovered that it was beneficial to show the complete legal situation of a parcel compared to the previous system where the user had to manually search for legal documents and deal with the ambiguous locations of legal land objects. The results of the SOA investigation showed that the application of the SOA concept to the construction of an MPC database will require extensive IT investment, especially a high specification server, but it is expected to reduce redundancy in data collection and processing and reduce the costs. The study also showed that existing legislation in the National Land Code 1965 should be amended.

The principal conclusion is that an open source system should be adopted before any further investment in IT software and hardware is made. Another conclusion is that a multipurpose cadastre system has to be managed by personnel highly trained in spatial, programming and IT competencies. An open source system combined with the SOA concept seems the best option if a multipurpose cadastre system is to contribute to the sustainable management of land resources within a rapidly developing Malaysia.

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Preface and acknowledgement

This thesis represents the work of two years investigation by the author on the multipurpose cadastre which is currently under development in Malaysia. The thesis derived the concept of multipurpose cadastre found internationally and a prototype multipurpose cadastre was developed to help the Malaysian government to steer the project.

This investigation was supported and funded by the government of Malaysia (Public Service Department of Malaysia) which including fees and living expenses for the periods of 24 months at Glasgow.

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Author's Declaration

I declare that this thesis is entirely the product of my own work, except where indicated, and has not been submitted by myself or any other person for any degree at this or any other university or college.

Sim Ching Yen

Definition/Abbreviations

AdV	The Surveying Authorities of the States of the Federal Republic of Germany
AFIS	Authoritative Fixed Point Information System
AGD	Australian Geodetic Datum
AKR	Automated Cadastral Register
ALB®	Automated Property Register
ALKIS®	The integrated official cadastral information system
ANZLIC	The Australian and New Zealand Spatial Information Council
ASCII	American Standard Code for Information Interchange
ATKIS®	The Authoritative Topographic-Cartographic Information System
BAM	Business Activity Monitoring
BKG	Federal Office for Cartography and Geodesy
BPEL	Business Process Execution Language
BT68	Borneo Triangulation 1968
CCDM	Core Cadastre Domain Model
CCI	Coordinated Control Infrastructure
CEN	European Committee for Standardisation
CP	Certified Plan
CRM	Cadastral Reference Mark
CSRS	Cadastral Survey Record System
DCDB	Digital Cadastre Database
DLS	Departments of Land and Surveys
DXF	Drawing Exchange Format
EDBS	Unique Data Base Interface
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
eLJT	electronic Land Surveyors Board or *electronik Lembaga Juruukur Tanah*
EPU	Economic Planning Unit
EXCO	Executive Committee
FBK	Field Book (Field Surveying Record Document)
FGDC	Federal Geographic Data Committee
FIG	International Federation of Surveyors
FVAV	Financial Share Ordinance *or Verordnung der Bundesversammlung über die Finanzierung der amtlichen Vermessung*
GCP	Geodetic Control Point
GDA	Geocentric Datum of Australia
GDC	State Geospatial Data Centre
GDM2000	The Malaysia Geocentric Coordinate Datum
GIM	Global Magazine for Geomatics
GIS	Geographic Information System
GLMS	GIS Layer Management System
GML	Geography Markup Language
G-NAF	Geocoded National Address File
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS 80	Geodetic Reference System 1980
GSDI	Global Spatial Data Infrastructure Association

HDM	Harmonised Data Model
HMDA	Home Mortgage Disclosure Act
HTTP	HyperText Transfer Protocol
ICSM	Intergovernmental Committee on Survey and Mapping
ICT	Information and Communications Technology
IDT	Issue Document of Title
INSPIRE	Infrastructure for Spatial Information in Europe
INTERLIS	Data Exchange Mechanism for Land-Information-Systems
ISO	International Organization for Standardization
ITRF	International Terrestrial Reference Frame
JUPEM	Department of Survey and Mapping Malaysia or *Jabatan Ukur dan Pemetaan Malaysia*
KLIC	Cables and Pipelines Information Centre
LADM	Land Administration Domain Model
LASSI	Land and Survey Spatial Information
LGDC	The Local Geospatial Data Centre
LIS	Land Information Systems
LKI	Survey and Mapping Information System
LSA	Least Square Adjustment
MaCGDI	Malaysian Centre For Geospatial Data Infrastructure
MPC	Multipurpose Cadastre
MRT96	Malayan Revised Triangulation
MS1759	Malaysian Standard Spatial Schema
MyGDI	Malaysian Geospatial Data Infrastructure
MyRTKnet	Malaysian Real Time Kinematic Network
NDCDB	National Digital Cadastre Database
NGDC	National Geospatial Data Centre
NLC	National Land Code
NSDI	National Spatial Data Infrastructure
OGC	Open GIS Consortium
OODBMS	Object-oriented Database Management System
PADU	The Utilities Survey Database or *Pangkalan Data Ukur Utiliti*
PCCR	Permanent Committee on Cadastral Reform
PCGIAP	Permanent Committee on GIS Infrastructure for Asia & Pacific
PDMK	Multipurpose Cadastre Geodatabase or *Pangkalan Data Multipupose*
PDUSSM	The Strata, Stratum and Marine Database or *Pangkalan Data Ukur Strata, Stratum dan Marin*
PMO	Prime Minister's Office
PPSME	CCI Working Portal Administrator
PSMA	The Public Sector Mapping Agency of Australia
PTD	District's Land Office or *Pejabat Tanah Daerah*
PTG	State's Land and Mineral Office or *Pejabat Tanah dan Galian*
PU	Survey Application / *Permohonan Ukur*
QT	Qualified Title (issued by land office before final title is produced)
R & R	Re-Coordination & Re-Population
RCU	Repository Creation Utility
RDT	Register Document of Title
RMSE	Root-Mean-Square Error
ROWID	Row Identity Number

RRR	Rights, Restrictions and Responsibilities
RSO	Rectified Skew Orthomorphic
RTK	Real Time Kinematic
RTKnet	Real Time Kinematic Network
SCDB	Survey Control Database
SDI	Spatial Data Infrastructure
SDI SC	Spatial Data Infrastructure Standing Committee
SKL	Layout and Precomp for field Surveyor / *Surihan Kerjaluar*
SOA	Services Oriented Architecture
SOAP	Simple Object Access Protocol
SPAK	Cadastre Inventory Management System or *Sistem Pengurusan Aset Kadaster*
SRS	Survey Record System
SQL	Structured Query Language
SUM	Virtual Survey System or *Sistem Ukur Maya*
TC211	Geographic information/Geomatics Technical Committee
TIFF	Tagged Image File Format
UDDI	Universal Description, Discovery and Integration
UML	Unified Modelling Language
UNECE	United Nations Economic Commission for Europe
UNFCC	United Nations Framework Convention on Climate Change
UPI	Unique Parcel Identifier
URL	Uniform Resource Locator
WCS	Web Coverage Service
WFS	Web Feature Services
WFS-T	Web Feature Service-Transactional
WGS 84	World Geodetic System 1984
WMS	Web Map Services
WPKL	Federal Territory of Kuala Lumpur
WSDL	Web Service Definition Language
XML	Extensive Markup Language

Chapter 1: Investigation introduction

1.1 Background

For many centuries cadastre systems have enjoyed a reputation for reliability, well defined procedures and ‘cast iron’ guarantees of rights in land. Property formalization, land markets and land information systems are considered keys to increased economic development, social stability and environmental management (Williamson, 1997). Property formalization is also an important pillar of capitalist economies (De Soto, 2000). Rapid technological and social change, globalization and the increasing interconnectedness of business relations, with their legal and spatial consequences, however, have put a strain on long established cadastre systems and consequently they have been unable to adopt many useful new developments (Kaufmann and Steudler, 1998).

Recently it has been shown that weaknesses in land and property management can have major negative impacts on the economy. For example the United States’ subprime mortgage crisis in 2008 is considered to have been caused by failure to monitor and regulate mortgage activities (Labaton, 2008). However a study by the United States’ Federal Geographic Data Committee (FGDC) has said that Home Mortgage Disclosure Act (HMDA) data can provide a brief overview of a mortgage transaction’s status (Buhler and Cowen, 2010); local government data, at the particular parcel level, allows other information such as utility shutoffs, planning code violations and unlifted mail tied to that parcel to be revealed. Such parcel data makes it possible to relate disparate data and get a complete picture of an individual mortgage and related housing conditions, aiding the monitoring and regulation of mortgage activities. Also the same parcel data, with network enabled links to local government, can provide community context and engage those affected by mortgage crises (Buhler and Cowen, 2010).

Moving away from the sphere of economics, unsustainable development around the world has caused environmental modifications, such as climate change (United Nations Framework Convention On Climate Change, 2006). Land-parcel data has, when available, been used to help emergency responders in managing disasters, but it is suggested that a modern (*i.e.* multipurpose) cadastre can supply much of the data needed for the prevention of those disasters in the first place (Buhler and Cowen, 2010). Based on the framework already offered by cadastre systems, establishing multipurpose cadastre will greatly improve the services provided by such systems, particularly as society moves towards sustainable development.

Multipurpose cadastre is an integrated land information system containing legal (*e.g.*, burdens, rights), physical (*e.g.*, topography, man-made features, utilities) and cultural (*e.g.*, land use, demography) information in a common and accurate reference framework (Wood and Agency, 1999). The reference framework typically is established using rigorous geodetic and survey control standards, such as a state plane coordinate system. A multipurpose cadastre is made up of multiple independent, interrelated layers of the sort commonly used to describe the graphic component of a GIS database. Each layer contains a set of homogeneous map features registered spatially to other database layers through the common reference framework. Data are separated into layers based on logical relationships and the graphic portrayal of sets of features (Wood and Agency, 1999).

Multipurpose cadastre, by providing accurate spatial information, supports the sustainable development planning, land administration and land management needs peculiar to each country. A country may be able to achieve sustainable development planning, land administration and land management through re-engineering existing land administration and land management procedures, including the laws and regulations required to maintain cadastre’s historic roles of guaranteeing an individual’s unambiguous property rights, public common interest and a government’s land tax income. A country could therefore achieve sustainable development by using this re-engineered land administration and land management approach.

The concept of multipurpose cadastre emerged more than 30 years ago. Innovations relating to multipurpose cadastre first appeared in Canada and then Australia in works by McLaughlin(1975) and Williamson(1985); in the United States, by 1983, the 'Panel on a Multipurpose Cadastre' had introduced the characteristics of multi-functionality and service to society as the requirements of a multipurpose cadastre. The concept of a multipurpose cadastre, proposed by the US Panel on multipurpose cadastre is illustrated in **Figure 1-1** (Majid, 2001).

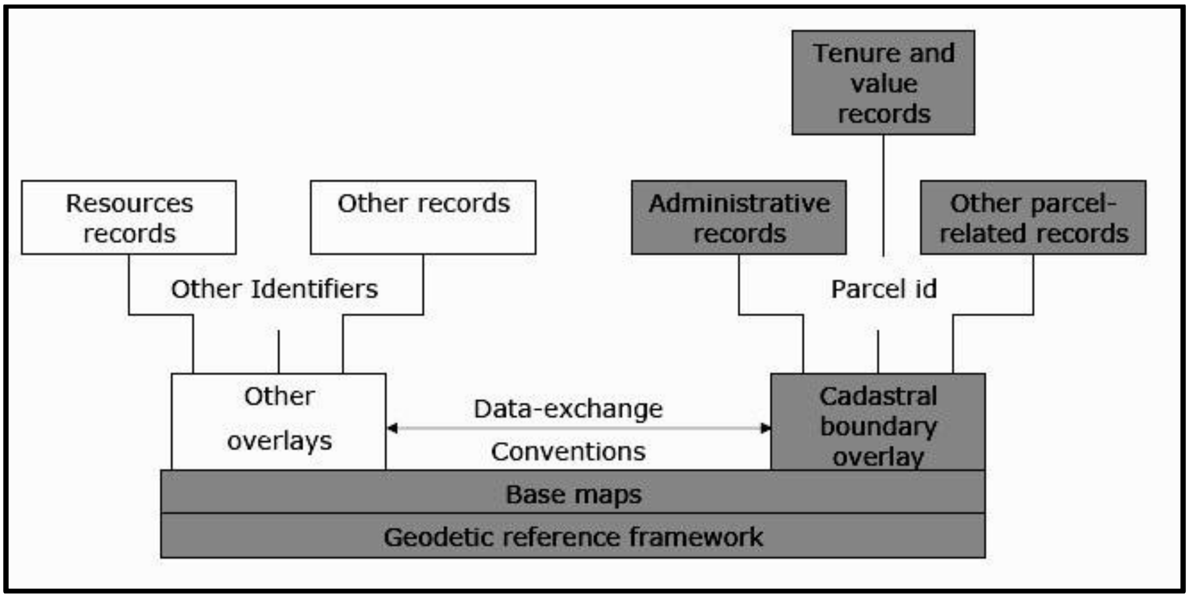


Figure 1-1 Component of multipurpose cadastre
(Majid, 2001)

In 1998, the 'Cadastre 2014' concept was presented by the FIG (Kaufmann and Steudler, 1998). 'Cadastre 2014' outlined the characteristics of a future cadastre system to meet the needs of both users and providers. This included all public and private land rights(Hirst, 2010). Cadastre systems were originally created to serve a legal or a fiscal purpose, or both, but they have evolved through time. In 1998, a survey by Kaufman and Steudler showed that cadastre data is used by many jurisdictions for purposes such as facilities management, base mapping, value assessment, land use planning, environmental impact assessment and *etc.*, as shown in **Figure 1-2**.

Purposes served by the cadastre

The Cadastre serves the following purposes:		legal basis exists: yes	no
legal purpose	27	27	2
fiscal purpose	27	19	7
facilities management	24	17	11
base mapping	26	17	10
value assessment	23	16	7
land use planning	25	14	11
environmental impact assessment	26	10	9
other	3	2	–

Figure 1-2 Examination of purpose served by the cadastre
(Taken from the report of Cadastre 2014 produced by Jürg Kaufmann and Daniel Steudler in 1998 based on questionnaire results from 31 delegates/corresponding members of the Commission 7 FIG)

The ‘Cadastre 2014’ concept anticipated that by the year 2014, the separation between the cadastre maps and other related registers (such as the register of properties, register of proprietors, register of charges, register of burdens, *etc.*) would be abolished (Kaufmann and Steudler, 1998). Since then, the cadastre functions in many countries have changed from only legal and fiscal to a multipurpose role which supports broad requirements. But, despite many attempts to define the role and contents of multipurpose cadastre, even within the ‘Cadastre 2014’ specifications, a consistent data model has not yet emerged (Wolfgang, 2001).

According to the renowned economics thinker, Hernando De Soto, since the beginning of mankind, we have invented representational systems such as writing, musical notation, double-entry bookkeeping - to convey what human speech could not easily or briefly convey. A cadastre title (or deed) is a representational system, conveying information about land and its assets and how to gain access to that land and those assets (De Soto, 2000). A cadastre title represents land and its assets in the form of map and a register record. A good representational system is needed to cater for the other purposes of cadastre.

A cadastre data model, in the context of a nation's spatial information, both incorporates the representational system that is a cadastre title and is an analytical tool for handling property and land information in one integrated homogeneous database. It can iintegrates all the information components of the multipurpose cadastre, such as a parcel and its amenities' geometries (points, lines, polygons), physical location (coordinates), attributes (rateable value for land tax, taxpayer, occupier, function, year of construction, material, *etc*.), unique identifiers, other parcel and amenity related records and legal status (individual or public rights, individual or public restrictions, form of tenure).

Around the world, there exists a variety types of land tenure, but these can be summarised as follows (Henssen, 1995).

The Anglo - American concept (feudal, hierarchical);

The Roman - French - German concept (allodial);

The Communist concept (state-owned, cooperative);

The Islamic concept (sharia);

The Customary concept (traditional).

Henssen also found that there exist different categories of title registration, which have the same principles but differ in procedures (Henssen, 1995).

The Torrens Group: e.g. Australia, New Zealand, Malaysia, some provinces of Canada, some parts of the USA, Morocco, Tunisia, Syria, etc.

The English Groups or French: e.g. United Kingdom, Ireland, France some Canadian provinces, Nigeria, etc.; and,

The German/Swiss Group: e.g. Germany, Austria, Alsace-Lorraine, Switzerland, Egypt, Turkey, Sweden, Denmark, etc.

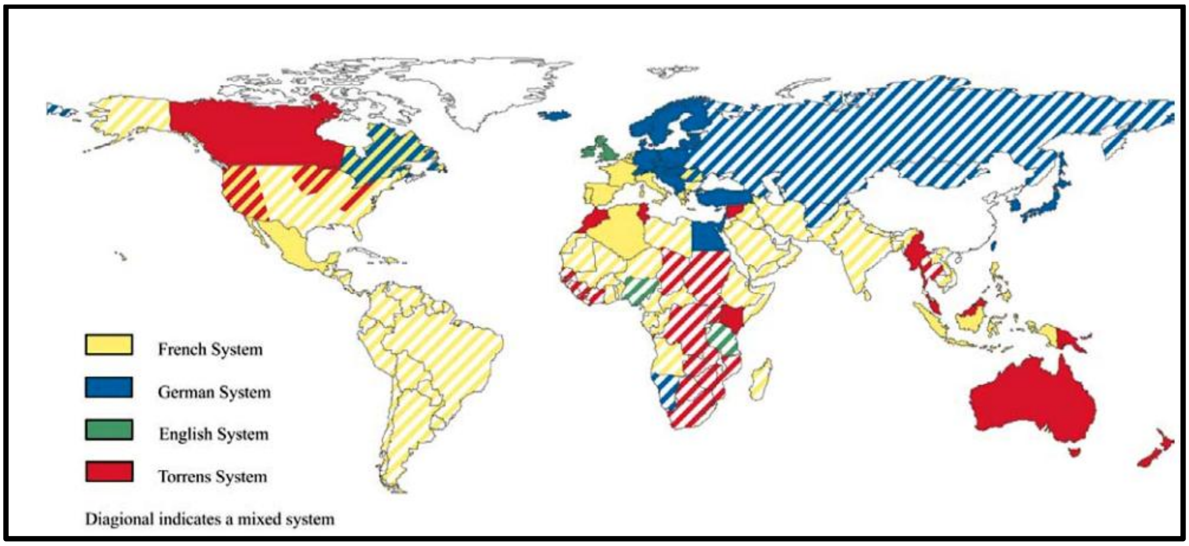


Figure 1-3 Cadastre mapping category around the world
(Enemark, 2005)

Referring to **Figure 1-3**, the mapping aspect differs between the three categories *i.e.* the English and French group makes use of large scale topographic maps, the German group of parcel-based cadastre maps, and the Torrens group of incidental survey plans (Henssen, 1995). These original tenure and title registration systems have a major influence on cadastre modernisation, such as multipurpose cadastre. A consequence of that is that every country will have its own unique solution to establishing multipurpose cadastre.

Briefly, what changes have so far been implemented in those countries currently addressing multipurpose cadastre implementation? The Netherlands and Switzerland do, now, both combine their national cadastre and Land Register under one authority Url:www.fig.net/cadastraltemplate (Williamson et al., 2012). Other countries, such as Germany still struggle to coordinate the role of states (Williamson et al., 2012) and the federal authority, all of which are involved in cadastre. Some previous government cadastre agencies in Germany have transformed into stated owned and semi private agencies as also happened in The Netherlands, but Hawerk (2005) has wondered whether it is still too early to forecast if these types of institution can provide a better service in the future.

As mentioned above, one of the main aims of multipurpose cadastre is to remove the separation of maps from the cadastre registers, and different organisational forms can achieve this.

Establishing collaboration between the organizations involved and budget limitations are the two main constraints that slow down effecting modern cadastre. To overcome this some state governments in the USA, for example, aim for cost recovery after the system is established (Folger, 2011). Perhaps privatization, or semi-privatization, of the organization maintaining and managing a system may be beneficial, as suggested in 'Cadastre 2014'(Kaufmann and Steudler, 1998) and as has happened in The Netherlands where The Netherlands Cadastre is an organisation with a private-sector management set-up (Nederlands Kadaster, 2009).

In the 1990s much cadastre reform took place around the world. Many countries started to introduce modern ICT to the process of producing cadastre maps. LIS (Land Information Systems, an alternate name for GIS, but one focused on cadastre) were being implemented, and some very large investments were made by many countries at this time. Unfortunately not all systems were successful. This may be due to different factors including system complexity, huge amounts of data, integration of different system technologies, out-dated technology, separate stand-alone system and so on (Onsrud, 2012).

In order to create a *parcel* based multipurpose cadastre system, organizations involved in many countries have introduced a fully automated cadastre survey, incorporating GPS survey methods, digital (*i.e.* coordinate based) cadastre and global or geocentric coordinates, to create an accurate cadastre database. After 30 years, countries like Australia, Malaysia, The Netherlands and Germany have successfully created an accurate digital cadastre database in some of their states or districts.

Countries such as Cyprus have resurveyed their lot parcels entirely (Dimopoulou. et al., 2003) but most of the countries in the world could not afford to do this, due to budget constraints. Instead many countries have chosen to set up precise control networks all over the country and to re-adjust their cadastre using the precise control network points' values. However a very dense control network is needed for this method to be successful.

Many countries have established a Spatial Data Infrastructure (SDI), with cadastre data as one layer of this. But, an SDI is only a platform to share data; integration into one homogeneous, seamless database cannot be achieved this way. In this context homogeneity and seamlessness are exhibited through data integrity (*i.e.* within the system different entities not having the same identifier, or the same entity not holding contradicting attributes) and consistent coordinates (*i.e.* the system entities, including when split by 'tile' boundaries, not being represented by different coordinate frames). Thus, even with a recognized SDI, harmonizing different agencies has become a critical issue, and consequently data do not often connect a) spatially, b) in terms of attributes, or c) topologically and are, in effect, all spaghetti.

In the early years of this century, EU members took an initiative to develop the Infrastructure for Spatial Information in Europe (INSPIRE). This offered guidelines for spatial data sharing, including cadastre parcel data, for purposes of environmental monitoring. Most of the EU members have adopted the guidelines to develop a modern parcel based cadastre according to the data specifications in INSPIRE. Most EU countries have prepared legal acts concerning INSPIRE, submitted to their parliaments (Rizzi, 2008).

Currently in Malaysia, the office of each a) individual sector of a state's administration, b) state's Land and Mineral Office (PTG), c) district's Land Office (PTD), d) city council and e) district council builds and accesses its own specialized registers and databases with their contents reflecting their office's competencies and responsibilities. However, the present state of ICT can produce better LIS delivery systems for users by connecting every single public register database in government agencies.

A cadastre data model provides data on ownership and position and thus, if appropriately designed, could become the backbone of the whole federal information system for Malaysia, supporting homogeneous and seamless access to spatial data, by public servants and the private sector.

Economic activities in Malaysia are shifting from agriculture to industry. Furthermore the density of population in Malaysia is increasing. Thus the land near cities such as Kuala Lumpur, Johor Bahru and Penang has to be carefully managed. Existing cadastre systems which only cater for a single purpose (i.e. Land Registration) are not able to provide effective solution and sufficient information for sustainable development, and this has led Malaysia to plan for upgrading its cadastre system so it can be used for the careful utilization of land, as well as other resources. As "land is an important part of nature and is the basis for nutrition, housing, energy production, resource exploitation, leisure activities, waste disposal, in short the maintenance and survival of humankind" (United Nations, 2005), so a sound multipurpose cadastre data model is a potentially vital contributor to sustainable development.

This investigation will focus on developing a new cadastre data model taking into account organizational requirements, and this investigation will also investigate legal requirements, as an additional focus.

This new model will be suitable for implementing a multipurpose cadastre in Malaysia following the 'Cadastre 2014' guidelines, which emphasized Legal Land Objects stored in different independent layers.

The definition of Legal Land Object depends on different laws in different jurisdictions. The rights (private and public) in land can refer to objects on the surface and objects beneath and above the surface. These objects include buildings, planning zones, national park boundaries, flood zones, etc, as well as land parcels

The development of this new data model should also incorporate ideas from those countries which have implemented, at least somewhat successfully, aspects of multipurpose cadastre.

Some different structures of data model will be investigated and the eventual new data model should be implemented in a multilayered digital cadastre database, with layers featuring: the land parcels; utility assets (such as gas pipe lines); land use; building, etc. This would be one homogeneous, seamless spatial database and, due to its contents, be a multipurpose cadastre.

Such a multipurpose cadastre should provide information to support land related management decisions taken at any single location, within Malaysia. The data would come from a number of organizations, including those supplying land and property information, the roads and traffic authorities, local government authorities and councils, public-private utility corporations and professional surveyors and lawyers, thus requiring the public and private sectors to work closely together. The result would be a digital geospatial model, rather than just a map, and would provide a very complete representation of the land. By incorporating textual attributes with graphic datasets, the separation of (graphic) maps and (textual) registers will be removed.

Besides technical constraints, legal and organizational aspects also affect the architecture and infrastructure to be implemented. More efficient data exchange with e-services, integrated processes within administration and self-service in updating may result in more licensed data providers or certified processes with direct access to the basic data base. This is the future service-orientated vision of a multipurpose cadastre. Organizational interoperability, as well as quality assurance, is required for cadastre and land-use planning (The United Nations Economic Commission for Europe, 2005).

1.2 Developments so far, in Malaysia

JUPEM (Jabatan Ukur dan Pemetaan Malaysia or The Department of Survey and Mapping Malaysia) is one of the leading organizations in developing multipurpose cadastre in Malaysia.

Within the 9th Malaysia Plan under a project named eKadaster, JUPEM revamped the old process of preparing title plans. The preparation time of title plans and the issuance of final title have been reduced from two years to less than two months. The tedious process of preparing final title plans has been replaced by eKadaster, a fully automated system from field to office. eKadaster is integrated with other systems such as eTanah (LIS system at the Land Register Office), eLJT (online task submission at the Licensed Land Surveyor Board), JUPEM internal task application modules and the JUPEM Geoportal. The eKadaster project has benefitted clients such as Licensed Land Surveyors, the State Land and Mine Offices, the Land Office and departmental staff who can now work beyond their office confines. The departmental organizational structure has changed and application modules are web-enabled, allowing staff access to work from anywhere, 24 hours a day.

For the eKadaster project, JUPEM has generated a homogeneous and accurate National Digital Cadastre Database or NDCDB, of cadastre parcels, for the whole country, except for Sabah and Sarawak. JUPEM has also created a new database as shown in **Figure 1-4** for strata title (i.e. parcels on elevated building floors), stratum title (i.e. sub-surface parcels) and marine parcels (i.e. on the seabed in territorial waters) called the Strata, Stratum and Marine Database or *Pangkalan Data Ukur Strata, Stratum dan Marin* (PDUSSM). These are all parcels which are not satisfactorily located by a boundary depicted on the Earth’s surface.

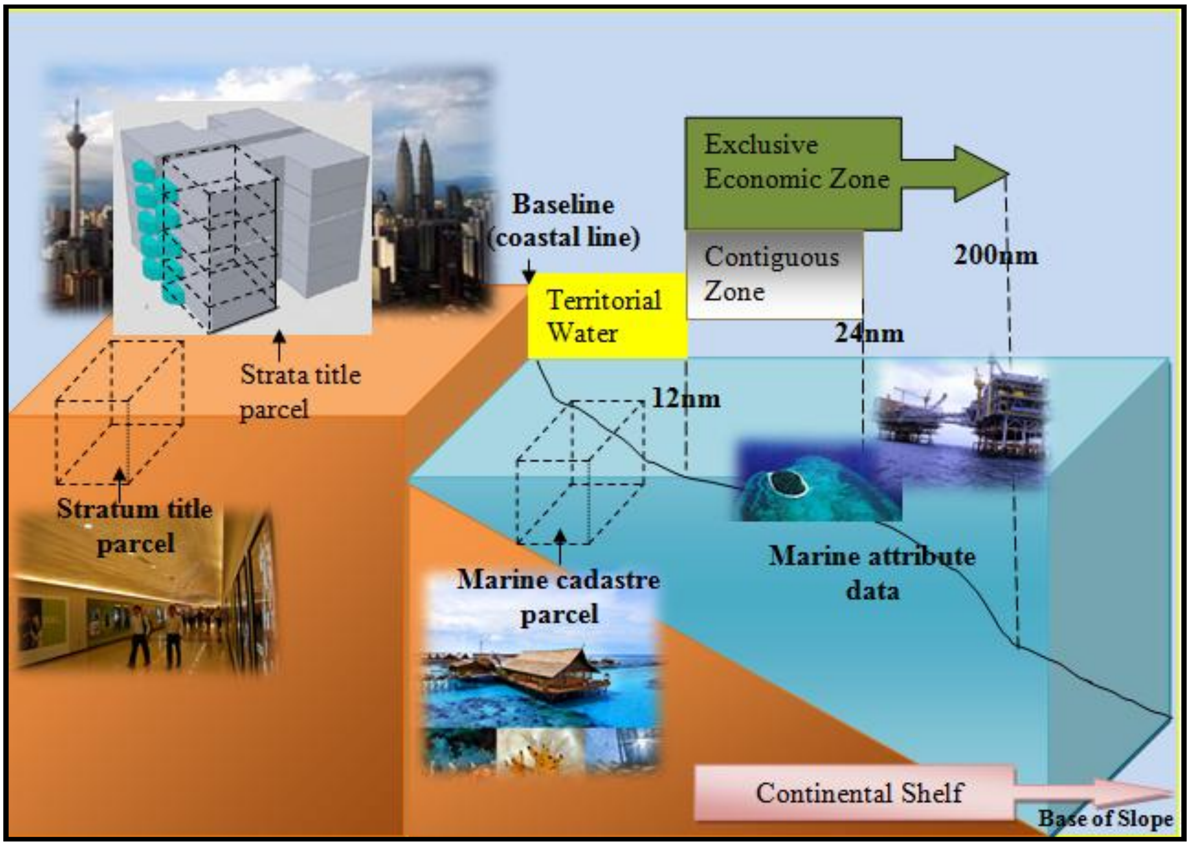


Figure 1-4 Illustration of strata, stratum and marine parcel
(nm = nautical mile)

Through the implementation of the eKadaster project, JUPEM has successfully repopulated the coordinates of the Digital Cadastre Database replacing plotting coordinates with field accurate absolute coordinates.

JUPEM outsourced the establishment of a coordinated control infrastructure (CCI) using GPS throughout the country in the field and tied the CCI points to parcel boundaries. The new Digital Cadastre Database emerged by using least squares adjustment to readjust the parcel coordinates using these CCI points. The Malaysia Geocentric Datum (GDM2000) which was launched in 2002 is used to produce the new geocentric coordinates, aiding migration from the old coordinate system to the new. Furthermore the new grid coordinates for parcels are based on a Cassini Geocentric system with its origin at the centre of the mass of the Earth, whereas the old coordinates were based on a Cassini Soldner projection which has a different origin for every state in Malaysia. Apart from that, JUPEM has introduced new fully automated field survey procedures combining GPS (RTK) and total station work, to be practiced by both government and licensed surveyors. An online task submission module for licensed surveyors and an automated data quality checking module were also designed in this project. **Figure 1-5** shows the whole process of repopulating the National Digital Cadastre Database (NDCDB) in the eKadaster project.

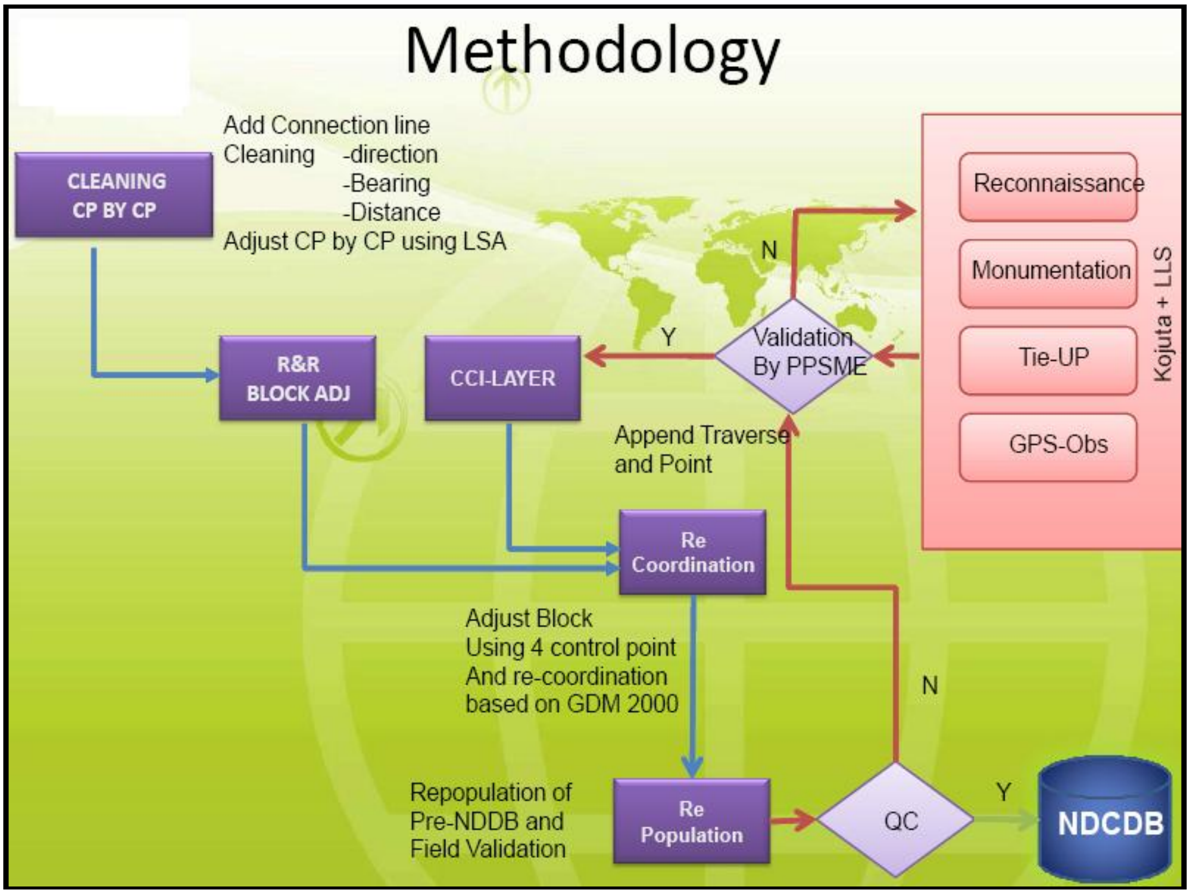


Figure 1-5 The methodology of repopulation of the NDCDB in eKadaster
((Teng, 2009a) (CP : Certified Plan; R & R = Re-Coordination & Re-Population; CCI = Cadastral Control Infrastructure; LSA = Least Square Adjustment; PPSME = CCI Working Portal Administrator; LLS = Licensed Land Surveyor; QC = Quality Checking)

eKadaster is part of Malaysia's plan to build a large scale spatial information system by strengthening the spatially enabled (survey) technology. The next step is to build a spatially enabled platform which involves multipurpose cadastre, the Utilities Survey Database or *Pangkalan Data Ukur Utiliti* (PADU), National Geospatial Data Centre (NGDC), the State Geospatial Data Centre (GDC) and the Local Geospatial Data Centre (LGDC) (Teng, 2009b).

1.3 Future strategic planning, in Malaysia

Continuing from the eKadaster project, under the 10th Malaysia Plan, JUPEM has proposed a multipurpose cadastre project to be executed in the five-year period from 2011 to 2015 to create a platform for large scale spatial information systems, as shown in **Figure 1-6**.

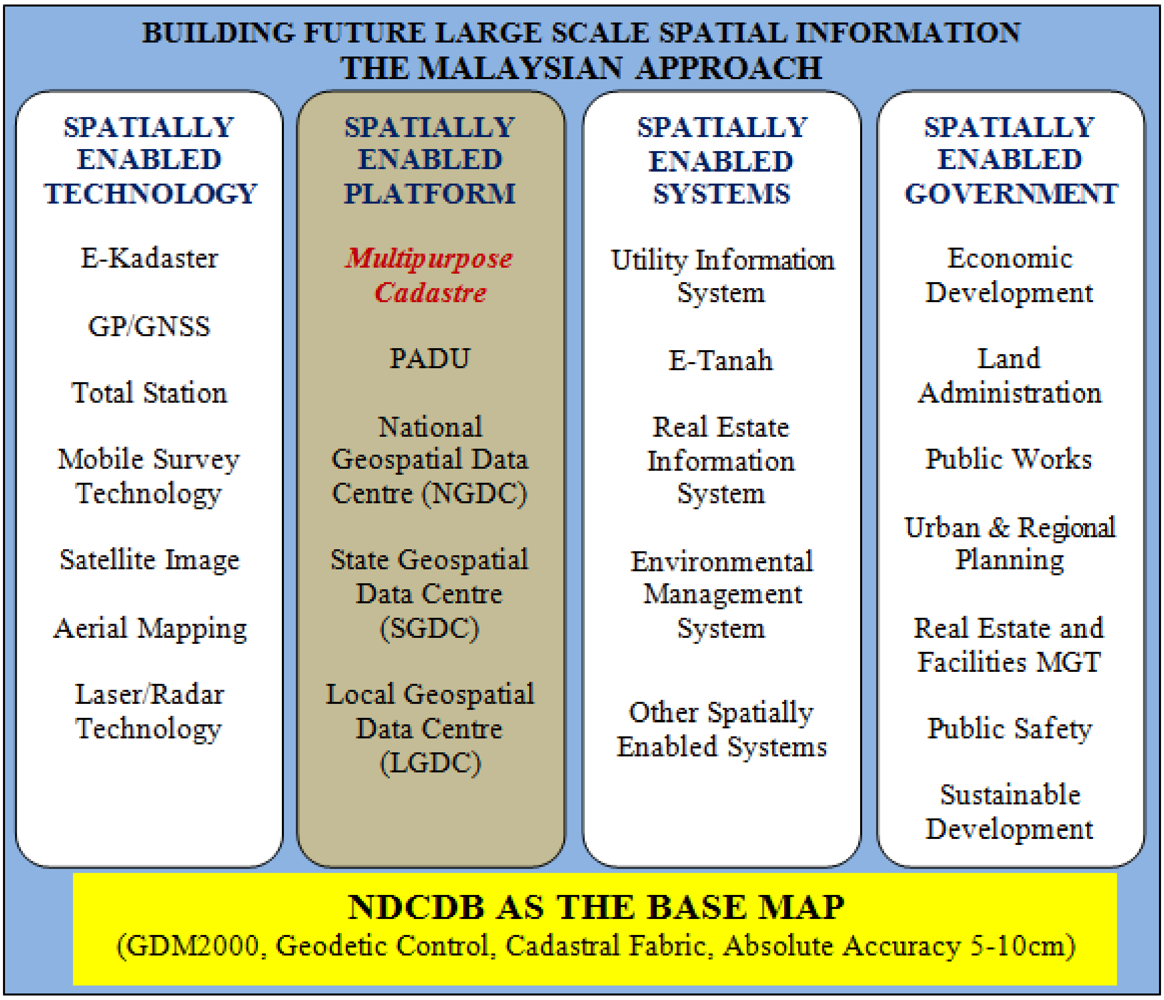


Figure 1-6 Malaysia's future plan for building large scale spatial information (Teng, 2010)

The strategic objectives of Malaysia's multipurpose cadastre project follow.

1.3.1 Strategic Objective 1-to strengthen the digital cadastre database (NDCDB)

To strengthen the digital cadastre database (NDCDB) by upgrading over 300,000 lots of third class or demarcation survey title. Before 2002, which saw the new Cadastre Survey Rule 2002 come into force, Malaysia had three classes of cadastre survey (a. 1st class with a 1 part in 8000 closure; b. 2nd class with a 1 part in 4000 closure; and c. 3rd class with a 1 part in 3000 closure) and demarcation survey title (in the Malaysian context a demarcation survey is a survey executed without a traverse and involving simple boundary demarcation carried out to identify land in the field; this approach was in use before the establishment of the National Land Code, 1965).

Until 2009, there were more than 7.9 million parcels or lots in the digital cadastre database, and there are still about 300,000 lots recorded under third class or demarcation survey quality, which have already been given title, but have not been incorporated into the digital cadastre database. To achieve the first aim of the project, JUPEM proposed outsourcing the work of the resurvey of the 300,000 lots to the private sector (using Licensed Land Surveyors) to use survey accurate methods tied to digital cadastre database points in the field. QC procedures would be designed to ensure the quality of the captured data.

1.3.2 Strategic Objective 2-to apply SOA concept in multipurpose cadastre system

To upgrade the data input and output using an SOA (services oriented architecture) approach.

The project also aims to upgrade the data distribution system using the SOA method.

JUPEM has proposed upgrading its provision from product oriented to services oriented which is shown in **Figure 1-7**.

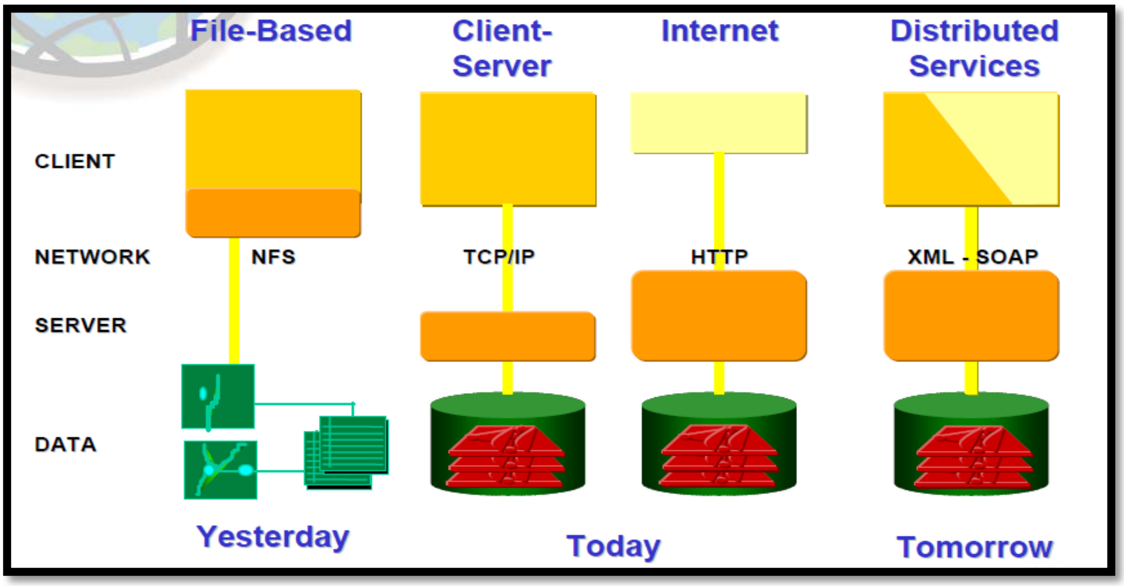


Figure 1-7 The evolution of Geospatial data serving
(Abdul Kadir, 2011)

The planned accuracy of the parcel based multipurpose cadastre database (PDMK) is 5cm for the land area. PDMK is expected to benefit the whole of Malaysia, that is its organizations and communities. It will be a tool that can be used to deliver specific services to users through service oriented architecture (SOA) procedures.

The SOA approach to user interaction must allow a variety of services to be offered by the captured spatial data. The services can be applied, issued and abstracted by users and stakeholders through a single, standards-based PDMK interface as shown in **Figure 1-8**.

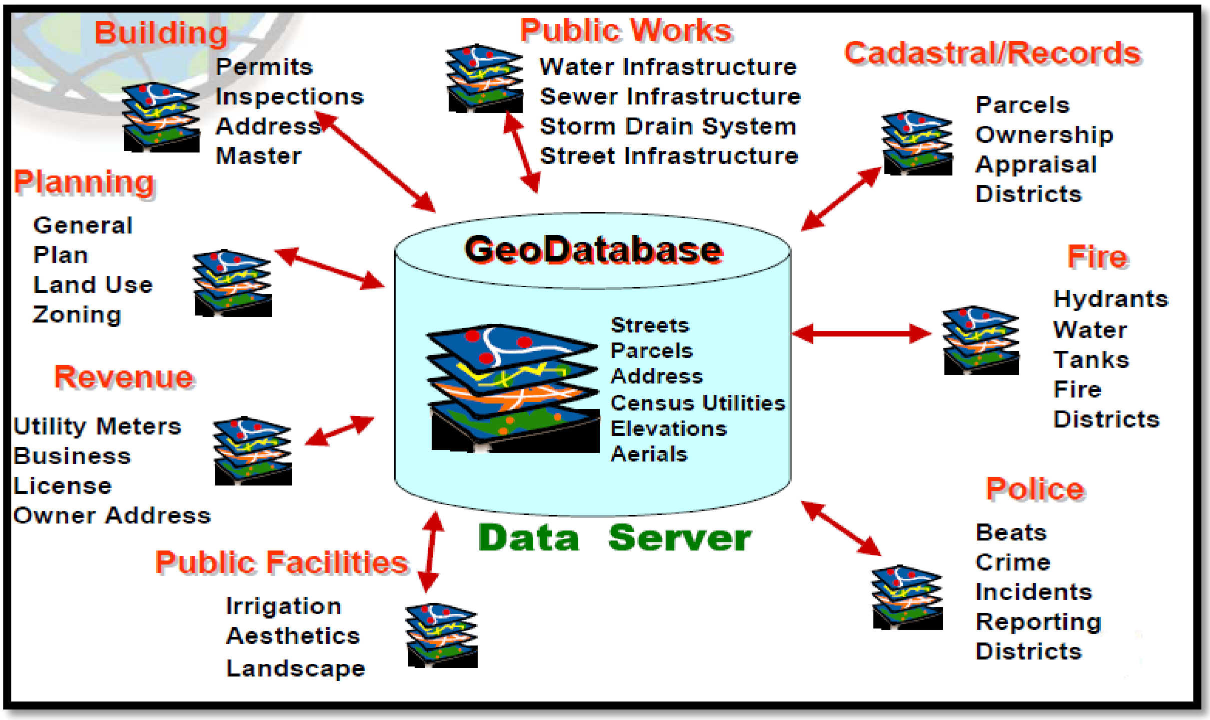


Figure 1-8 Diversity of MPC data layers
(The diversity of the data layers that can be used to abstract information from the Multipurpose Cadastre Geodatabase (PDMK) (Abdul Kadir, 2011))

For example, underground utility information such as gas pipes, sewerage pipes or electricity cables can be made available to support a high-value real estate market. Another example is demographic information, urban morphology and economic status which could all be used in the strategic planning for the Mono Rail route planning (Khairiah, 2008). 3D Building footprints, as shown in **Figure 1-9** (Teng, 2009a), captured through the multipurpose cadastre, will allow the location and ownership information to be compiled together and used by people whether they have the latest, easiest or most affordable GIS technology.

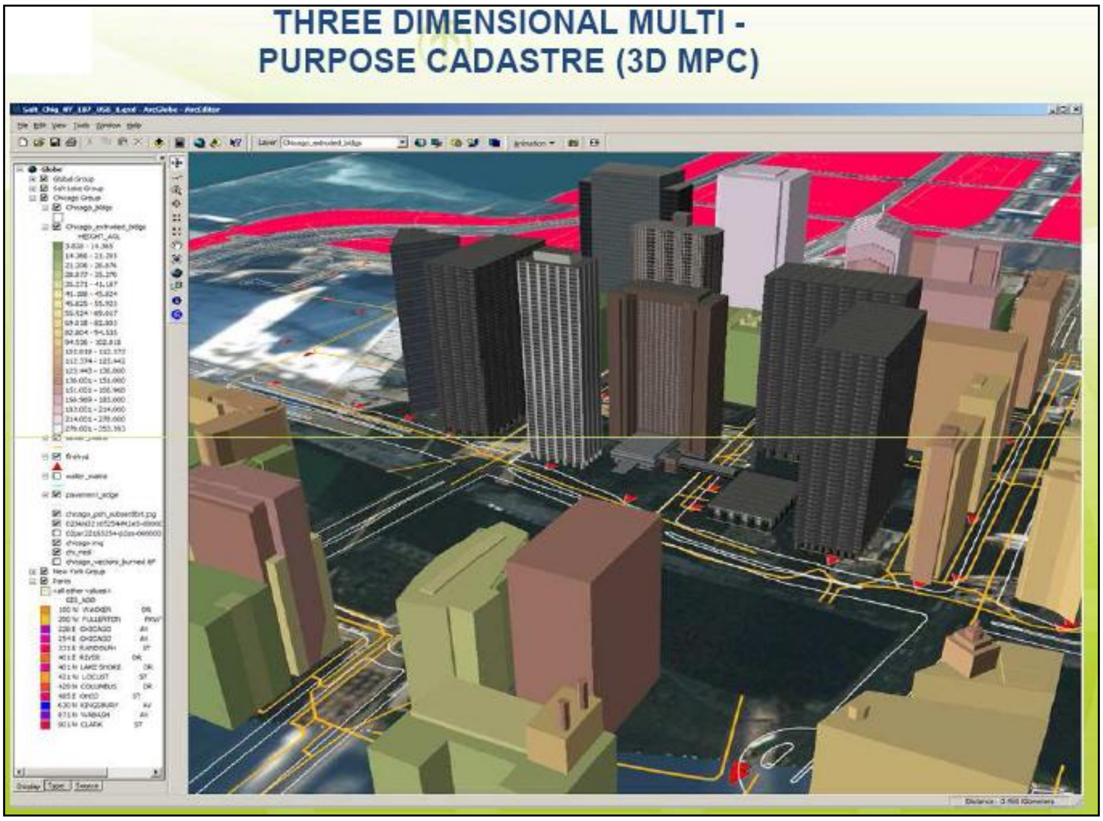


Figure 1-9 The 3D building features and multipurpose cadastre data
(showing building footprints extended to original shape and structure, which contain each floor's parcel (Teng, 2009a))

1.3.3 Strategic Objective 3-to develop marine cadastre

JUPEM will continue to complete its Strata, Stratum and Marine Database (PDUSSM) by focusing on marine elements, which involves the need to establish marine boundaries, registration and title and the use of national or international law. Considering 3D or 4D coordinates and the invisible boundaries of marine parcels, appropriate use of existing technology will aid visualising the ownership of a marine parcel in the 11th Malaysia Plan (2016-2019) (Abdul Kadir, 2011).

JUPEM will gather spatial and attribute information related to the marine cadastre in the area from the base-line (low water mark) to the edge of Malaysia's continental shelf.

In line with the development of a 3D marine cadastre, JUPEM has also planned to establish active permanent RTK-GPS control stations on suitable Malaysian islands and to establish passive RTK-GPS control stations on all islands and national entities. After the establishment of this marine infrastructure, JUPEM has planned to carry out a seabed topographic survey, and a shipborne and airborne gravity survey in Malaysian waters to develop a precise marine geoid model having 5cm accuracy. The data will eventually overcome current problems, as shown in **Figure 1-10**, and create a gravimetric geoid representing a seamless vertical (height) datum for land-marine areas as shown in **Figure 1-10** (Teng, 2010).

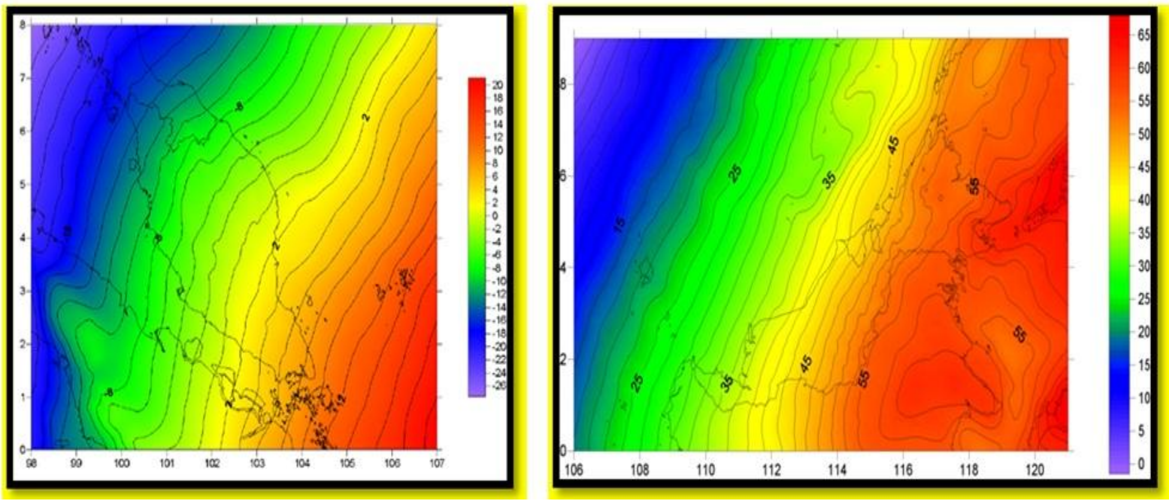


Figure 1-10 Current geoid models for Malaysia (land and sea)
(Yet to be made seamless (Forsberg, 2008))

The development of the marine component of PDUSSM shall be implemented in phases, focussing on marine concessions that have already been granted permits or leases (sand leases, aquaculture leases etc.), state or local territorial waters (except for Sabah and Sarawak) and federal territorial waters included in the Marine Park Gazette (i.e. the collection of marine reserves). The development of the marine component of PDUSSM will focus on metadata, to ensure that the quality of the datasets obtained and processed for PDUSSM is known.

For example the creation of a land and sea interface through the multipurpose cadastre will clarify ambiguous information, especially in the Coastal Zone, where the mapping problems of the coastal zone have been neglected because of the overlapping factors of the power and authority of several agencies as shown in **Figure 1.11**.

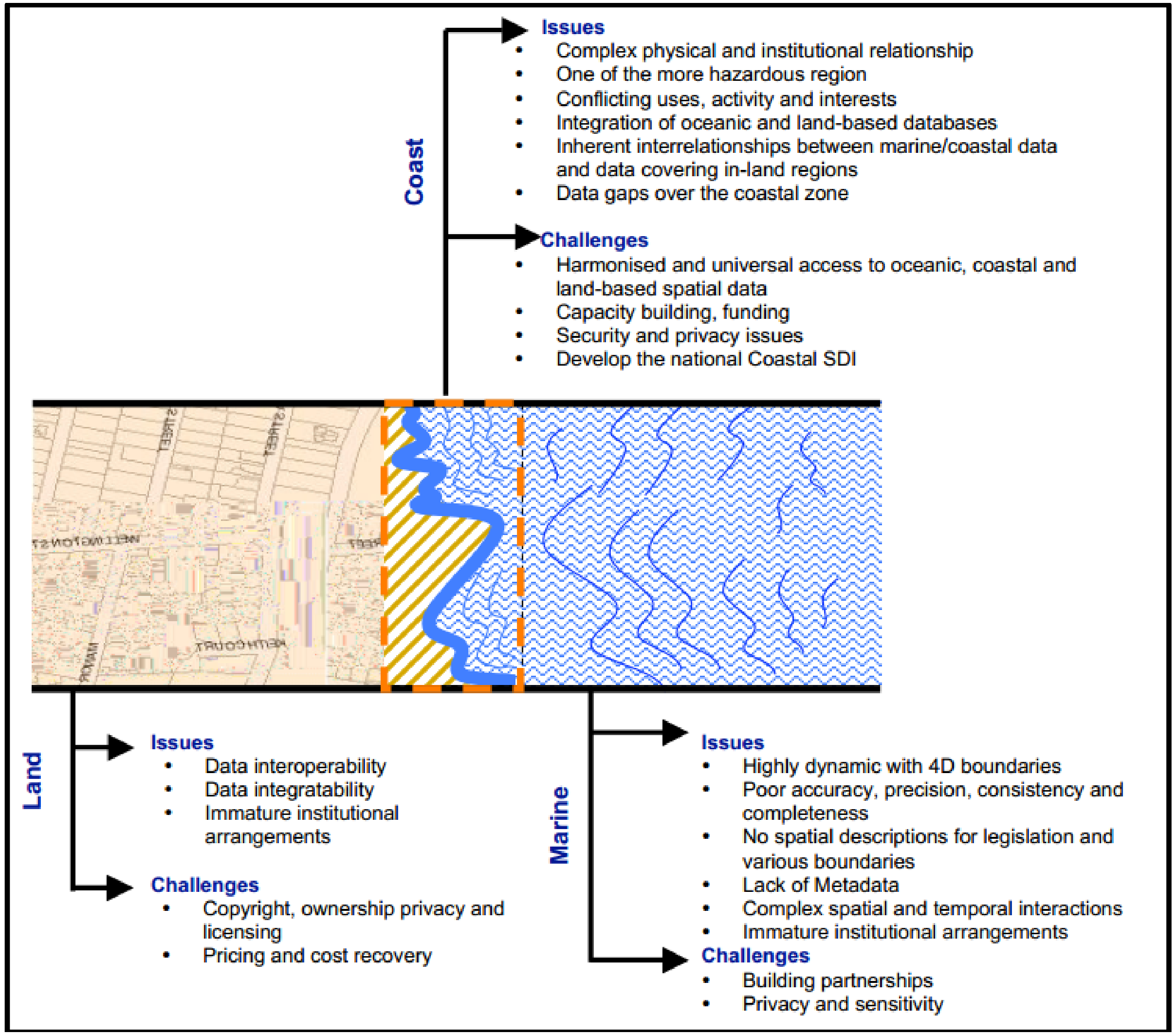


Figure 1-11 Land and sea interface problem
(The problems that arise in the land-sea interface today that can be addressed through the multipurpose cadastre (Rajabifard et al., 2008))

The Customs Department, the Marine Park or the National Maritime Enforcement Agency can use the PDMK to identify cases of encroachment, the misuse of land, the exploitation of nature, etc. Thematic analysis of the local population for the purpose of planning and property development, etc., can be carried out by Local Authorities, property companies and local or foreign investors

1.3.4 Strategic Objective 4-to develop PDMK

To develop a Multipurpose Cadastre Geodatabase or *Pangkalan Data Multipupose Kadaster (PDMK)*.

After the completion of an accurate digital cadastre database and PDUSSM, the Multipurpose Cadastre Database (PDMK) will be developed in phases, with the first phase being implemented in the Federal Territory of Kuala Lumpur (WPKL) and Putrajaya as shown in **Figure 1.12**. The Utilities Survey Database or *Pangkalan Data Ukur Utiliti* (PADU) will also be initially developed in these areas. This area also has geoid model of 1cm accuracy (Height Modernization System - HMS) determined by JUPEM in Klang Valley in 2008. This precise geoid model can assist in forming 3D coordinates easily when combined with RTKnet survey technology during cadastre field survey.

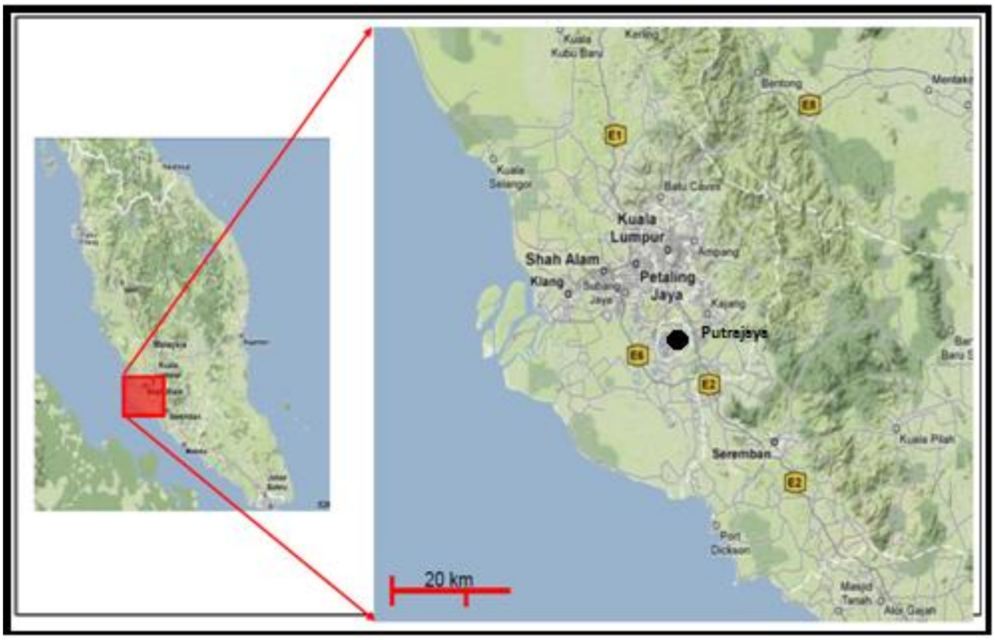


Figure 1-12 The area of the MPC pilot project
(The priority area for developing the Multipurpose Cadastre Database (Teng, 2010))

Multipurpose cadastre field survey should use survey accurate measurements based on digital cadastre database coordinates developed in the eKadaster project. It shall focus on obtaining spatial information of man-made and natural features such as buildings, components of transport networks and hydrography in WPKL and Putrajaya. The core datasets in the PDMK are expected to be as follows (Teng, 2010):

- NDCDB (including PDUSSM);
- building footprints;
- transportation;
- hydrography;
- street addresses; and,
- geonames.

Meanwhile, other data sources that meet the desired accuracy of PDMK will be obtained either by data sharing among the sections in JUPEM or from other government agencies. The relationship between datasets in the formation of PDMK is shown in **Figure 1.13.** Quality Checking (QC) of outsourced data or from other government agencies will be conducted to ensure that the standards of PDMK are met.

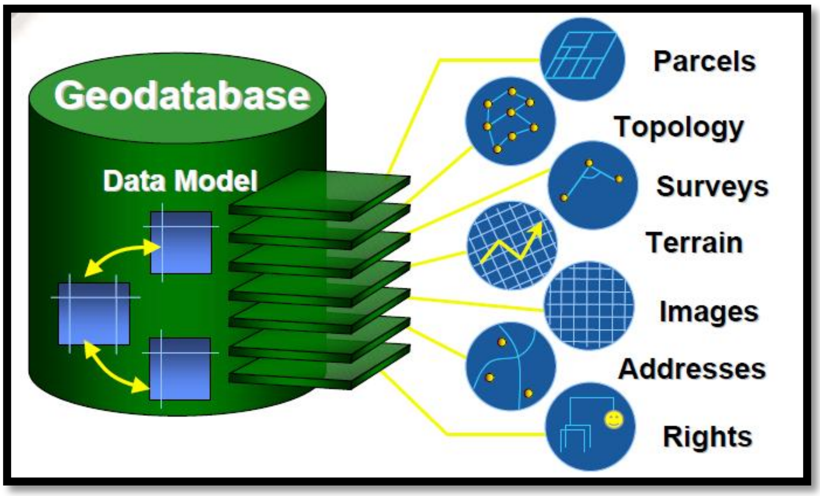


Figure 1-13 The relationships of MPC data
(In the formation the of Multipurpose Cadastre Geodatabase (PDMK))

PDMK will support spatial data interoperability of departments of the Malaysia government and create a spatial database which will eventually encourage the development of a spatially enabled society.

Information served from a PDMK should assist government in the decision making process both in terms of management and administration as the country moves towards sustainable development.

JUPEM has currently created one GIS layer containing spatial information augmenting the digital representation of the parcel boundaries held in NDCDB. This layer contains data on roads, hydrography, administration boundaries and textual information from state land offices concerning lot parcels. This layer is managed by the GIS Layer Management System (GLMS) and the PDMK will allow integration of this GIS layer with the cadastre data held in the NDCDB.

Themes such as the distribution of wealth, population, health and flood-prone areas can be used to further the national spatial data infrastructure (or NSDI, but named MyGDI in Malaysia, see url: www.mygeoportal.gov.my). The contribution to the Global Spatial Data Infrastructure (GSDI) will be made following significant completion of MyGDI and further promote the development of local, national and international compatibility.

GSDI is a concept driven by the Global Spatial Data Infrastructure Association with volunteered contributions from organizations, agencies, firms, and individuals from around the world. The purpose of the organization is to promote international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic, and environmental issues of pressing importance (Global Spatial Data Infrastructure Association, 2011).

1.3.5 Strategic Objective 5-to upgrading of survey and IT software and hardware

To strengthen the infrastructure of the survey system by updating technology and hardware specifications for existing survey instruments and software.

1.4 Aims of the research

This research (or investigation) into multipurpose cadastre will focus on creating a cadastral data model, the development of multipurpose cadastre Service Oriented Architecture (SOA), and investigating MPC's organisational and legal requirements.

The cadastral data model (i.e. External, Conceptual and Logical Data Models) will be based on existing data and user needs. Three feasible data models exist as follows:

Type 1: Spatially-referenced data model based on Legal Land Objects, processed in independent layers, shown in **Figure 1-14**;

Type 2: Land Parcel based data stored in a Relational Object oriented database with high geometric accuracy;

Type 3: Hybrid data model which integrates Type 1 and Type 2 data models.

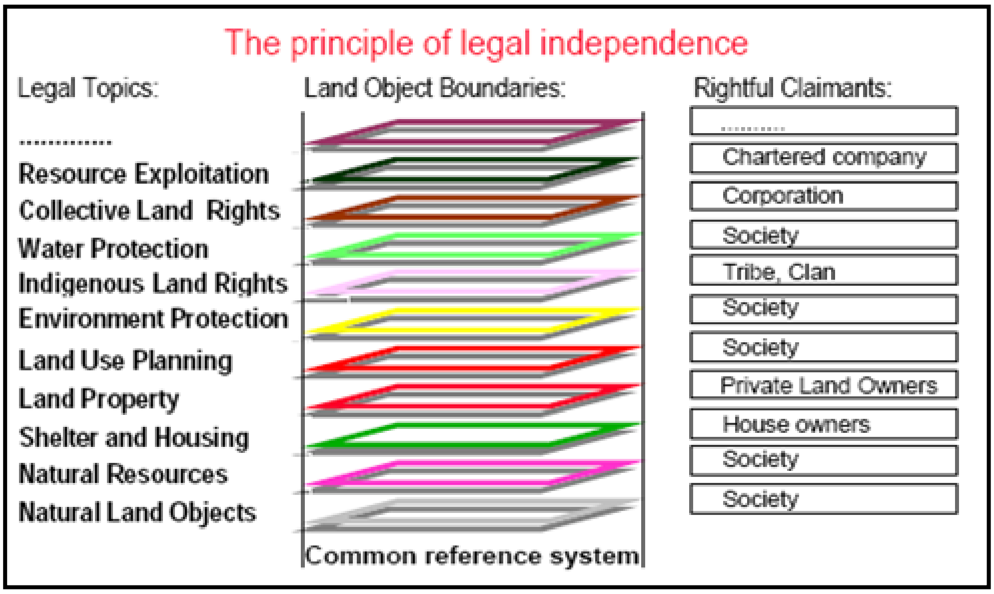


Figure 1-14 Data model type 1 concept
(Legal Land Objects are processed in independent layers(Kaufmann, 2002))

Type 1 structure permits immediate application, it is not necessary to rearrange the information. A new layer of legal objects (e.g. Flood Protection Zones) can be simply added. If a law is repealed, the layer can be removed without affecting other layers. Within Type 1, considering buildings as legal land objects, there are three solutions to their modelling:

1 to link the buildings directly to their parcels as attributes;

2 to link the buildings to their parcels as objects/entities; and,

3 to consider the buildings as individual objects, not linked directly to their parcels.

The link between parcel and building in solution 3 is based on the fact that the two objects can be detected as spatially close (**Figure 1-15**).

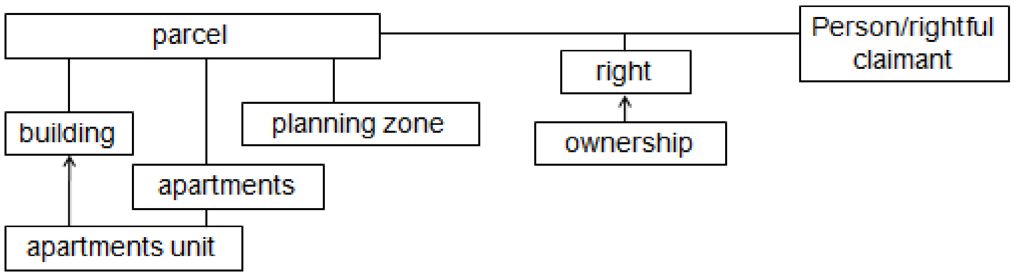


Figure 1-15 The schema of Type 1, solution 3

Type 1 is considered low cost but layers are not linked by accurate geometry which may cause boundary conflict. Building a very accurate parcel database, new legal land objects can be generated from parcel boundaries (**Figure 1-16**).

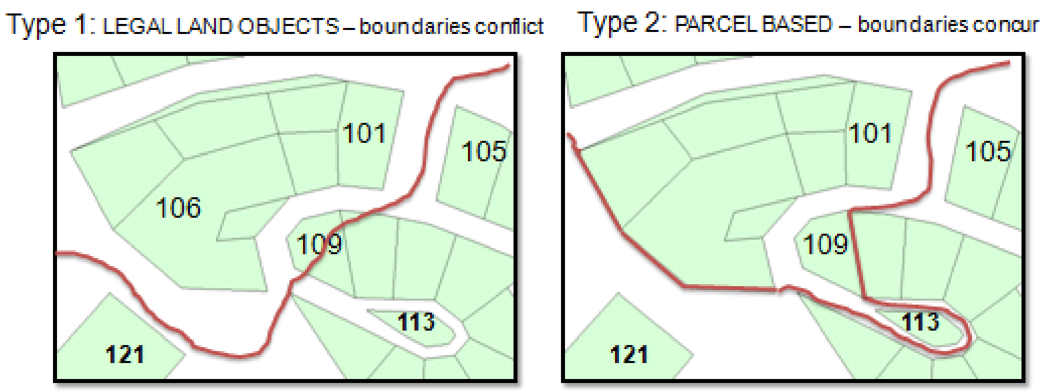


Figure 1-16 Comparison between data model type 1 and type 2

A Type 2 parcel based digital cadastre will provide the geospatial reference for all other data sets. Derivation of transformation parameters for these other data sets has already commenced, in JUPEM, using a Least Squares procedure. Misregistrations can be mitigated using survey accurate methods.

This investigation will focus on developing a Type 2 data model which will:

- comply with the ISO 19100 series of geo-information standards, including 'Rules for application schema' (ISO19109), 'Spatial schema' (ISO19107) and 'Geography Markup Language' (ISO19136), and also the Malaysian Standard Spatial Schema (MS1759) Feature and Attribute Codes;

- contain metadata for each data item following the ISO/TC 211 standard and the template developed by MaCGDI (Fauzi Nordin, 2006).

- use GDM 2000 (the Geocentric Datum of Malaysia) ;
- provide all information entities with a unique parcel identifier;
- offer an optimised SOA (Service Oriented IT Architecture);
- be a robust system, easy to update and maintain; and,
- store data in an Object Oriented Relational Database (Oracle) .

Not all legal land objects can be generated from parcels, e.g. mineral rights and habitat zones, and other factors influencing data model design such as user demand, budget, population, land use, land potential and land conflicts will also be considered.

Organisational issues introduce major constraints; the financial and technical issues are minor. In Malaysia, with 13 states, 3 federal territories, other government and private entities all being potential producers of parcel data, the organizational issues are complex. Overcoming organisational boundaries even among federal agencies has been difficult.

In the context of this investigation procedures and standards will emerge, which will allow each level of government (city, state and federal) and the relevant private sector organizations to access the multipurpose cadastre in an efficient and appropriate manner. Processes for gathering data, storing data and distributing data as required by users will be established. The design of the user facing processes (between different organizations, in both government and private sectors) will benefit from the application of SOA techniques.

Finally, PDMK is expected to have an impact on existing law related to land, such as the National Land Code, and this must be considered.

All of this is a challenge, but the intention is to familiarise the author with the problems, to better support his colleagues in their endeavours to create the PDMK, particularly in issues related to user support and SOA.

1.5 Objectives of research

The objectives to be met by this investigation are presented in the following five sections.

1.5.1 To create a MPC database data model

There is a need for a data model both understood at the external level by decision makers and satisfying their needs, likewise at the conceptual level by operators, and at the logical level by database administrators. This will avoid inconsistency and time wasting at planning and regulatory levels through on-line access to cadastre information. The multipurpose cadastral data model to be created will support the provision of data for decision making in the development process. Because of existing investments, the data model will be created for implementation within Oracle – a commercial database management system having graphic capabilities and will enable the supply of spatial data to dependent tools including ArcGIS, MapInfo and AutoCAD.

1.5.2 To investigate the organizational requirements of a MPC system

Established cadastral systems enjoy a reputation for reliability. This must not be lost; a multipurpose cadastre system requires standardised organisational data flow procedures for: i) gathering data; ii) importing data into and storing it within the database; and, iii) distributing the data as required by the users. But established cadastre systems have not adapted easily (or even well) to new developments. Currently in Malaysia, the government is developing MyGDI (url:www.mygeoportal.gov.my) to enhance awareness of geospatial data availability and to improve access to geospatial information by facilitating data sharing among participating agencies. Procedures, guidelines and standards for the multipurpose cadastre system organizational data flow will be developed taking into account the existing MyGDI environment.

1.5.3 To investigate the legal requirements of a MPC system

Malaysia's cadastre system is based on a registered title and a linked lot parcel map. Civil law protecting registered rights on a lot parcel are effective, but protection could be strengthened by addressing other rights on objects in the lot parcel, for example buildings, trees and sewers. Although cadastre data are used for facilities management, value assessment, land use planning, environmental impact assessment, etc., legal support rarely exists for non cadastre purposes. Further, although historically responsibility for cadastre lay with the states, much now lies with the private sector even if some of the strategic planning aspects should be in the hands of central government. Consequently there may be gaps and overlaps in the relevant legislation.

This investigation will consider the regulations in Malaysia's National Land Code 1965 and suggest where amendments are needed in order to support the multipurpose cadastre. Existing legislation concerning each data class in the multipurpose data model will also be gathered and proposals made for its access via the MPC. Means for legalizing the data model and making its use compulsory by all involved in land development will be considered. A means for regulating data sharing will be proposed.

1.5.4 To run a case study for the integration of multipurpose datasets into the multipurpose database

A case study to create a multipurpose cadastre data model from real data can assist in the examination of the existing situation, as well as in the assessment of existing data (its formats, datums, accuracies, etc.) from different private and government agencies. Data integration, data distribution and multipurpose cadastre service distribution guidelines will be developed. This case study will use example Malaysia data sets to build a small version of PDMK, in order to develop guidelines for its implementation.

1.5.5 To investigate the application of the SOA concept in MPC

It is expected that MPC will involve different kinds of data stored in different silos scattered about the whole nation, under different authorities, in both the private and government sectors. Present concepts of data warehousing and single databases may not be the ideal solution. This investigation will also consider the benefits of the relatively new IT concept, SOA, to MPC through a small application project.

1.6 Methodology

The investigation's methodology is represented as ten tasks as described below.

TASK 1 REVIEW OF MULTIPURPOSE CADASTRE

Executing a literature review of the progress of MPC in The Netherlands, Switzerland, Germany and Australia (with a study visit to The Netherlands).

TASK 2 INVESTIGATE THE LEGAL IMPLICATIONS OF PDMK

Examining legislation affecting the multipurpose cadastre system including the National Land Code 1965, the Strata Titles Act 1985, the Licensed Surveyor Act 1958, land use and planning policy and state land administration policy. Proposing policies for legalizing MPC.

TASK 3 INDENTIFY PDMK DATA USERS AND SUPPLIERS

Identifying organizations currently: i) in charge of gathering data for the MPC database; ii) responsible for preparing the Geomatics data for the MPC database; and, iii) responsible for preparing the output from the MPC database. Based on this identification, designing a data flow from data supplier to information user.

TASK 4 PROPOSE QC PROCEDURES

Proposing quality check (QC) procedures for the MPC data based on ISO 19113 "Geographic information - Quality principles", ISO 19114 "Geographic information - Quality evaluation procedures", and the JUPEM requirement that the cadastre database must have 1cm accuracy (RMSE).

TASK 5 PROPOSE COORDINATE TRANSFORMATIONS

Proposing means for integrating all data into one seamless database by implementing appropriate coordinate transformations and reformatting. Developing and documenting procedures to merge cadastre data (GDM2000) and topographic data (MRT96).

TASK 6 DESIGNS AND CREATE THE DATABASE

Creating a data model in an Oracle OODBMS for a parcel based database. Proposing how the data can be maintained by the data provider to support the procedures identified in the data flow analysis of TASK 3.

TASK 7 EXECUTE A CASE STUDY

Testing the data model on a case study. Testing the data flow using web based software and identified constraints.

TASK 8 REVIEW SOA APPROACH

Investigating SOA as it can be used in MPC especially catering for spatial data.

TASK 9 EXECUTE TECHNICAL PROCEDURES USING SOA APPROACH

Designing MPC data distribution using SOA concepts and current web based software.

TASK 10 REPORTING

1.7 Structure of the dissertation

Altogether there are seven chapters in this report as shown in **Figure 1-17**.

Chapter One is the introductory chapter.

Chapter Two will review of some of the multipurpose cadastre systems that exist internationally. The researcher will investigate and compare the current system from several different countries. This is a very important step before the establishment of a modern cadastre in Malaysia. The lesson from others countries should help Malaysia to avoid of repeating the same mistake while successful methods which suit local environments can be adopted as references. The methods to acquire the related information in this chapter are through literature review, communications with key persons and study visits to some successful cadastre organizations.

An understanding of the legal and organizational requirements in the existing structure in Malaysia is the aim of Chapter Three. The multipurpose cadastre will involve more complex cadastre data such as utilities, topography and 3D parcel data. These data are proposed to be legalised in order to gain trust from the public and users. Because citizens are involved with the land registration or the cadastre, their confidence in the system must be assured. The public must be informed of the purpose of the system and must understand how and why it works. The process of legalizing must not create any legal difficulties and finally can gain support from public. All the legal issues that are expected to arise will be presented in this chapter. Apart from that, this chapter will also look into the organizational aspects in Malaysia that are required in this project.

Chapter Four will focus on the core of this investigation. Using the information in chapter two and three, the researcher will design and develop a multipurpose cadastre data model which is suitable for Malaysia. This chapter also looks at various functions and quality control associated with the data model which can be performed in order to fulfil the user requirement. This chapter will involve technical processes to create the data model; the researcher is expected to deal with various data formats, different coordinate systems and different datums. In performing these processes the researcher has to use software tools, database tool provided by Oracle.

Chapter Five will review the SOA concept for application in multipurpose cadastre system especially for spatial data application; this chapter will investigate the software tools needed to accomplish Web Map Services, Web Feature Service and the SOA BPEL process in multipurpose cadastre.

Continuing the technical process of chapter Four, in chapter 6, the researcher will design the examples of the technical task from the findings of Chapter 5.

Chapter Seven is the concluding chapter to the thesis; it discusses the system, procedures, products, etc. Recommendations for future tasks are also presented.

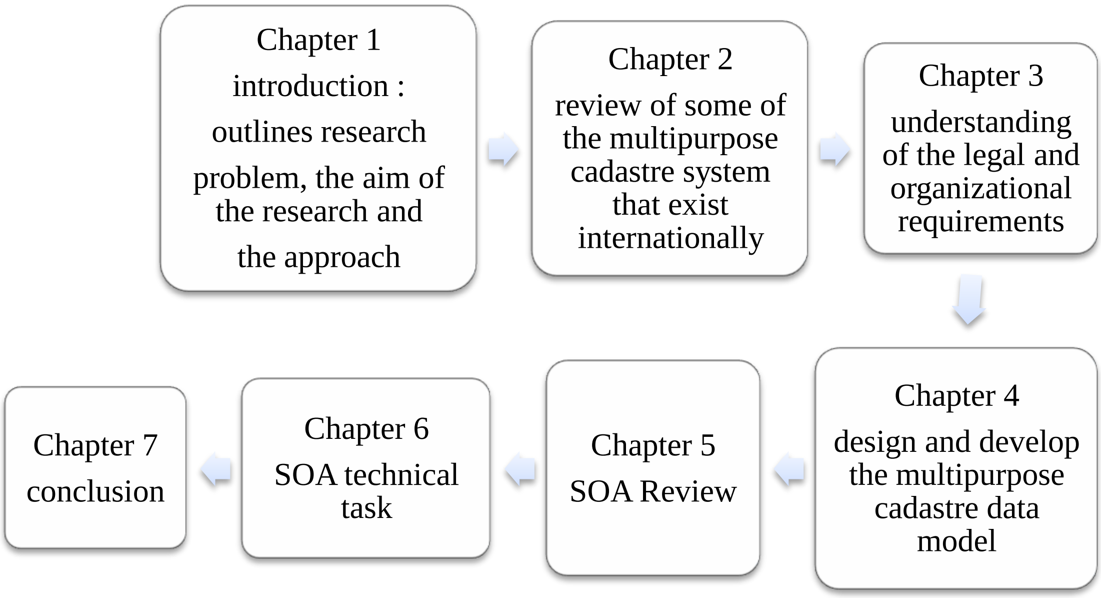


Figure 1-17 Structure of dissertation

Chapter 2: Review of modern (multipurpose) cadastre in The Netherlands, Australia, Switzerland and Germany

2.1 Chapter introduction

The concept of multipurpose cadastre (MPC) emerged more than 30 years ago, starting from innovative concepts introduced in the 1970s and 1980s by McLaughlin in 1975 and Williamson in 1985 and leading to the FIG Statement in 1995 on the Cadastre, the Bogor Declaration in 1996, Cadastre 2014 by Kaufmann and Steudler in 1998 and the Bathurst Declaration in 1999 (Bennet et al., 2011). In this period cadastre functions and roles in many countries have changed from a legal and fiscal role, which supports land transfer, the land market, land valuation and land tax to a multipurpose role which supports sustainable development planning and land management. This chapter will review existing multipurpose cadastre systems found internationally.

One of the main objectives of MPC is to remove borders between maps and registers. However, few countries have made efforts to rearrange their organizations involved in cadastre and land registry, although both The Netherlands (Nederlands Kadaster, 2012) and Switzerland (Swiss Federal Directorate of Cadastral Surveying, 2011) have combined their registration and mapping authorities into one authority. In the 1990s some cadastre reform had taken place around the world, many countries had started to introduce modern ICT to the process of producing cadastre maps. Also during this period Land Information System (LIS) were being implemented, many countries having invested much money in such systems.

The nature of the development stage of multipurpose cadastre varies among countries. The evolution from a single purpose cadastre to a multipurpose cadastre is much driven by users' demands. A multipurpose cadastre typically develops gradually system by system and service by service, depending on the availability of financial sources, GIS knowledge and ICT technology.

The main factor driving multipurpose system establishment is the urge to combine the fiscal record and the legal management of the land record to be used for the purpose of sustainable development (Majid, 2001)

GIS interoperability concepts, including the influences of the international standardization organizations such as CEN and ISO and the Open GIS Consortium, OGC, which introduced the core cadastre domain model, impact most of the countries wishing to develop modern cadastre or MPC (Van Oosterom et al., 2006). Technologies, such as database software and the internet, are available to make the objectives of MPC viable in the real world. It will be shown that the technologies that are used in The Netherlands, Australia, Switzerland and Germany are automated systems, flexible database management and web based data capture and distribution.

The modern cadastre that was promoted by The International Federation of Surveyors (FIG) to all its country members in 80s and 90s was a step towards the multipurpose cadastre concept (Majid, 2001).

Considering data, worldwide Spatial Data Infrastructures (SDIs) present cadastre data as the main core data in their layers (Chukwunwike Onyeka, 2005). This chapter will show that to use SDI with cadastre data as the main data source for sustainable development planning has became popular among countries which are actively involved in cadastre, with data integration becoming the main technical issue when creating a homogeneous, seamless databases. But it has also emerged that, apart from the technical issues, coordinating the organizational problems of different agencies has become critical.

2.2 The development of modern cadastre

The Netherlands Cadastre, Land Registry and Mapping Agency (Nederlands Kadaster) has developed two main database called AKR (Automated Cadastral Register) and LKI (Survey and Mapping Information) which are, respectively, set up for storing digital cadastre map information and digital register information. Some new services have been developed which are used by those involved in cadastre, for example recently The Netherlands Cadastre introduced electronic conveyancing through its web portal Kadaster-on-line which has benefited specific customers such as those notaries (lawyers) in charge of property transactions who are now able to use unique deed identification to convey their electronic deeds and execute market transaction (Nederlands Kadaster, 2012). The Netherlands Cadastre also maintains the 'maritime register', used to list mainly larger ships, such as tankers and merchant vessels.

Besides formal cadastre activities, new services such as the electronic exchange of cable and pipeline information have been developed. The utilities companies can now share data among themselves and with the customers using an online system called KLIC (Cables and Pipelines Information Centre) which is managed by The Netherlands Cadastre. KLIC is accessible by parties in the excavation chain and provides standardized information about the position and location of underground cables and pipelines. By introducing these example new services for special customer needs, The Netherlands is gradually moving towards a multipurpose cadastre system.

In Australia, for which the Torrens system was originally created, there is more emphases on a rigid cadastre system which concentrates on a highly accurate cadastre database. Most of the states in Australia have developed a seamless parcel based database or Digital Cadastre Database (DCDB) which is graphically accurate. These parcels are digitally linked to their titles through unique identifiers. Currently the Digital Cadastral Database (DCDB) still serves only to provide an index of cadastre data, although a proportion of the DCDB coordinates have survey accuracy sufficient to assist in boundary survey and validation but some state legislation does not permit these to be used thus.

In Western Australian 93% of survey parcels have survey accurate coordinates. The DCDB data is available directly online to the public, made available through PSMA Australia Limited. PSMA Australia Limited is a company owned by Australian state, territory and federal governments, established to coordinate the collection of fundamental national geospatial datasets and to facilitate access to these data. Multipurpose cadastre system can be found in Victoria, for example the supply of DCDB data can be tailored for different customer needs through web tools made available by Land and Survey Spatial Information (LASSI)

(Url: www.land.vic.gov.au/lassi). Customers are able to customize the information, such as parcel data, and build the desired map using web map services.

In Switzerland different survey methods have been used to develop digital cadastre data, such as photogrammetry and laser scanning. Fixed control points were set up nationwide using the geodetic survey of 1995 (LV95). The Federal Office of Topography, Swisstopo, has established a new high-accuracy satellite-based survey datum. Switzerland is developing a modern cadastre system using its own programming language, INTERLIS. Currently Switzerland is developing a cadastre system which has followed the concept of Cadastre 2014 where data are stored in independent information layers, for example in the Canton of Zurich as shown in the **Figure 2-1** (Kaufmann, 2010).

Information topic		Data owner	Data acquisition	Data maintenance, Data administration, Data output
Other topics		other		
Land use planning Forestry	planning zones	Canton, Communities		
Cable TV	facilities	Private firms		
Electric power supply	facilities	Power company		
Civil protection	protection zones	Communities		
Fresh water Waste water	facilities	Corporations, Communities, ...		
Railways Telecom	rails, facilities	Railways Telecom	Railways Telecom	Railways Telecom
AV93	basic data	Canton	Canton (licensed surveyors)	Canton (licensed surveyors)

Figure 2-1 The concept of building land information system in Canton of Zurich (Kaufmann, 2010)

In Germany, the former parcel register in most states is now operated in a digital system called the Automated Property Register (ALB). The cadastre maps are digitised in most parts of Germany and called the Automated Property Map (ALK). The mapping data is kept by the Official Topographic and Cartographic Information System ATKIS. The parcel data in Germany includes additional information, such as the results of the official soil assessment reference. The integrated official cadastre information system, called ALKIS, was developed using ISO standard UML (Unified Modelling Language) to integrate ALB and ALK. The final ALKIS can be integrated with ATKIS (Hawerk, 2005).

Since 2007, Germany has been developing a new system called AFIS (Authoritative Fixed Point Information System)-ALKIS-ATKIS or the AAA reference model to integrate all the existing systems.

2.3 Data integration and quality checking

Data integration and quality checking methods are very important aspects of realizing a multipurpose cadastre system. Data integration is mainly influenced by GIS technology, geodetic knowledge and organization management. Data integration and quality checking will be considered for each of The Netherlands, Australia and Germany.

2.3.1 The Netherlands

In The Netherlands, the cadastre map contains national grid, geometry (cadastre boundaries, geodetic control points, building) and attribute data (parcel identifiers, street addresses, and house numbers). The parcel boundary database is stored with the intention of being topologically correct. The database is designed to be boundary based and not closed polygon parcel based. This concept can be considered by Malaysia while heading towards object oriented and topological correct NDCDB.

The spatial extensions of the objects in the tables Boundary, Parcel and Line are indicated by a minimal bounding rectangle (MBR) of the type ‘box’. The box includes a boundary, a topographic line or a complete parcel. This box can be spatially indexed and is useful for efficient retrieval purposes based on rectangle selections. Parcels are not stored in polygon geometry, but the area can be calculated from the parcel table and boundary table using the so called ‘Chain-method’. The edges in the Boundary table contain references to other edges, according to a winged edge structure as showed in **Figure 2.2** and are used to form the complete boundary chains (Van Oosterom and Lemmen, 2001).

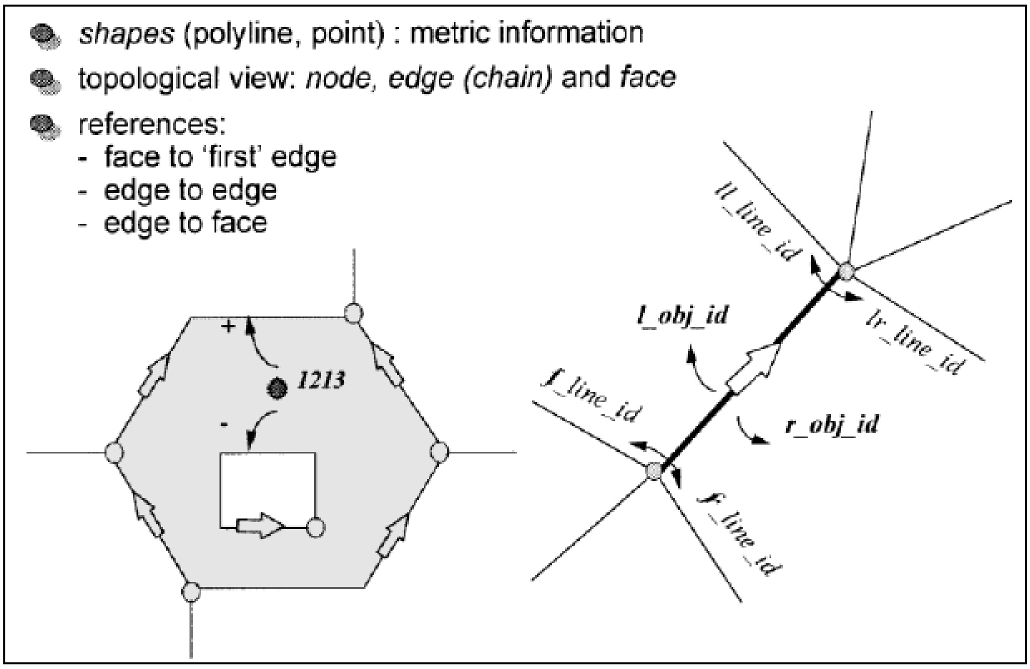


Figure 2-2 The Netherlands Cadastre's topology model concept
(Lemmen et al., 2001)

This concept enables calculations on the correctness of the topology after adjustment of any newly surveyed boundaries of the cadastre data. The boundaries also hold attributes for example temporal data (date of survey). It is considered that if each parcel would be represented in the database by a closed polygon, it would be complicated to represent the basic object of cadastre surveying, that is: one boundary between two neighbouring parcels. Closed polygon representation would lead to double or triple storage of co-ordinates which complicates the data management in a substantial way. A closed polygon also has little relation to reality. One more reason for the boundary-based approach is in the classification of boundaries. The administrative, cadastre and political boundaries can be subdivided into sections (or cadastre zones), municipalities or provinces, which is made possible by classifying boundaries as 'section-boundary', 'municipal-boundary', ' province-boundary' or ' national boundary' (Van Oosterom and Lemmen, 2001).

The Netherlands Cadastre uses an automated topology error detector during data 'check in' and 'check out' called X-Fingis. This works on files to make the cadastre data topologically consistent. Besides using automated software, user interpretation also helps to create a topologically consistent database.

After the process of making the database topologically consistent, The Netherlands Cadastre needs to make sure the cadastre map and the large scale topographic base map are fully co-ordinated and reconciled with each other.

The Netherlands Cadastre database is divided into two automated systems, the registers records are stored in the Automated Cadastral Register (AKR) system while the cadastre maps are in the Survey and Mapping Information System (LKI), but these two systems can be integrated using an interface connection for cadastre registers and maps updating as shown in **Figure 2.3** (Van Osch and Lemmen, 2004).

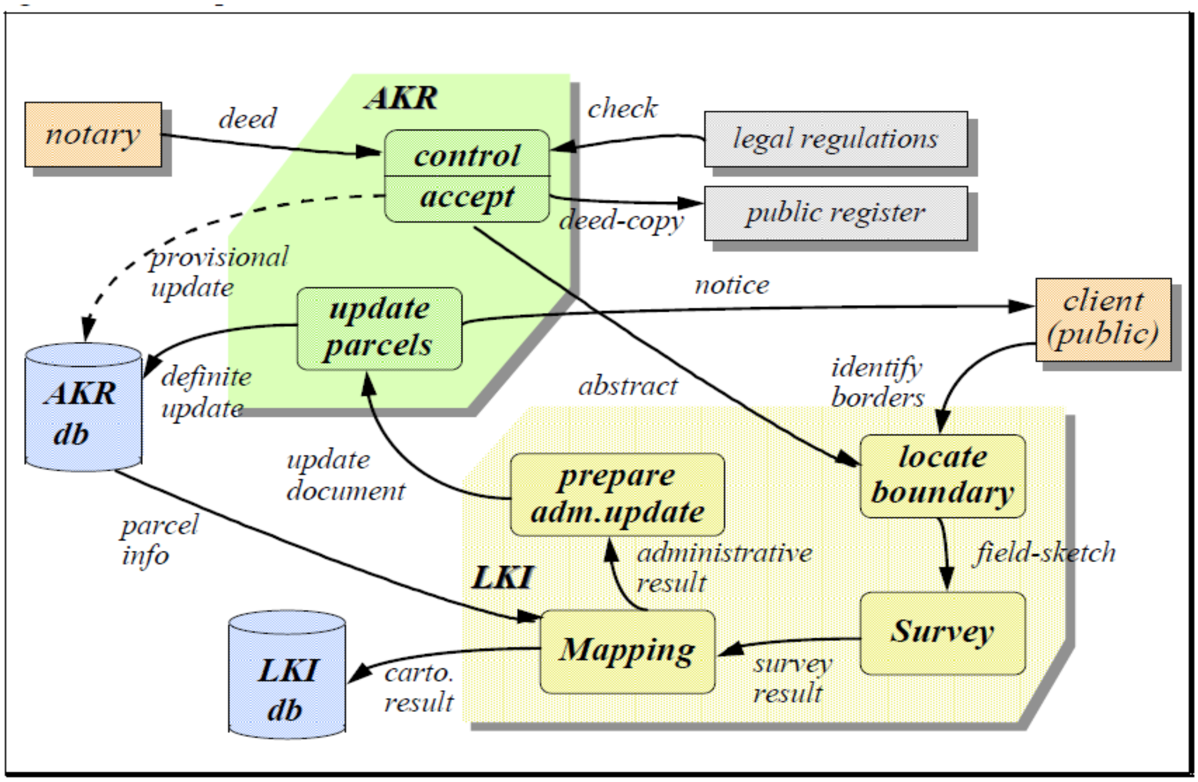


Figure 2-3 The existing cadastre update process in The Netherlands
(Van Osch and Lemmen, 2004)

As shown in **Figure 2-4** registry and survey activity are connected by several interfaces using client server applications. This enable users in different locations to access both systems during updating processes (Van Osch and Lemmen, 2004).

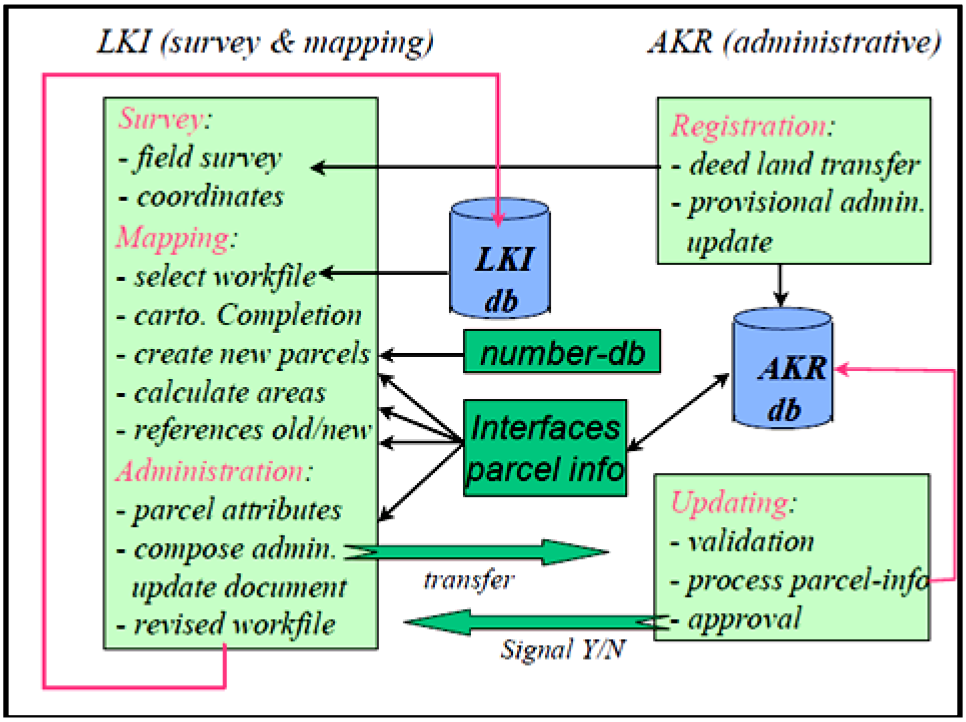


Figure 2-4 **Procedure of cadastre updating in The Netherlands**
(Van Osch and Lemmen, 2004)

The Netherlands government is working to develop The Dutch System of Key Registers which will integrate main registration records such as buildings, addresses, cadastre parcels, persons, companies, topography (small scale and large scale) and real estate across 499 different organisations (Ellenkamp, 2009).

2.3.2 Australia

Australia is the world's largest island but has low population density (2.4 people per square km), its cadastre system is based on Torrens system which requires accurate boundary lines to be established in the field and on maps. The states and territories are responsible for producing land titling and large scale mapping.

Data have been maintained in eight states separately; each operates and maintains their own form of cadastre system (Williamson et al., 2012). Due to this, building modern cadastre varies among states, and an accurate digital cadastre database is still yet to be established for the whole country. Nevertheless there is a seamless national parcel based (graphic or raster) cadastre database called 'Cadastral Lite' or CadLite which was developed by the

Public Sector Mapping Agency (PMSA) Australia Limited. PSMA Australia Limited is an unlisted public company that is wholly owned by all the state and territory governments (Paull, 2009)

The Cadlite database integrates names of suburbs, local government areas boundary locations with 10.5 million parcels. Due to the database only being accurate graphically, it can only used for purposes such as small scale town planning, location finders, properties' market reports, etc.

The Geocentric Datum of Australia (GDA94) was introduced for data uniformity purposes in 1994 to replaces the Australian Geodetic Datum (AGD). It is based on the global geodetic framework ITRF. In 2000, the Digital Cadastral Database (DCDB) and the Survey Control Database (SCDB) in Queensland state were available on GDA94 (Webb, 2005) This step was followed by Malaysia which introduced the Geocentric Datum of Malaysia in 2000.

In 2010, under the provision of the Survey and Mapping Infrastructure Act 2003, the Queensland Government established guidelines to survey the ambulatory boundaries which are the boundaries of land adjoining water subject to tidal influence or adjoining non-tidal boundary watercourses (Queensland Government, 2011) This guideline is very useful for study by the Government of Malaysia because Malaysia's MPC does plan to include solutions to the problem of shoreline boundaries' determination.

The cadastre database is developed separately by state government with slight differences in detail. Most of the databases show parcels, addresses, buildings, unique identifiers, coordinates, street names, geographic dimensions, etc. (Williamson et al., 2012).

In 2008, the Australian government introduced a data model called the Harmonised Data Model (HDM) version 2 to integrate cadastre data, topography, place names and address which is shown in **Figure 2-5**.

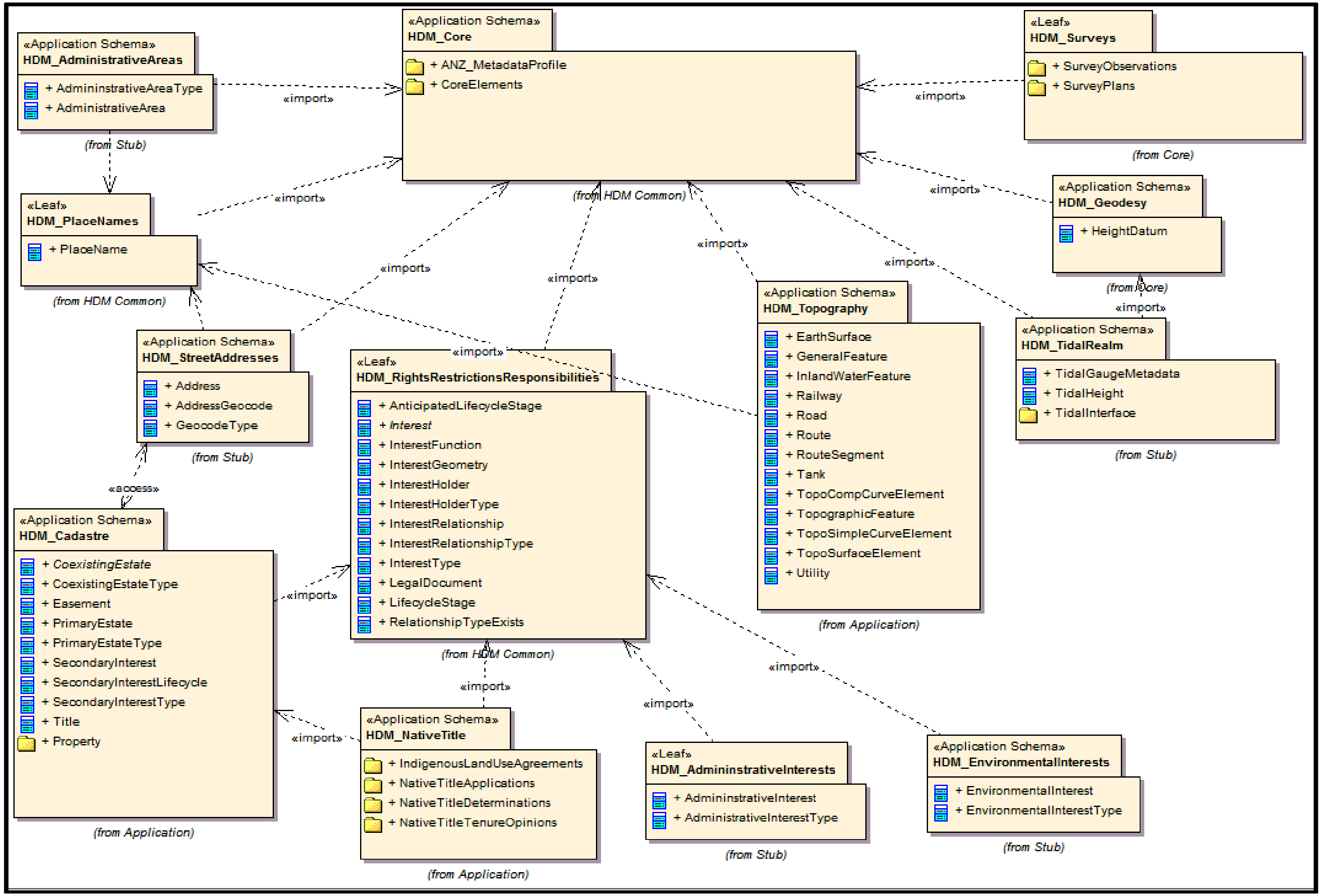


Figure 2-5 Harmonised Data Model (HDM) conceptual diagram
(Intergovernmental Commitee on Surveying & Mapping, 2011)

It was developed using Unified Modelling Language (UML) and uses Extensive Markup Language (XML) for data transfer. This version 2 introduced the native title model and the Rights, Restrictions and Responsibilities concept which is shown in **Figure 2-6**. It follows the ISO/TC211 standards shown in the list below (Intergovernmental Commitee on Surveying & Mapping, 2011):

- ISO 19103 – Conceptual Schema Language covers the language, rules and guidelines required to achieve implementation of neutral models for geographic information.

- ISO 19104 – Provides the guidelines for collection and maintenance of terminology in the field of geographic information.

- ISO 19107 – Spatial Schema, to describe the spatial characteristics or attributes of geographic features and a set of spatial operations consistent with these schemas.

- ISO 19108 – Temporal Schema, to define the concepts needed to describe the temporal characteristics of geographic information as they are abstracted from the real world.

- ISO 19109 – Rules for Application Schema, to define the rules for the application schema, including the principles for classifying geographic objects and their relationships to application schema.

- ISO 19110 – Methodology for Feature Cataloguing, covers a basis for the description of packages of geographic information enabling access to a distributed network.

- ISO 19111 – Spatial Referencing by Coordinates, defines the conceptual schema for the description of spatial referencing by coordinates and the minimum data required to define one, two and three dimensional coordinate reference systems.

- ISO 19118 – Encoding covers the encoding rules for how to map from the implementation neutral UML models to a corresponding representation of data according to these models in XML.

- ISO 19119 – Services define the implementation specific profiles for the implementation neutral models, ensuring that there is well-defined mapping between these to ensure interoperability between different implementation platforms.

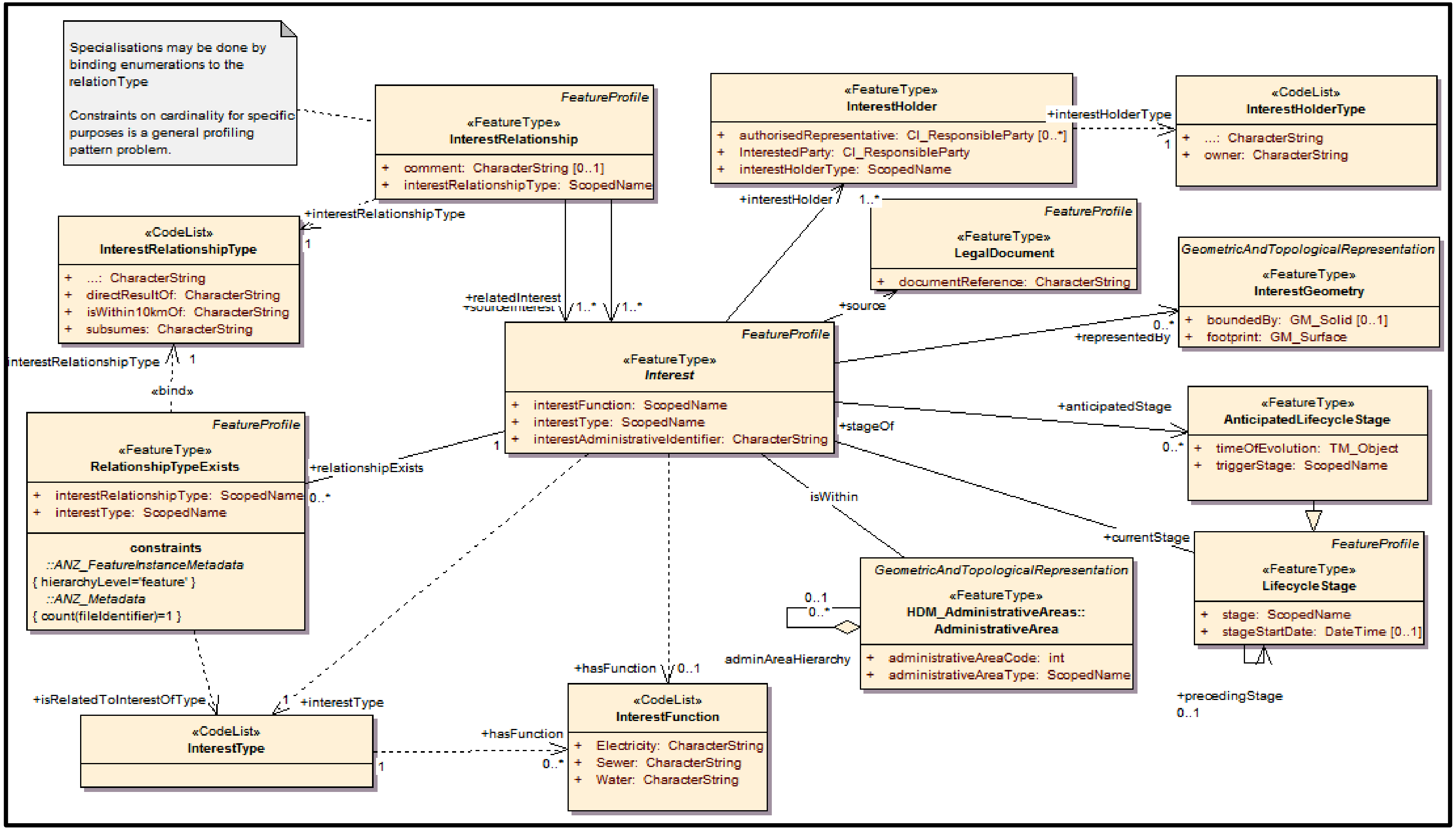


Figure 2-6 Right, Restriction and Responsibility conceptual diagram
(Intergovernmental Commitee on Surveying & Mapping, 2011)

2.3.3 Germany

Early in this millennium, the Working Group of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) developed a model of an integrated Official Cadastral Information System called ALKIS and redesigned the Authoritative Topographic-Cartographic Information System (ATKIS), first developed in the 1970s. Since 2007, Germany has been developing a new system called the AFIS (Authoritative Fixed Point Information System)-ALKIS-ATKIS or AAA reference model.

Before ALKIS was developed, the Land registration system in Germany was a 'duplex' system. The legal situation of each parcel was described in the land register, called the "Grundbuch". The geometric descriptions of boundaries were in the Automated Cadastral Map (ALK), field records and textual records in the Automated Property Register (ALB)(Hawerk, 2005).

The ALIKIS approach aimed at GIS interoperability similar to those emerging from the concepts promulgated by the international standardization organisations CEN, ISO and especially the Open GIS Consortium (OGC) which then played an important role in future decision making (Germany Adv, 2009). ALB, ALK and ATKIS were not thought able to meet more modern technical requirements. When ALB and ALK were developed, standards for data bases were not designed for commercial relational data base management systems.

AdV decided to stop upgrading ALB and ALK in 1995, and develop new integrated systems for cadastre and topography. ALKIS for the cadastre model and ATKIS for the topography model (which contains digital landscape models at the scales 1: 25,000, 1: 250,000 and 1: 1,000,000).

ALKIS was modelled by using the draft documents of the data base description language EXPRESS (EXPRESS-L for the textual or lexical part and EXPRESS-G for the graphical part) developed by the European Standards Body CEN using ISO standard Unified Modelling Language (UML) and for the definition of the data interface to be based on Extensible Markup Language (XML) documented in ISO standard 15046.

The AFIS-ALKIS-ATKIS or AAA reference model is based on international standards, such as ISO, OGC, FIG 2014 and Geography Markup Language-GML3 which is shown in **Figure 2-7**. This AAA reference model provides one coherent information system for all relevant, fundamental data for spatial referencing and builds a common and consistent spatial data infrastructure in Germany (Germany Adv, 2009).

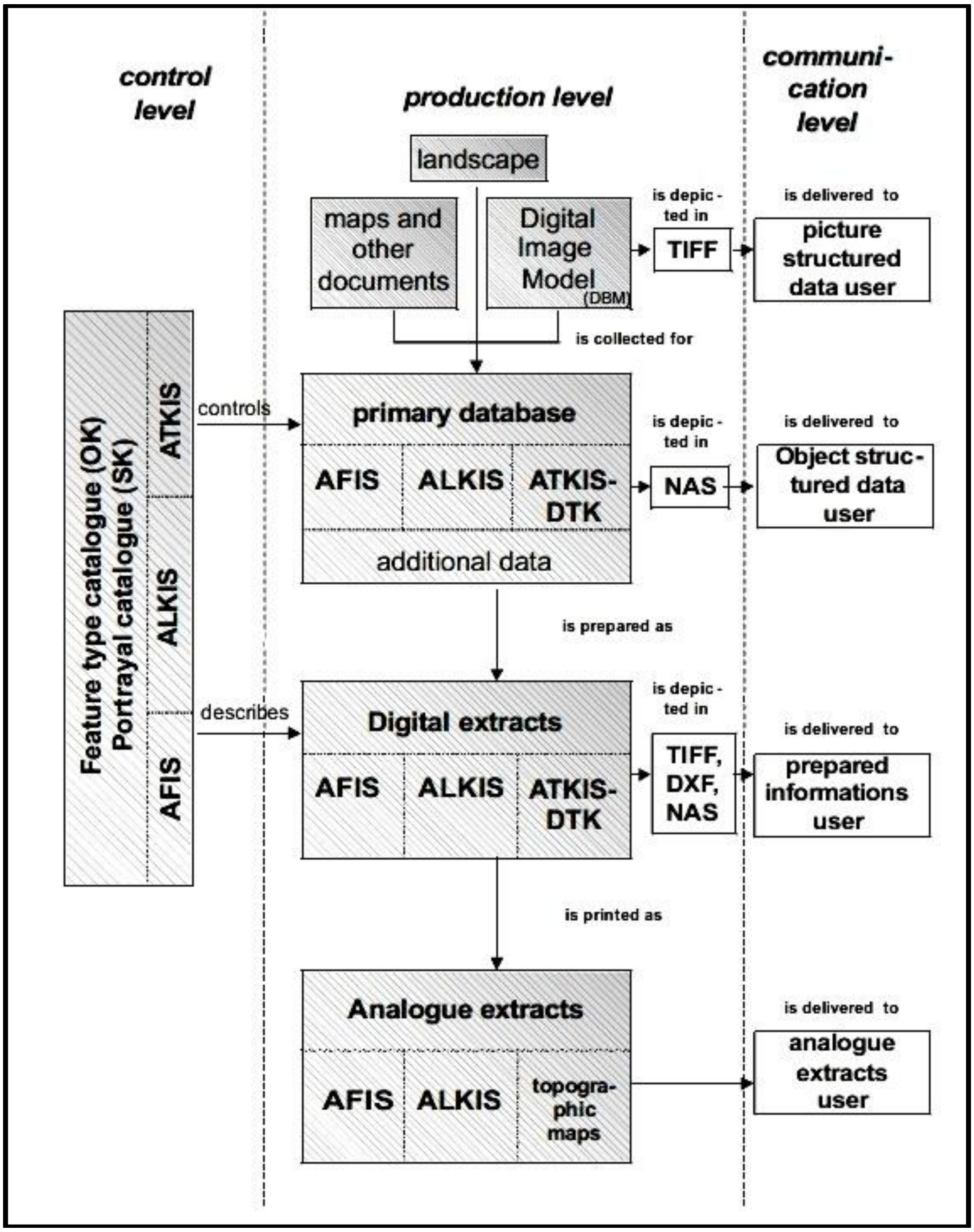


Figure 2-7 Common AFIS-ALKIS-ATKIS reference model
(Germany Adv, 2009)

2.3.4 Switzerland

Switzerland is a country that has the most complicated structure of organisation in its cadastre system among the study countries in this investigation as shown in **Figure 2.8**. Due to this Switzerland appears to provide more emphasis on data exchange between these agencies.

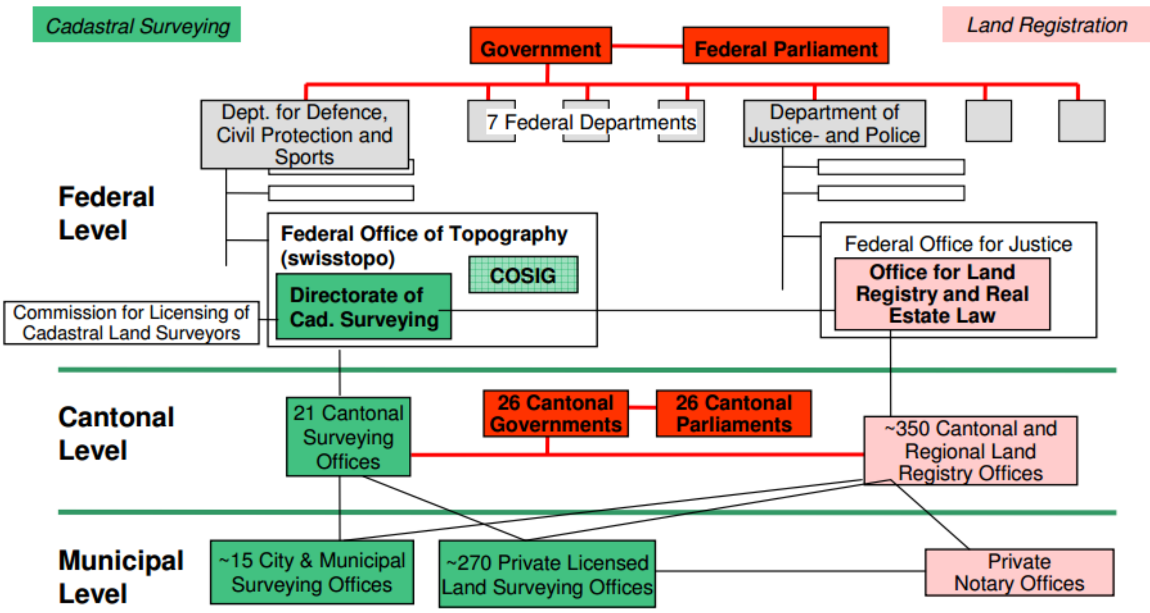


Figure 2-8 Organisation of the Swiss cadastre
(Steudler, 2011)

While most of the European countries are using Unified Modelling Language (UML) to develop their data model and support data integration, Switzerland developed her own geographical data description language to interface data in cadastre survey data called INTERLIS (Data Exchange Mechanism for Land-Information-Systems). Since it was introduced, it has become Switzerland's standard spatial data integration language. There are two version of INTERLIS that can be found, version 1 Swiss Standard SN612030 has been developed for the relational model and version 2 Swiss standard SN612031 has been developed for the object oriented model. Although it was developed in Switzerland, it has also has been used internationally (Steudler, 2005).

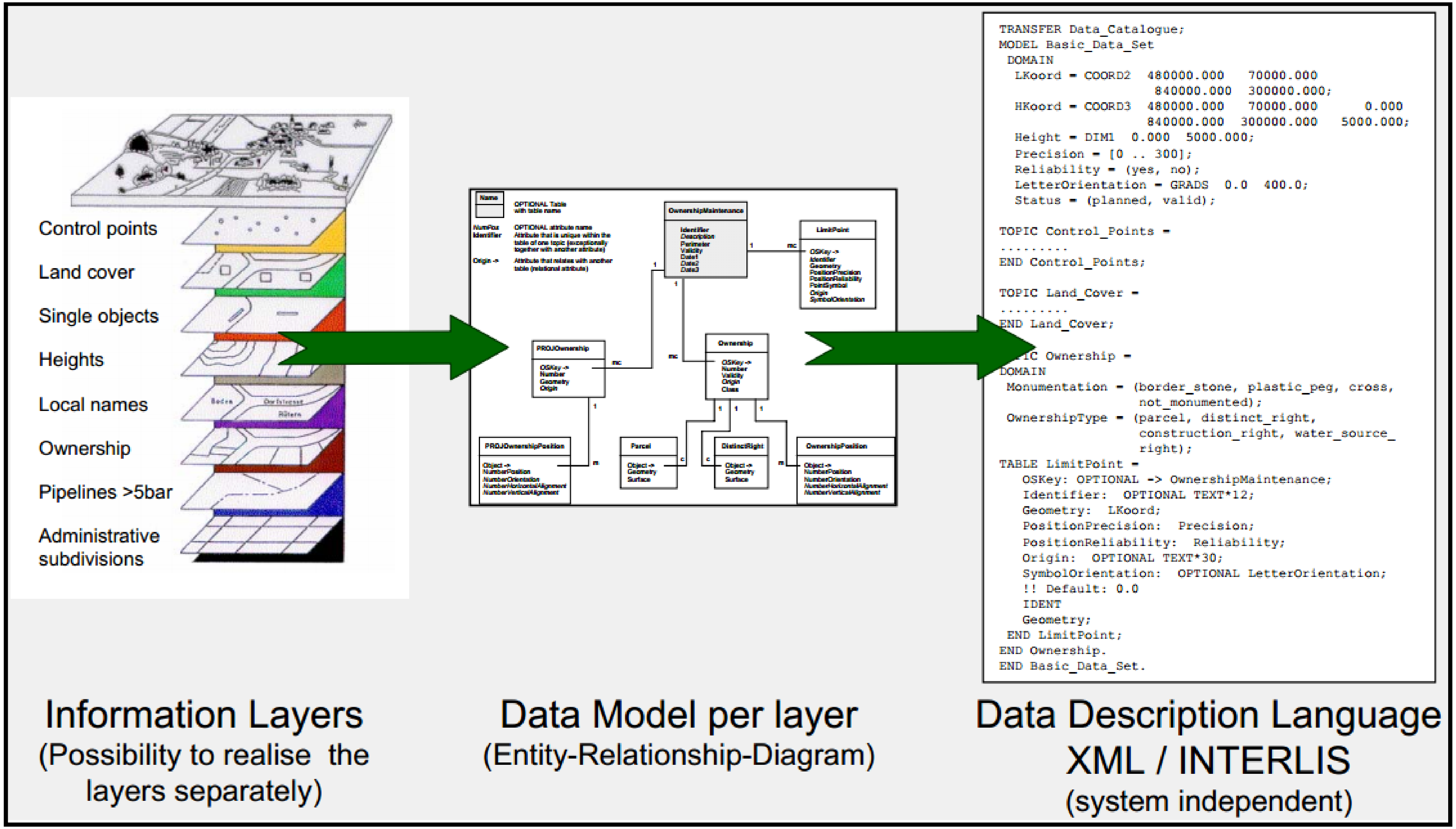


Figure 2-9 Data modelling in Swiss cadastre
(Steudler, 2011)

The layers of cadastre survey model are as follows (as shown in **Figure 2-9**):

- Control points;
- Land cover (building, roads and etc);
- Single objects (wall, bridge and etc);
- Height (digital terrain model);
- Local names (place names);
- Ownership (land Parcels);
- Pipelines (oil and gas);
- Territorial boundaries;
- Area of land subsidence and landslide;
- Building address (street name, house number, postcode, etc.);

  and,
- Administrative subdivisions.

INTERLIS has also been used to interface with other spatial data such as noise maps and zoning plans. (Steudler, 2005)

Malaysia can learn from Switzerland by developing its own MPC system using open source language where the system is easier to maintain and is expandable, adapting to the demands from users.

2.4 Data distribution method

Most countries like The Netherlands, Australia, Switzerland and Germany chose the Internet as the method of distributing the data. Switzerland uses Web Map Services (WMS) and Germany, using ALK interfaced with the customers' data base, distributes the unique data base in DXF and TIFF formats and the Nationwide harmonized ALB is distributed using an interface called WLDG which produces ASCII data In the ALKIS system, the new NAS interface (standard based data exchange interface) will be developed by using ISO standards 15046 for XML (Geographic information) for data distribution.

Australia, besides using the Internet as a medium of distribution, chose a business approach by appointing, as already indicated, a data distributor called Public Sector Agencies (PSMA) Limited owned by state, territory and federal governments.

PSMA is a self sustaining company which has relied on the spatial data gathering, maintenance and distribution business. PSMA can appoint value added resellers by following a standard policy of licensing, restriction, pricing and security. PSMA has also plans to use services orientated architecture (SOA) for the collection, assembly and delivery of national datasets.

2.5 Cost recovery policy

The Netherlands Cadastre operates similarly to the private sector: all services provided are charged, and the Cadastre is obliged to fully recover its costs. It has established “Kadaster International” which provides international consultancy, pilot projects, training, project management and study tours. But some local projects still receive funds from the Dutch Government.

Australia’s very low population density (2.4 people per square km) has caused an insufficient market size for cadastre data. The government strategy is to establish Public Sector Mapping Agencies (PSMA) as data reseller to mitigate the cost and associated risk for private companies selling data. Shareholders of PSMA measure their profit not by the size of the dividend returned to them but by the value received by all Australians via access to and utilization of the national datasets. The company’s focus is the maximization of this value (Paull, 2009).

Switzerland and Germany depend much on funds from government for their cadastre operations. In Switzerland financing is shared between the three levels of government – confederation, cantons and municipalities. The financial share of the Confederation is regulated in the FVAV (*Verordnung der Bundesversammlung über die Finanzierung der amtlichen Vermessung*) ordinance as shown in **Figure 2-10**.

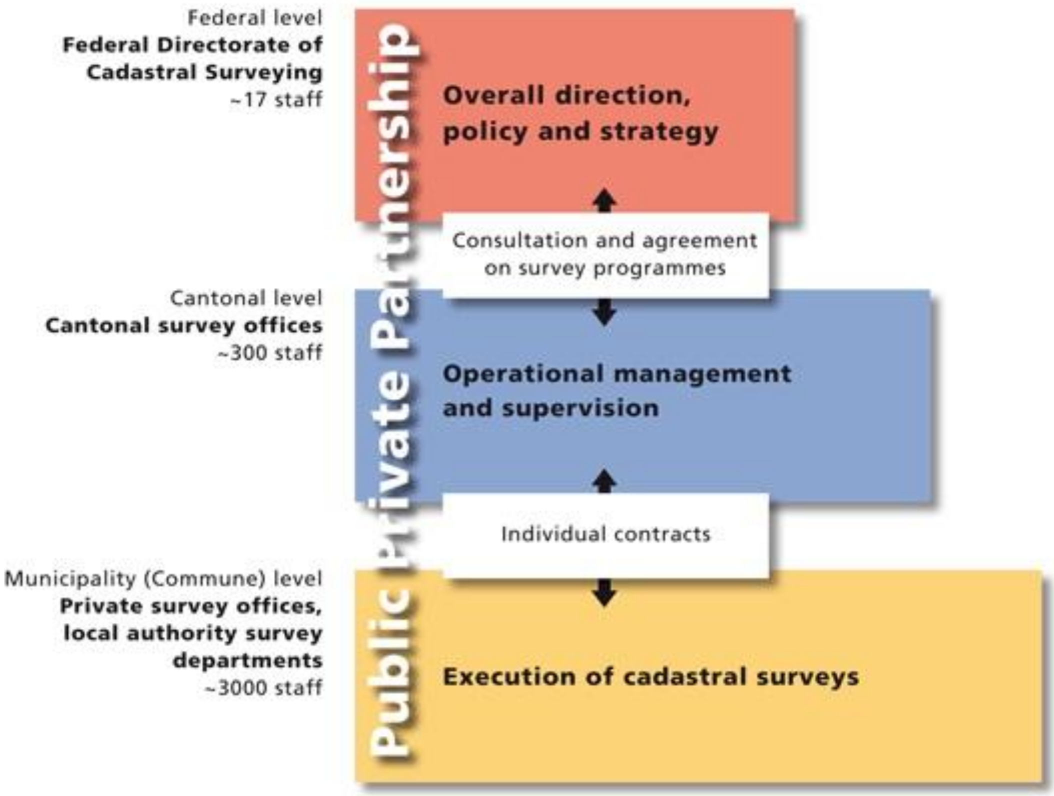


Figure 2-10 Management of funds among organisations in Swiss cadastre
(Url: http://www.cadastre.ch/internet/cadastre/en/home/topics/about/organization.html)

In Germany the licensed surveyors (in the private sector) are charged with carrying out the cadastre field work for the public, while the public sector carries out the office work (Hawerk, 2005).

2.6 The services available

The main service of The Netherlands Cadastre is to register real estate, they also provide an independent Housing Value Index which is an information source for the property and mortgage market; register high value moveable property (for example tankers, ships and aircraft); and, provide information related to public law (for example the location of boundaries and other spatial restrictions).

In Australia, the Cadastre Authority provides the data and information as follows:

- Cadastral Lite (parcel and land tenure data);

- administrative boundary datasets (electoral boundaries, bureau of statistics boundaries, etc.);

- transportation and topographic datasets (road centre line, river, recreation park, etc.); and,

- Geocoded National Address File (G-NAF), consisting of: physical addresses, features of interest dataset (hospitals, banks, post offices, etc.).

The cadastre in Germany is a parcel-based system, according to Hawerk (2005), in the ALKIS system, there are about 20.5 million geo-referenced house addresses derived from the real estate cadastre all over Germany. The data structure of ALKIS is compliant to ISO norms and OGC standards. Since the advent of ALKIS there have been visible improvements in road maps, in internet services or mobile “apps” and single house presentations especially on large scale maps, and the base for exact routing (Hawerk, 2005). Alternative uses in combination with house addresses and house numbers are being developed.

ALKIS also can serve as reference data for professional geoinformation systems documentation and facility management data as a basis for 3D city modelling (LoD1, LoD2), and gazetteer services in the internet in combination with socio-demographic information for customers (Germany Adv, 2009).

In Switzerland, a cadastre map (parcel and ownership information) is an official document. The cadastre is 3D, with height derived from a national Digital Terrain Model kept in a different layer. Apart from that it also contains city and district street maps, zoning plans and utility asset maps. SwissTopo supplies data to customers in the form of cadastre data models called MOpublic, in formats such as INTERLIS1, INTERLIS2, GML, ESRI shape files and DXF.

(URL:http://www.cadastre.ch/internet/cadastre/en/home/products/mopublic.html)

2.7 Summary of chapter 2

The Australian cadastre practices the Torrens system, and due to that the cadastre systems in Australia and Malaysia are almost identical, so development towards modern cadastre can progress simultaneously in both countries. Both countries are sharing the same experiences technically. While Australia started much earlier towards multipurpose cadastre system, Malaysia is in a fast track towards completing an accurate digital cadastre database for the whole country. Malaysia has an advantage because it is a smaller landmass, has less complexity of jurisdictions and has more demand from users for greater economic growth.

Funding and cost recovery were a challenge for countries in Europe and Australia to modernise their cadastre system. Australia chooses to create a business process that improved their digital cadastre database without investing heavily. Keith Clifford Bell from the World Bank in a recent interview in GIM International Magazine (2012) said cadastres in most countries are over-engineered in pursuit of high accuracy with little emphasize on the real need to build and maintain sustainable cadastre systems. He explained that accuracy and technology should always be based on fitness for purpose, which should be achieved over time, by public demand. He quoted that modern cadastre systems should also consider the broader society not only strengthening geospatial technology silos (Mathias, 2010).

Mitigating costs to the private sector through a business process, without government aid, was chosen by most of the countries. Optimising the existing data and modernising the end product to meet certain customer requirements, to recover costs and create profit then reinvest in the data quality and the system is a more intelligent way to develop modern cadastre.

The cadastre systems which run by self funded organisations depend on economic growth to develop. While there is still the exceptional case in Malaysia where many projects are still funded by the federal government, eventually Malaysia will face the same situation, when its economy is affected by global economic downturns. The cadastre system in Malaysia may in future no longer receive such a great amount of public funding. It is vital for Malaysia to keep the cadastre system low cost, well managed and sustainable.

Malaysia may not necessarily follow what other countries in the world have done, but must never neglect the technology that impacts cadastre systems when this can be shown to be about improving transparency, good governance and peoples' access to services. Due to cadastre systems evolving over time - adapting to economic and societal changes, Malaysia should develop her own open source system that can be maintained locally by local human resources.

Data integration became the main technical issue when creating a homogeneous, seamless database for MPC system. But it has emerged that, apart from the technical issues, coordinating the problems of different agencies has become critical. The legal implication of the implementation of a multipurpose cadastre system should be taken into account and is further elaborated in the next chapter.

Chapter 3: The organizational and legal requirement of the existing structure in Malaysia

3.1 Chapter introduction

Considering organisational requirements, these constrain development of a multipurpose cadastre. The financial and technical issues are minor compared to the organizational ones. With 13 states and 3 federal territories in Malaysia and other government and private entities which are potential producers of parcel data, the organizational issues are complex. It is not a simple task to assemble parcel data if the relevant information is sourced from several states and government agencies. Overcoming organisational boundaries even among federal agencies has been difficult.

As well as 2D cadastre parcels, the multipurpose cadastre (MPC) will involve also more complex data such as utilities, topography and 3D parcel data. It is proposed these more complex data are legalized (in the case of conventional cadastre parcels in Malaysia their legalization involves the National Land Code 1965 which requires any alienation of land to citizens to be surveyed and a plan needs to be deposited in the Land Survey and Mapping Office) in order to gain the trust of users and the public in general. Land registration or the cadastre involves public interest, any new system shall minimise impact on them, and government must continue public confidence in the new amended system. In the mean time, the public must be educated in how the amended system works. The process of legalizing must not create more legal difficulties than at present, overall, and must gain support from the public.

This chapter will present the organizational arrangements in Malaysia that are related to this project, including the legal issues. The chapter will propose simplifying the bureaucratic processes within the data supplier organizations and between these organizations and the users.

3.2 Background of cadastre's legislation in Malaysia

Malaysia's cadastre system and history of land matters can be traced back to before World War II and are influenced by the changes of geopolitics in the country. Three phases of ruling power influence the cadastre legal system in Malaysia. These are the Monarchy or Sultanate System from the 15th century for customary land, the spread of Islamic law affecting Muslim owned land and the British Colonial rule which introduced constitutional government and the common law system evolving, initially, from the Deed System of 1807-1856 implemented in the Straits Settlement (Penang and Malacca) to, eventually, the Torrens System in 1966 for the whole of peninsular Malaysia.

Malaya consisted of federated states and non-federated states. Malacca and Penang (Straits Settlement) and were joined by Singapore, Sabah and Sarawak in 1963 to form the Federation of Malaysia in 1963, six years after independence in 1957, but later Singapore separated to became independent, in 1965.

The Federation of Malaysia is modelled after the British parliamentary system and ruled by a Constitutional Monarchy, consists of 13 states (Johor, Melaka, Negeri Sembilan, Pahang, Selangor, Kedah, Kelantan, Terengganu, Pulau Pinang, Perlis, Perak, Sabah and Sarawak) and 3 federal territories (Kuala Lumpur, Labuan and Putrajaya). Before British colonization and the independence of Malaya, Sultans (kings) of each state were solely in charge of land matters in their state. This power was transferred to the State Authority headed by legislative state government, after Malaysia became a democratic country.

The Federal and State division of power in the Malaysia Constitution is described in the following table:

Federal	State	Concurrent
external affairs, defense, internal security, civil and criminal law, federal citizenship and naturalization, finance, trade, commerce and industry….	land and its administration, Islamic law, Malay customary rules, permits and licenses for mines prospecting, agriculture, forests and local government…	town and country planning, housing and national parks…

Table 3-1 The list of federal and state division of power
Source : (The Commissioner of Law Revision Malaysia, 1957)

Examples of customary rule which were retained and still exist, now, are found within the matriarchal system or *Adat Perpatih* and applicable in the districts of Kuala Pilah, Rembau, Jelebu and Tampin of Negeri Sembilan. *Adat Perpatih* originated in West Sumatra, Indonesia, and was practised by indigenous people called the Minangkabau people. For example according to *Adat Perpatih*, property division is under two categories - inherited or acquired property, and the following conventions may be applied:

- property which is inherited belongs to the wife, property which is acquired during the marriage is shared by the couple

- personal property is taken back when a wife passes away.

There are also conventions that once the wife’s portion of acquired wealth passes on to her daughters, but if the husband passes away, his acquired wealth will belong to his wife and to be shared among his daughters.

Based on the PCGIAP country report (Williamson et al., 2012), the Torrens system was first introduced in Malaysia between the years 1879 and 1890, through the Fijian Act. It is statutorily presented in the National Land Code 1965

(NLC) for Peninsular Malaysia, in the Sabah Land Ordinance for the state of Sabah and in the Sarawak Land Code for the state of Sarawak.

The Malaysian cadastre system is divided into two components: the land register and the cadastre survey. Every land parcel that has a registered proprietor is issued with an Issue Document of Title (IDT) which is kept by the proprietor, and another duplicate document called Register Document of Title (RDT) which is kept in the register office. The documents are legal proof that ensures the rights of the proprietor and is a guarantee from the government of indefeasible title. The indefeasible right is explained in section 340(1) of National Land Code 1965. Both the RDT and the IDT have an attached plan of the land, certified by the State Director of Survey.

Compared to the United Kingdom's system which uses 'general boundaries' and a topographical map as reference of the boundary location, Malaysia is practising a 'fixed boundary' system which requires a parcel's boundaries to be surveyed in the field. The boundary points that construct the boundary line should be demarcated with markers of such as concrete stone, pipe, spike, etc. The calculation of the boundaries should be based on correct mathematical procedures within misclosures stated in law. Upon the completion of the survey, a plan that shows the location of a particular parcel and its adjacent boundaries is produced, to be certified by the JUPEM State Director of Survey. This plan is called a Certified Plan (CP). In the last process of land registration, a State's Land Office will utilize this plan for producing the title documents.

3.3 Organization of the existing cadastre system

The users of the cadastre system can come from different authorities; they have different responsibilities and levels of authority.

Land registration is administered by the State Land Offices and coordinated by the Department of Land and Mines, whereas cadastre surveys are controlled by the Department of Survey and Mapping, Malaysia (JUPEM) which is a federal department. JUPEM is responsible for undertaking cadastre survey work within

Peninsular Malaysia but is supported by licensed land surveyors. However in the states of Sabah and Sarawak, the cadastres are administered by the Departments of Land and Surveys (DLS). These departments have, it could be argued, the ideal setup of having land registration and cadastre surveys under the control of a single organization, which is a State entity.

As the cadastre system is an important tool that controls economic activity in Malaysia, nearly every organization, regardless of whether it is from the public sector or private sector, is a user of the cadastre system.

3.4 Organizations expected to be involved in the MPC system

It may be a long list of organizations who will be involved in multipurpose cadastre in the future, but the whole scheme can be drafted according to the objectives taken from Chapter 1, namely:

"Multipurpose cadastre, by providing accurate spatial information, supports the sustainable development planning, land administration and land management needs peculiar to each country. A country may be able to achieve sustainable development planning, land administration and land management through re-engineering existing land administration and land management procedures, including the laws and regulations required to maintain cadastre's historic roles of guaranteeing an individual's unambiguous property rights, public common interest and a government's land tax income. A country could therefore achieve sustainable development by using this re-engineered land administration and land management" (United Nations, 2005).

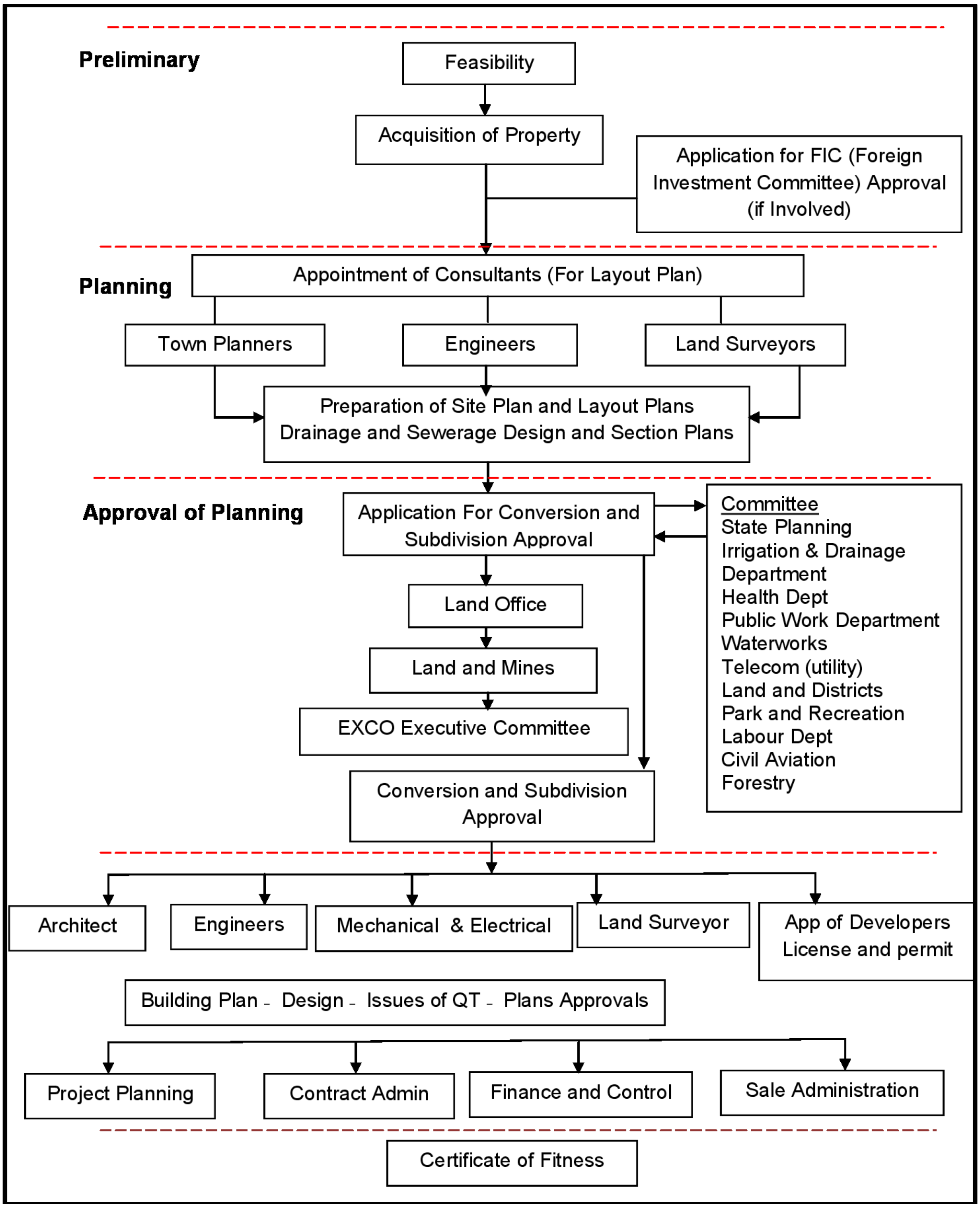


Figure 3-1 **Preliminary planning approval of planning in Malaysia**
(Tan, 2001)

Land development is the process of converting land to residential, commercial, industrial or other purposes. The outcome will impact on residential density, the physical environment and the social economy. **Figure 3.1** shows the current planning process for land and property development in Malaysia. The most important stages are the preliminary stage, the planning stage and the approval of planning stage; these determine the success of the development.

In the preliminary stage, the organization that may be involved is either the developer or the land owner. At this stage the information needed from the MPC are the private and public restrictions on that particular land parcel.

In the planning stage the professional consultant from the private sector or public sector such as town planner, engineer or land surveyor will be involved in preparing site plans and layout plans, drainage and sewerage designs and section plans. Such a user will need very accurate geometric data from the MPC, such as NDCDB and mapping data.

In the approval of planning stage, the authorities will consider the application with advice from various government departments such as the state planning department, waterworks department, public works department, etc. This group of authorities needs a wide range of data and layers in one integrated database. Accuracy of geometric data is important for some departments, such as the forestry department, to see if there is any overlapping of a particular land parcel with a forest reserve; likewise the utilities company. But some may need to see the whole picture, which does not require high accuracy geometric data, such as the health department and the labour department who only want estimates from attribute data, for example, of the resident population (demography data).

Analysis of the process of land development will reveal the users groups and their requirements.

The next task is to list the data suppliers of MPC. This can be done by analysis of the existing organizational flow of the National Spatial Data Infrastructure (NSDI), in Malaysia known as MyGDI. The multipurpose cadastre system organizational data flow will be developed by taking into account the data custodian concept and the MyGDI data flow which are outlined in **Figures 3.2** and **3.3**.

Data Custodians and Lead Agencies

Data Theme & Sub-Theme	Agencies (Data Producers / Custodians)	Lead Agency
1. ADMINISTRATIVE BOUNDARY		
Jurisdictional Boundaries	Dept. of Survey & Mapping Malaysia, Land & Survey Dept.(Sabah & Sarawak)	Dept. of Survey and Mapping Malaysia
Electoral Boundaries	Dept. of Survey and Mapping Malaysia	
Planning Zones	Town & Planning Dept.	
2. CADASTRAL		
Cadastral Land Parcels Qualified Title Parcels	Dept. of Survey & Mapping Malaysia Land & Survey Dept.(Sabah & Sarawak) District Land Offices (All States in Peninsular Malaysia)	Dept. of Survey and Mapping Malaysia
Land Tenure	Land Office, Land & Survey Dept.(Sabah & Sarawak)	Land Office
Valuation	Local Authorities,Valuation Dept., Land & Survey Dept.(Sabah & Sarawak)	Valuation Dept
Data Theme & Sub-Theme	**Agencies (Data Custodians)**	**Lead Agency**
Building	Dept. of Survey & Mapping Malaysia, Valuation Dept., Land & Survey Dept.(Sabah & Sarawak), Local Authorities	Dept. of Survey and Mapping Malaysia

Figure 3-2 Example of SDI data suppliers, lead agencies and the data custodian concept
(Fauzi Nordin, 2007)

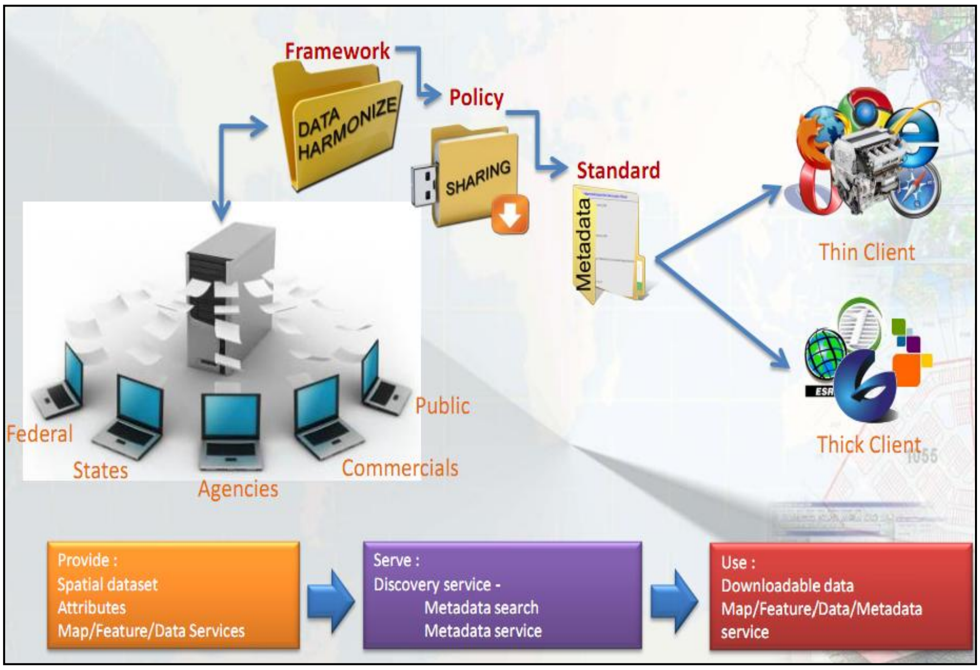


Figure 3-3 The data flow of MyGDI
(Fuziah, 2010)

Three steps are proposed, to develop the organisation of the MPC data flow, as described below.

Step 1

Initiate the gathering of existing legislation concerning each data class in the multipurpose data model and show how this can be accessed by the stakeholder at the land development planning stage.

The system will show a collection of legislation in the attributes or metadata of the database, its boundaries will be shown in the database following query and depend on the requirements of the decision maker. Most of this legislation is involved with public restrictions and, as suggested in Cadastre 2014 (Kaufmann, 2002), the database will show the complete real situation in the field.

Examples of written law that should be embedded in the database:

1. National Land Code 1965
2. National Land Code (Penang and Malacca Titles) 1963
3. Strata Title Act 1985
4. Town and Country Planning Act 1976
5. Street Drainage and Building Act 1974
6. Rules & Order, and Building and Common Property (Maintenance and Management) Act 2007
7. Land Acquisition Act 1965
8. Environment Quality Act 1974
9. Malay Reserve Enactment 1913
10. Mining Act 1960
11. Continental Shelf Act 1960
12. Group Settlement Act 1960
13. Land Conservation Act 1960
14. Forestry Act 1993
15. Wildlife Conservation Enactment 1997 in Sabah state
16. Wildlife Protection Ordinance 1998
    and,
17. The Sarawak Government Gazette

Unfortunately, it seems, only written law can be attached to a database, although some decision making can be based on unwritten laws such as those pertaining to culture, values, codes of ethics and social relations.

STEP 2

Evaluate provisions in the National Land Code 1965 relating to MPC. Propose means for legalizing the MPC data model and making its use compulsory by all involved in land development.

Before the final survey of a particular property, no title can be registered and issued as final. The cadastre survey has to be completed and the final title prepared by the Survey Department or Licensed Land Surveyor. It is asserted that Section 396 (1) of National Land Code 1965 (Act 56) specifies that, for the purpose of the act, land shall not be taken to have been surveyed until:

" (a) its boundaries have been determined by right lines;

(b) its boundaries as so determined have been demarcated on the surface of the land by boundary marks or, if by reason of the configuration thereof or for any other cause the placing of boundary marks on the actual line of the boundary is to any extent impossible or impracticable, boundary marks have been so placed as to enable that line to be ascertained;

(c) the area enclosed by its boundaries as so determined has been calculated;

(d) a lot number has been assigned thereto by the Director of Survey; and,

(e) a certified plan, showing the situation of the land, the position of its boundaries as so determined and of the boundary marks placed thereon and the area and lot number thereof, has been approved by the Director of Survey."

(National Land Code, 1965: 292-293)(Malaysia International Law Book Services Legal Research Board, 2011)

Section 396 in the National Land Code 1965 clearly states the importance of parcel boundaries' surveys. The purpose of Section 396 is to ensure undisputed title, as suggested by the Torrens System. The implementation of MPC should maintain the original objective of the cadastre system of Malaysia. Therefore it is not necessary to amend this section.

An additional goal (or purpose) introduced into the cadastre system by MPC is to have sustainable development in the country. This will require amending some provisions involved in planning and land use control, such as the subdivision, amalgamation and conversion sections in the National Land Code 1965.

The data model can be made visible and legalized at the stage of application for conversion and subdivision approval in the land development process. Any person who wants to develop land should conform to the conditions in the National Land Code 1965 and other controls of land use imposed by the state (Land Office) and local authorities (District Council and City Council). Development procedures are very simple and convenient if based on well documented and easily digestible legislation, but inconsistencies of criteria, conditions, considerations and policies for approval of development applications arise from changing rules based on political, socio-economic, environmental considerations, etc. This may lead to confusion among developers, legal practitioners and even the authorities who approve the applications. Thus, this proposed MPC model should be used in the approval process as it shows the complete situation and all information about the plot of land.

Therefore, under Section 124A, 137(1)b, 148(1)b, 204D(d) regarding subdivision, amalgamation and conversion in the National Land Code, 1965 it is recommended that the additional processes discussed below, shall be included.

The Layout plan and pre-computation plan should be overlaid with the MPC data model before being approved.

A sustainable development report from the MPC system should be generated and attached together with the application submission. This report may contain an Environment Impact Assessment (EIA) report based on the Environmental Quality Act 1974.

An example of the amendment of conditions for approval of the sub-division of land that can be implemented within section 136 of the National Land Code by inserting a new additional clause in (c) (which can be named (c) i) is presented below, following the restatement of (c):

c)

- that the sub-division would not contravene any restriction in interest to which the land is subject;
- that the sub-division should not be contrary to any written law in force, and that any law imposed has been complied with;
- that any necessary approval of the planning authority has been obtained; and,
- that the sub-division is not contrary to any plan approved by the State Authority for the development of the area.
  (Malaysia International Law Book Services Legal Research Board, 2011)

(c) i)

- the planning plan shall be submitted together with the sustainable development report, upon approval;
- that no land revenue is outstanding;
- that written consent has been obtained from every person or body entitled to the benefit of the land, such as a charge on the land, a lease on the land, etc.;
- in the case of agricultural land, it will not be less than two fifths of a hectare;
- that the shape of each subdivided lot will in the opinion of the State Authority suitable for the purposed for which it is intended to be used; and,
- a satisfactory means of access is available, as of right, either to a road, a river, a part of the foreshore or a railway station, or to a point within the land from which such a means of access will be available.

In current practice, applications for conversion and subdivision for approval are submitted through a Licensed Land Surveyor to the Land Office (State). The licensed Land Surveyor is the professional who has the expertise and should be assigned to help the local authority in the process of layout plan approval.

The State can impose a land use category in the title document for the purpose of land development planning when the land is first alienated. This refers to the long term land use planning as the approval of subsequent development on the same land will be based on the condition that has been written into the title document. By categorizing land into agriculture, building and industry and imposing conditions and restrictions based on the National Land Code 1965 it is ensured that its use conforms with the National Economy and Land Use Policy suggested by Federal departments.

Considering the National Land Code 1965, Section 115 for Agricultural Land, Section 116 for Building Land, and Section 117 for Industrial Land have specified conditions and restrictions on the land use for a parcel. A title document expresses the category in which the parcel falls. The proprietor then has to obey the implied condition. For example, for Agricultural Land Section 115, a proprietor is prohibited from building a commercial house or factory on the land. But this is very hard to regulate in the field, by the Land Office. Section 115 should be amended by giving power to the land officer to check the physical condition of the land by logging in to the MPC database.

Article 91(5) in The Federal Constitution confers power to the National Land Council to formulate a national policy for the promotion and control of the utilization of land in the country for mining, agricultural, forestry or any other purpose in consultation with the Federal and State governments and the National Finance Council. As land is a state matter it can be expected that each state will want to decide what it can do with its land rather than be subjected to a national policy. The deputy Prime Minister, who is the chairman of this council, can persuade states to use the same data model as a reference guide in their state land policy and thus solve serious national issues, such as illegal logging.

STEP 3

Propose the means for regulating data sharing.

The Geospatial Act that is proposed by JUPEM and the Spatial Data Committee shall address the question of data sharing. It should be tabled at a Cabinet meeting in 2013. This act will focus on data confidentiality and security, custodianship, information sharing, data integration and geospatial data standards.

It is suggested that JUPEM has to strengthen its NDCDB and data should be integrated with building data, mapping features and Land registration. The combination of these data should be given priority in the Geospatial Act as it will become the reference and background for other data.

When data sharing is regulated, sharing the update data is another issue; this requires technology such as SOA to enable the data suppliers to update their data easily. This, i.e. SOA, is going to be a subsequent focus of this report, dealt with in chapter five and six.

3.5 Summary of Chapter 3

Malaysia has well organised written land law, for example the provision in KTN 1965 was written following the Torrens system and is sufficiently flexible to support MPC. It has been found that the implementation of this system will involve rearranging of existing legislation and turning unwritten law, such as customary law, to written law. The legislation will be presented in map or digital, the latter providing access to the whole (legal) picture of public rights and private rights in a particular parcel.

As land matters fall under the state, the state government shall work closely with the federal government for the implementation of MPC. MyGDI could be the guideline on how data were shared among organisations, but the concepts of data custodian, data warehouse may not necessarily be ideal for MPC to share data. The priority purpose of MPC is providing information to help sustainable development, the organisations who are involved in the development process shall be targeted as the first user group. The proposed of Geospatial Act will also be the spring board for this system to become reality. This chapter has provided 3 steps that deal with legislative and organisational issues.

Chapter 4: Design and development of a multipurpose cadastre data model

4.1 Chapter introduction

Chapter Four will focus on the core of this investigation. Using the information in chapter two and three, a multipurpose cadastre (MPC) data model which is suitable for Malaysia will be designed and developed. This chapter also looks at various functions and quality control procedures associated with the data model which can be executed in order to fulfil the user requirements. This chapter will involve technical processes to create the data model; the chapter also deals with various data formats, different coordinate systems and different datums.

The structure of the database in JUPEM will be emulated, particularly utility data, also other data that can be considered part of a multipurpose cadastre. A database will be designed to include data ‘check in’ and data validation procedures.

An easement case study will be conducted using the database to simulate a multipurpose cadastre service. This case study will utilize parcel, utility and building data.

In performing these processes tools provided by Oracle to develop and prototype the applications will be used. The database will be developed in the open source environment using the SQL language and map rendering using Oracle Fusion Middleware MapViewer which utilizes JAVA and XML format.

4.2 Tools involved in this chapter

The following Applications Development tools are used:

- Oracle database 11g version Release 2 enterprise edition;
- Oracle SQL Developer version 3.0.04;
- Oracle SQL Developer Data Modeler version 3.0.0.665;
- Oracle Fusion Middleware MapViewer version 11g ps4 (11.1.1.5.1);
- Oracle Map Builder 11g ps4 (11.1.1.5.0); and,
- OC4j Standalone 11g ps4 (11.1.1.5.1).

The following Programming Languages are used:

- Structured Query Language (SQL) with Oracle Spatial Function; and,
- Java, XML and GML (Generated by SQL developer).

4.3 Data design

As suggested in the chapter 1, three feasible data models (Types 1, 2 and 3) will be investigated as summarised below.

Type 1. A spatially-referenced data model based on Legal Land Objects as suggested in the document of Cadastre 2014 by FIG, processed in independent layers, with data stored in different service providers' locations and retrievable by SOA methods.

Type 2. Land Parcel based data stored in a Relational Object oriented database with high geometric accuracy and with other agencies' existing data collected by JUPEM and stored in a centralised relational database;

Type 3. A Hybrid data model that integrates Type 1 and Type 2 data models, and depends on service types and applications.

In this chapter, data model Type 2 is developed and discussed in detail.

The data model Type 1 structure allows legal objects to be stored independently, thus to remove legal objects or add in legal objects can become the responsibility of an independent authority or agency. It is expected that SOA technology can be a key to turning this into reality, SOA will be discussed further in Chapter 5 and 6.

The combination of both Type 1 and Type 2 will be discussed in Chapter 5. The Type 2 data model design was influenced by the Oracle Spatial technology used to develop the database. Oracle Spatial is part of Oracle Enterprise Edition, it provides open standard/source data types which can be developed using SQL language.

4.4 Investigation of existing data structure

In Malaysia, under the eKadaster project, the creation of NDCDB is of paramount (i.e. parcel) importance for achieving a "survey accurate" coordinated cadastre lot database.

Multipurpose cadastre field survey should use survey accurate measurements based on digital cadastre database coordinates developed in the eKadaster project. It is thus useful to investigate the existing data structure of NDCDB which is shown in **Figure 4.3**.

4.4.1 Database technology in JUPEM

JUPEM is currently using MapInfo, Professional MapInfo, MapBasic MapInfo and MapXtreme to manage ASCII files for field operation and for office operations to update the Oracle database (Oracle Database version 10g Enterprise Edition is currently used in JUPEM).

At the heart of the proposed eKadaster Database Design is an object-relational database that is based on Oracle Spatial with MapInfo Professional as the front-end. Oracle Spatial is an Object-Relational Database Management System. Object-Relational database systems such as Oracle 10g Spatial facilitate the definition, storage, retrieval, and manipulation of user-defined data types in the database through the use of user-defined functions and index methods.

Thus Oracle Spatial can handle spatial information represented using a spatial object data type, and accessed or manipulated using spatial index methods and functions. Because 'spatial' is now just another attribute represented in the database, users can use it as another qualifier or criteria when searching or browsing the database. There are several major benefits to managing the spatial and attribute data in a single Oracle Spatial database (Murray, 2011), given below:

Major benefits of the Oracle Spatial database approach to spatial data management include:

a. handling large database files;

b. allowing multi-user access and, thus, better data management for spatial data; users gain access to fully functional spatial information systems based on industry standards with an open interface (e.g. SQL); to their data spatial data can be stored in an enterprise-wide database, thereby facilitating many more spatially enabled applications;

c. offering an open system and that, by using an open SQL platform, proprietary data structures are avoided, thereby allowing for the seamless integration of e-business and location-based services. This facilitates the task of delivering applications that meet the increasingly demanding analysis and reporting needs of a growing information and knowledge management community.

4.4.2 Oracle Spatial technology

The spatial data model has a hierarchical structure consisting of elements, geometries and layers. Spatial layers are composed of geometries that are in turn composed of elements. An element is the basic building block of 'a geometry'.

For example, elements might model utility poles (points), roads (line strings), or county boundaries (polygons). In the case of polygons with holes (such as an island within a lake) the exterior ring and the interior ring of the polygon are considered as two distinct elements that together make up a complex polygon. A geometry is the presentation of a user's spatial feature, modelled as an ordered set of primitive elements (Kothuri et al., 2007).

A geometry can consist of a single element, or a homogeneous or heterogeneous collection of primitive types. A ‘multipolygon’, such as one used to represent a set of islands, is a homogeneous collection. A heterogeneous collection is one in which the elements are of different types. A layer is a heterogeneous collection of geometries that share the same attribute set. For example, one layer in a spatial information system might include geographical features, while another describes census areas, and a third describes the network of roads and bridges in an area. Layers correspond to a table or set of tables while a geometry is one instance of the type MDSYS.SDO_GEOMETRY and is stored in a particular row and column in a table (Kothuri et al., 2007).

According to Oracle, the type MDSYS.SDO_GEOMETRY is a container for storing points, lines, polygons, or homogeneous or heterogeneous collections of these elements. Attributes consist of a geometry type identifier, a spatial reference system identifier, an element descriptor array and an ordinate array, among other things. The ordinate array contains the values for coordinate pairs or triplets that define the vertices of the geometric elements. The element descriptor array defines how these ordinates should be assigned to the element or elements that constitute the geometry. This array also determines whether a pair of vertices (or a triplet) is connected by a straight line segment or a circular arc. Arcline string and Arc polygon are elements whose vertices are connected using circular arcs. A compound element is one whose vertices are connected by a mix of straight line and circular arc segments (Murray, 2011).

4.4.3 Database schemas in eKadaster

Oracle Spatial provides SQL schemas and functions that facilitate the storage, retrieval, update and query of collections of spatial features in an Oracle database.

<table>
<tr><th>Database</th><th>Schema</th><th>Table Groups</th></tr>
<tr><td rowspan="4">• eKadaster</td><td>• NDCDB (National digital cadastral database)</td><td>• Pre_NDCDB
• NDCDB
• New_PDUK_Archived
• CRM
  o CCI (cadastral control infrastructure)
  o CRM (cadastral reference mark)</td></tr>
<tr><td>• eGLMS (electronic geographical layer management system)</td><td>• PU/Precomp/SKL/Presurveyed
• Qualified title/ QT
• Warta
• Road/Jalan
• Building/Bangunan
• AdminBdy (boundaries)
• Townkg
• Hidrography/Hidrografi
• Index Grid</td></tr>
<tr><td>• CSRS (cadastral survey record system)</td><td>• CSRS
• eSIM (Spatial)
  o eFees
  o eNotification
  o CCIWP</td></tr>
<tr><td>• PDUSSM</td><td>• Strata</td></tr>
</table>

Figure 4-1 The list of Oracle database schema in eKadaster

Each schema defines the tables, the fields in each table and the relationships between fields and tables. The eKadaster database design consists of the schemas shown in **Figure 4.1**.

eGMLS (GIS Layer Management System) has been developed to produce an application which is able to create, capture and maintain GIS data such as Building (e*Bangunan*), Road (e*Jalan*), Administration Boundaries (eAdminBoundary), Hydrography (e*Hidro*), Reserve (e*Warta*) etc. This indicates that in the eKadaster project, efforts towards MPC have already been made.

4.4.4 NDCDB schema and NDCDB group table

JUPEM amended the database structure in 2006, when a coordinated cadastre system was introduced. The old and new structure is referred to in the **Figure 4.2 (**old structure**)** and the **Figure 4.3 (**new structure**)**.

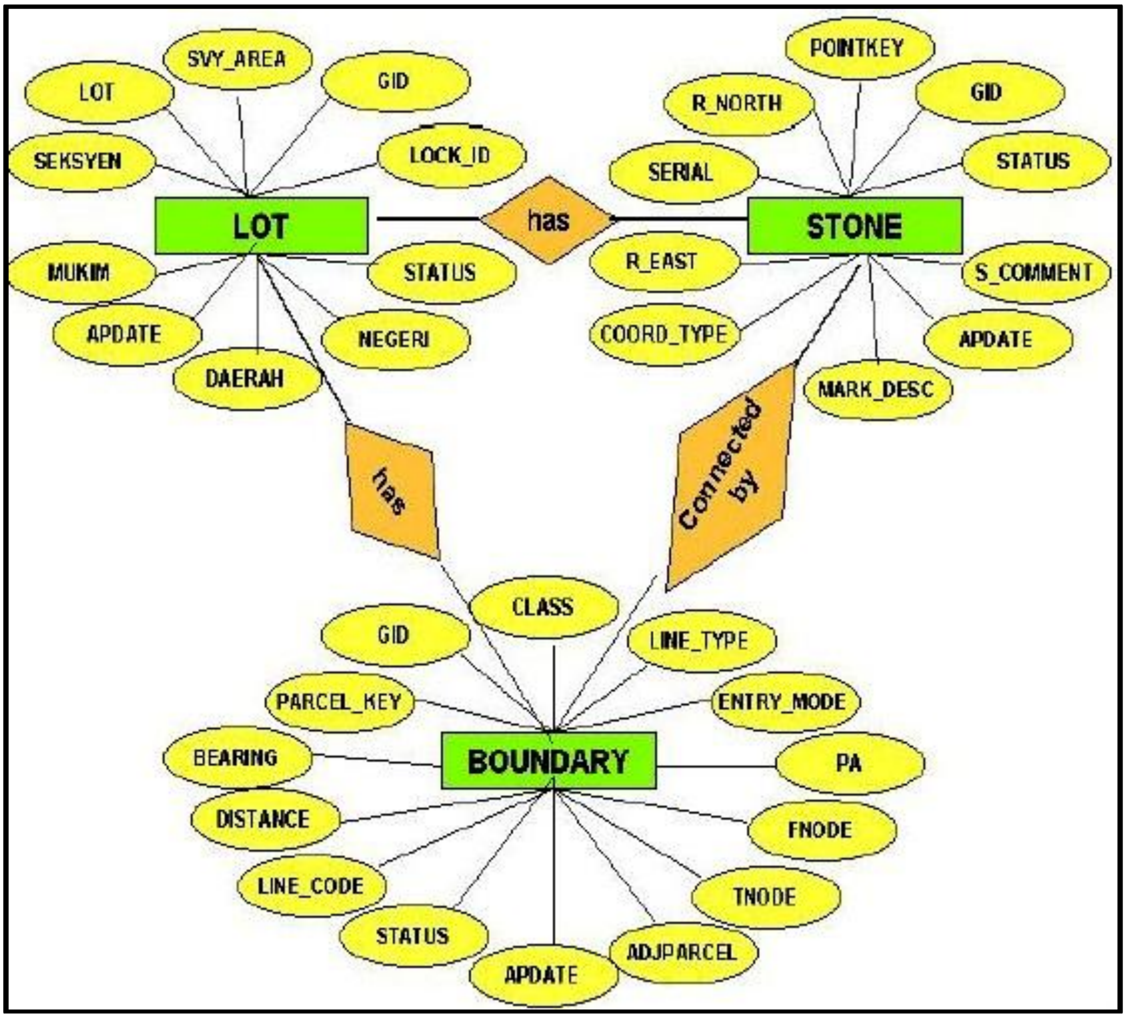


Figure 4-2 The relationship of objects (old NDCDB structure)
(between tables LOT (NDCDB_LOT), STONE (i.e. boundary marker) (NDCDB_STN) and BOUNDARY (NDCDB_BDY), (Abdullah Hisham, 2003))

NDCDB_BDY	
Field Desc.	**Type (Varchar)**
UPI	Varchar2(16)
ADJPARCEL	Varchar2(16)
BEARING	Varchar2(9)
DISTANCE	Dec(12,4)
FNODE	Dec(13,0)
TNODE	Dec(13,0)
TARIKH_KEMASKINI	Date

NDCDB_PLAN	
Field Desc.	**Type (Varchar)**
PA	Varchar2(15)
APDATE	Varchar2(8)
APPROVER	Varchar2(35)
APPROVERIC	Varchar2(12)
SURVEYOR	Varchar2(35)
SURVEYORIC	Varchar2(12)
SURVEYCOMPLETED	Varchar2(8)
NOSYITPIAWAI	Varchar2(30)
TARIKH_KEMASKINI	Date

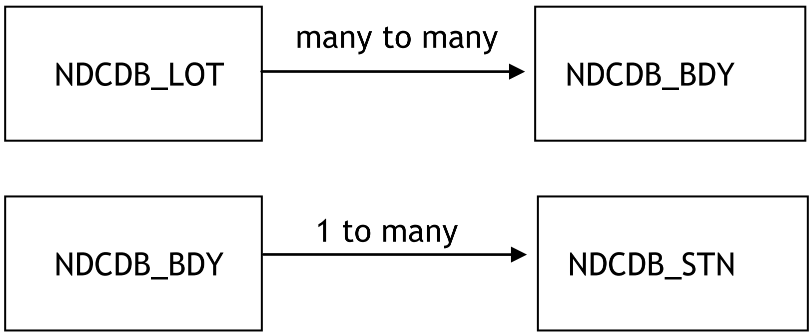
NDCDB_LOT	
Field Desc.	**Type (Varchar)**
NEGERI	Varchar2(2)
DAERAH	Varchar2(2)
MUKIM	Varchar2(2)
SEKSYEN	Varchar2(3)
LOT	Varchar2(7)
UPI	Varchar2(16)
NOPEJTANAH	Varchar2(70)
NOFAILUKUR	Varchar2(30)
S_AREA	Dec(18,3)
KOD_KEGUNAANTANAH	Varchar2(2)
PA	Varchar2(15)
APDATE	Varchar2(8)
TARIKH_KEMASKINI	Date

NDCDB_STN	
Field Desc.	**Type (Varchar)**
STN_ID	Dec(13,0)
SERIAL	Varchar2(8)
MARK_DESC	Varchar2(13)
NORTH_CAS	Varchar2(12)
EAST_CAS	Varchar2(12)
STD_ERR_NORTH_CAS	Dec(18,6)
STD_ERR_EAST_CAS	Dec(18,6)
NORTH_RSO	Varchar2(12)
EAST_RSO	Varchar2(12)
TARIKH_KEMASKINI	Date

Figure 4-3 The existing (new) structure of NDCDB
((Teng, 2009a)- a translation from Malay is found in the **Appendix A**)

There are four main tables in the NDCDB database: NDCDB_BDY (Boundary table), NDCDB_PLAN (Certified Plan table), NDCDB_LOT (Parcel table) and NDCDB_STN (Boundary Point table). The NDCDB_PLAN table is used currently to produce certified plans for title documents and it is not necessary for the MPC database.

The three tables NDCDB_BDY, NDCDB_LOT and NDCDB_STN are used to form the reference data for MPC database. The relationship between the three tables could be strengthened by introducing a few extra linking keys such as in NDCDB_BDY table where it is found that only one adjacent parcel attribute exists while it is more suitable to have two adjacent parcel attributes. The relationship between the three tables can be presented as follows:



4.4.5 Prototype of MPC database

This prototype contains five examples of features as follows:

a) three features from NDCDB database which are parcel, boundaries and station (the reader should note that several alternative words are used for this feature in this thesis and include 'stone', 'marker', 'boundary marker') table;

b) one building feature from the digital topography map (i.e. Town Map); and,

c) one utility feature from the Utility Map.

Building and utility features are the only two data samples used in the prototype described in this chapter, although the idea of a multipurpose data model is to integrate various data such as natural resources, demography data, transportation, etc. However the technical knowledge and experience gained in this case with only two data samples can be used with the remaining data features.

The prototype developed using the Oracle Spatial database platform, in SQL developer, is shown in **Figure 4.4**.

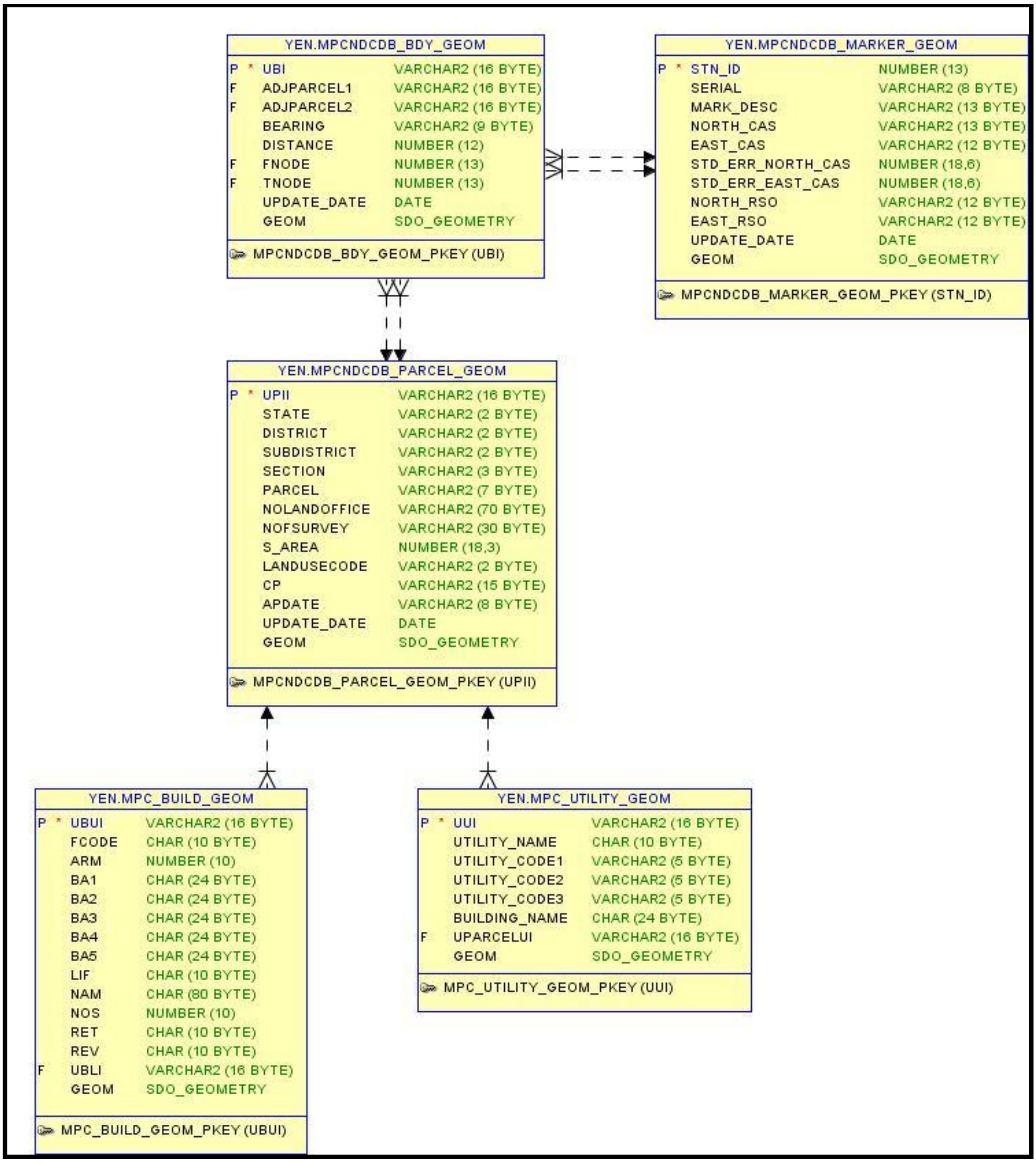


Figure 4-4 Prototype of MPC database
(created using spatial model table generated by Data Modeler)

The NDCDB raw data are in ESRI shape files, and an Oracle Java Shapefile Converter provided by ESRI, is used to convert all the geometries and attributes from shape files into the spatial features. This Oracle Java Shapefile Converter's name is oracle.spatial.util.SampleShapefileToJGeomFeature. An example command to use this converter, under a DOS Prompt is:

```
set ORACLE_HOME=d:\app\cysim\product\11.2.0\dbhome_2

set
clpath=.;%ORACLE_HOME%\jdbc\lib\ojdbc5.jar;%ORACLE_HOME%\md\j
lib\sdoutl.jar;%ORACLE_HOME%\md\jlib\sdoapi.jar

java -cp %clpath%
oracle.spatial.util.SampleShapefileToJGeomFeature -h
localhost -p 1521 -s orcl -u yen -d yen -t Parcel_shape -f
Lot -r 18000000 -g geom
```

As an explanation, the Oracle database is created in the localhost 1521 laptop, has instance name orcl, username yen and password yen, the output Oracle database table is Parcel_shape and the shapefile name is Lot. 18000000 is the SRID (Spatial reference ID) number for the GDM2000 coordinate system that has been created in Oracle. The geom is the row that stores the coordinates of this parcel feature (the operation is shown in **Figure 4-5**).

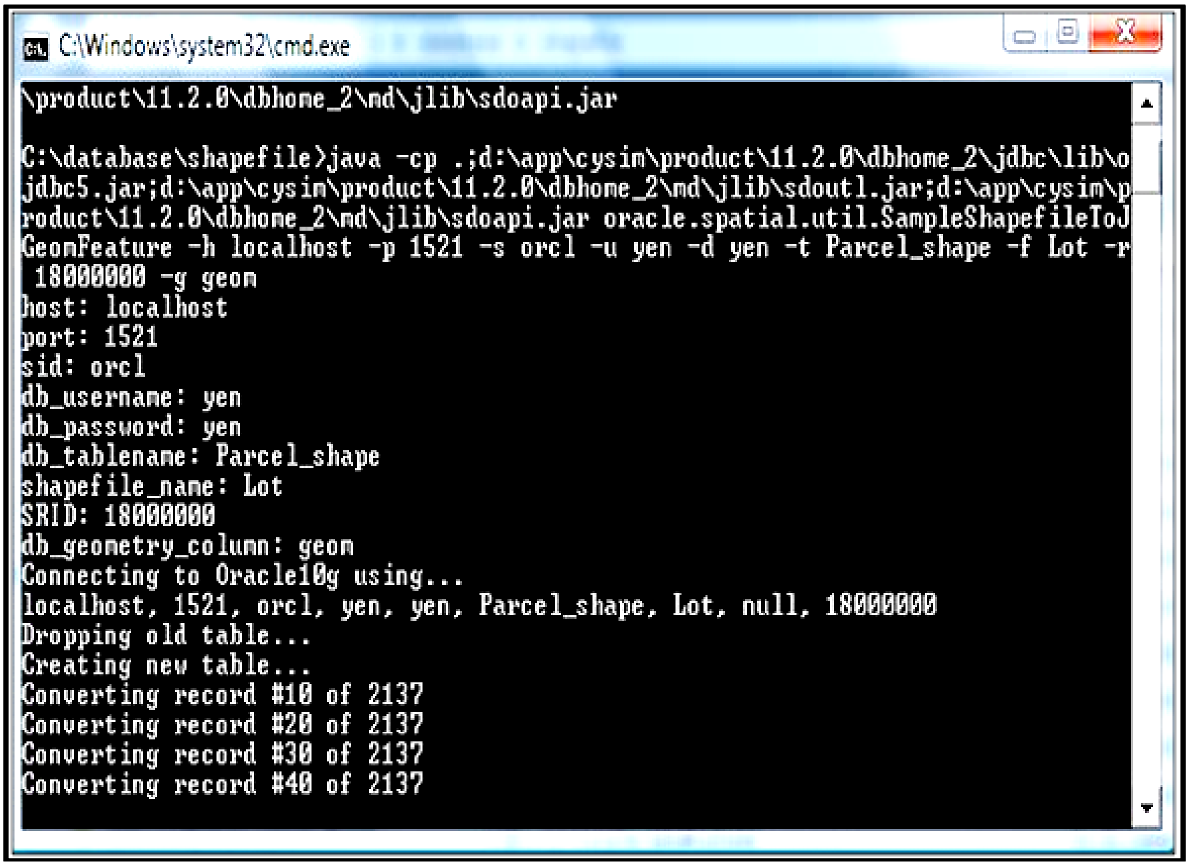


Figure 4-5 The operation of Shapefile converter

Further relevant information:

- the programming syntax to create the database is in the **Appendix B;**
- the detailed report of the database created is in the **Appendix C**;
- the quality of data is checked using a validation command that exists in the Oracle database, and Mapviewer is used for visualization and query; and,
- the new coordinate system created in Oracle Spatial (i.e. SRID) to support the GDM2000 datum is that now used widely in Malaysia.

4.4.6 Data integrity

Data integrity is checked by providing constraints and linking keys between tables. For example a constraint of 'not null' was given to the UPI (Unique Parcel Identifier) because this column is a foreign key in the building table and in the boundary table. An absence of this value will result in a rejection when data undergoes 'check in' from a particular provider. However, if there are many data constraints applied to the database, then database query will be slowed down.

The constraint of 'uniqueness' is also given to column names, to ensure there is no repetition or redundant data stored in the database (the example shown in **Figure 4.6**).

The **Table 4.1** examples of Entities reports show the relationship between the building data table (MPC_BUILD) and the parcel data table (MPCNDCDB_PARCEL).

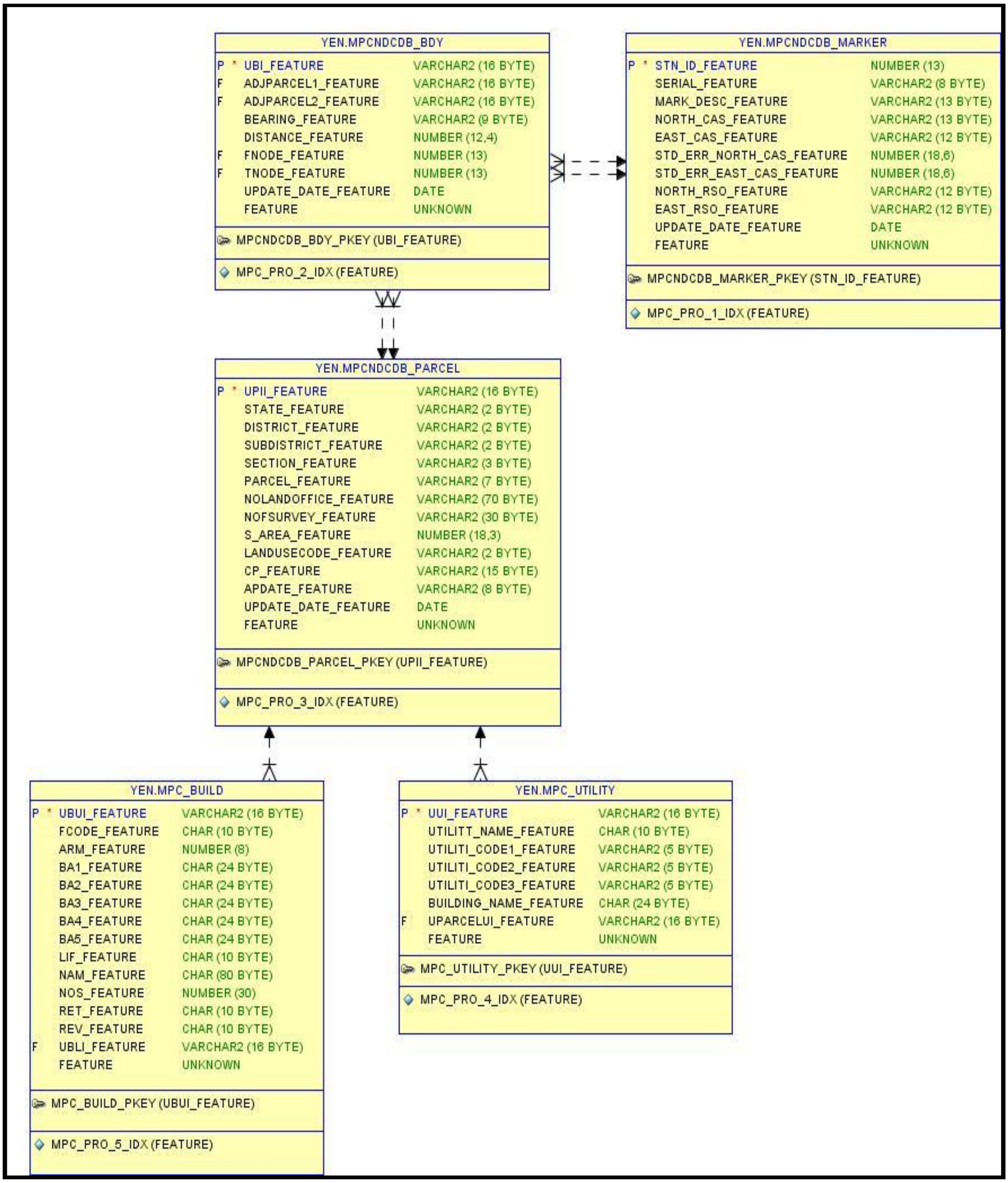


Figure 4-6 The presence of constraint in the database
(primary keys (P) and foreign keys (F) effecting constraints)

Entity Name	MPC_BUILD
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name
Relational_1.YEN.MPC_BUILD

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	15

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	4.4.6.1.1 UBUI_FEATURE				4.4.6.1.2 VARCHAR (16 BYTE)	4.4.6.1.3 LT				

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_PARCEL				4.4.6.1.4 0..*:0..1			4.4.6.1.5 Y

Table 4-1 Example of entity report

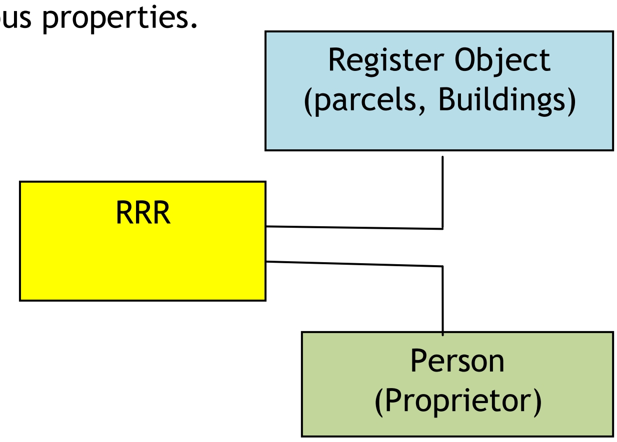
(The detail of report is in **Appendix C**)

The building table contains the attribute UBLI_FEATURE which is a foreign key (see **Figure 4-6**) thus linking it with the parcel data table (MPCNDCDB_PARCEL), via its primary key (UPII_FEATURE) to which it is identical. This model is simple and useful example of a parcel and its legal object (a building) that have a one to one relationship.

A more complex and flexible database should be built to cater for multi-storey buildings (Legal Objects), such as a Strata (i.e. storeys above ground) or Stratum (i.e. storeys below ground) Title.

For a Stratum Title, the land below the surface of the parcel can be alienated to a particular proprietor. The Strata and Stratum Titles require a 3D cadastre and Oracle Spatial has the capability of storing in 3D. In this case, space described by accurate geometry is important; currently JUPEM has developed a different application and database to store these layers, because most of the parcels' data do not yet have height data; until 3D cadastre is implemented in Malaysia, the databases have to be separate.

JUPEM has proposed that the building foot print be integrated into the MPC database. The building data is crucial to users when the legal object (a building) does not belong to the parcel's proprietor - for example some spaces in a strata scheme (such as landing spaces in flats, apartments, condominiums and multiple storey offices) belong to the management body and individual apartments may have various properties.



The concepts of rights, restrictions and responsibilities (RRR) in the Land Administration Domain Model (LADM) and the Core Cadastre Domain Model (CCDM) introduce another two extra tables in the database, RRR and Person.

Register object (Parcel, Building) is connected with Person (Proprietor) using RRR table.

According to Lemmen, “the CCDM contains both legal and administrative object classes such as persons, rights and the geographic description of real estate objects. This means, in principle, that data could be maintained by different organizations. The model will most likely be implemented as a distributed set of information systems, each supporting the maintenance activities and the information supply of parts of the dataset represented in this model, thereby using other parts of the model. The model can also be implemented by one or more maintenance organizations operating at national, regional or local level. Different organizations have their own responsibilities in data maintenance and supply and have to communicate on the basis of standardized processes in so called value adding production chains” (Lemmen and Van Oosterom, 2006) .

The data model should be expanded by introducing not only attributes in the Register Object (Parcel or Building) but as separate RRR and Person tables.

A topology model is also another constraint to be implemented in MPC to ensure the database is geometrically correct.

4.4.7 3D cadastre role in MPC

Oracle Database 11g supports the storage and retrieval of three-dimensional spatial data, which can include point clouds (collections of points), lines, polygons, surfaces and solids.

The SDO_GTYPE is the code for the type of geometry, and SDO_ELEM_INFO is the sequence or layout of a set of geometry as shown in **Figure 4-7**.

Type of 3D Data	SDO_GTYPE	Element Type, Interpretation in SDO_ELEM_INFO
Point	3001	Does not apply. Specify all dimension values (3) in the SDO_POINT_TYPE attribute.
Line	3002	2, 1
Polygon	3003	1003, 1: planar exterior polygon 2003, 1: planar interior polygon 1003, 3: planar exterior rectangle 2003, 3: planar interior rectangle
Surface	3003	1006, 1: surface (followed by element information for the polygons)
Collection	3004	Same considerations as for two-dimensional
Multipoint (point cloud)	3005	1, n (where n is de number of points)
Multiline	3006	Same considerations as for two-dimensional
Multisurface	3007	Element definitions for one or more surfaces
Solid	3008	Simple solid formed by a single closed surface: one element type 1007, followed by one element type 1006 (the external surface) and optionally one or more element type 2006 (internal surfaces) Composite solid formed by multiple adjacent simple solids: one element type 1008 (holding the count of simple solids), followed by any number of element type 1007 (each describing one simple solid)
Multisolid	3009	Element definitions for one or more simple solids (element type 1007) or composite solids (element type 1008)

Figure 4-7 The list of 3D geometry supported in Oracle Spatial
(Wammes, 2011)

4.4.8 Topology structure model

In Oracle Spatial, a spatial feature can be stored in two ways:

- Object storage: stores each feature as a separate but complete object. This can be accomplished with Oracle's SDO_GEOMETRY type. Object storage is optimal for applications that require manipulation and display of geometry data as complete objects, for example, map generation.

- Topology storage: each feature is modelled in terms of its basic topological elements which are Nodes, Edges and Faces. Topological storage is optimal for data collection as well as for applications that require topological consistency for example land management. (Topology is a branch of mathematics that defines objects in space and how they interact.)

4.4.8.1 The advantages of using topology

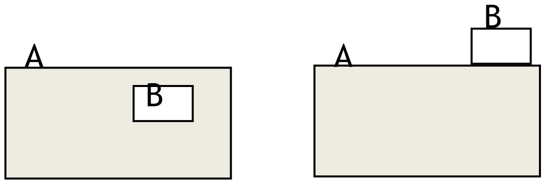
There are several advantages of using a topology data model over an object data model:

- There is no redundant storage of data. In the object data model, the edges between two adjacent land parcels are stored twice, once for each land parcel. In the topology data models, the shared edges are stored only once. In addition, Oracle's topology data model allows features from different layers to share topological primitives, for example roads and land parcels.

- Data remain consistent in the topology data model. In the object model, the shared edges between the adjacent parcels are stored twice. The parcel boundaries may be slightly inconsistent because the edge coordinates of the adjacent parcels may not be perfectly aligned. Also, if an adjacent edge between parcels changes, it must be changed in two places. The topology data model eliminates data inconsistency issues, an aspect of integrity.

- The topological relationships are very easily and quickly determined using the topology data model.

Examples of topological relationships include TOUCHES, INSIDE, CONTAINS.



A Contains B
B is Inside A

A Touches B
B Touches A

4.4.8.2 Topology concepts of nodes, edges, and faces

Nodes may represent point features which bound an edge. An edge is always bounded by two nodes; it may be directional and may represent linear features. Faces may represent polygon features.

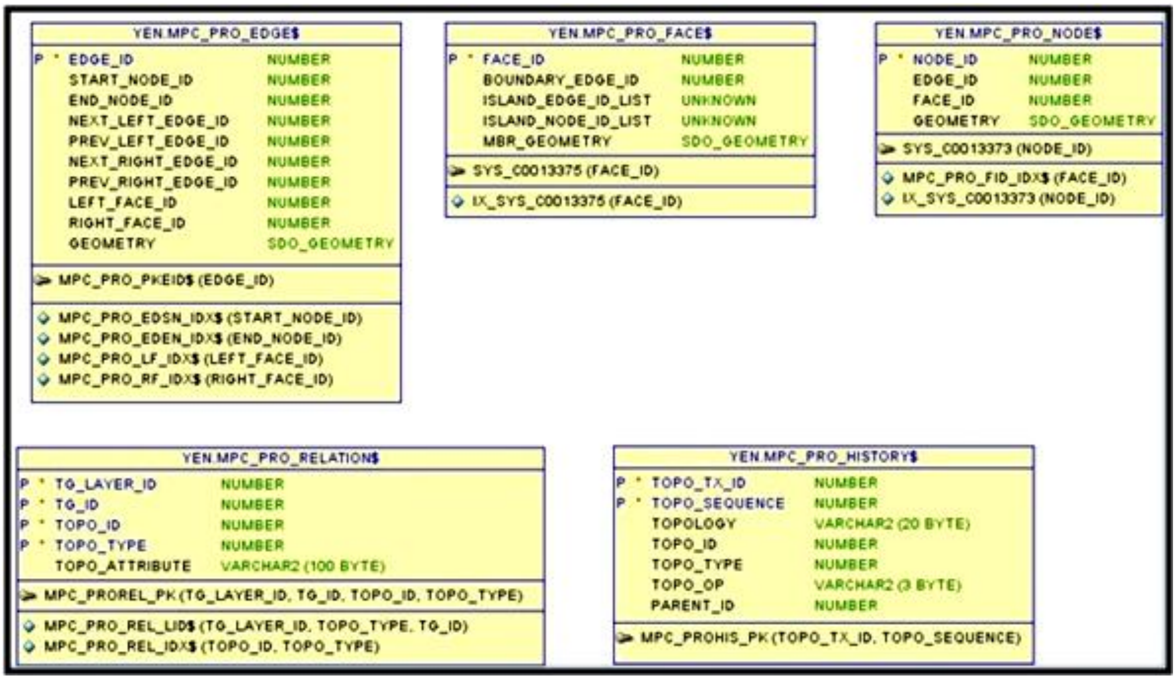


Figure 4-8 Tables of topology
(Example that created in this database)

In the topology data model as shown in **Figure 4-8**, when SDO_TOPO.CREATE_TOPOLOGY is called, the following tables are created:

- Three tables that contain the topology primitives:

  <topology_name>_NODE$ (Stores node primitives)

  <topology_name>_EDGE$ (Stores edge primitives)

  <topology_name>_FACE$ (Stores face primitives)

- One table to maintain the transaction history - the merges and splits of edges and faces:

  <topology_name>_HISTORY$ (a single table that maintains the transaction history for the merges and splits of edges and faces).

There follows an example of data migration from spatial geometry.

Create topology using the command:

```
EXECUTE SDO_TOPO.CREATE_TOPOLOGY('MPC_PRO', 0.005,1800000);
```

MPC_PRO is the topology name, 0.005 is the tolerance, and 1800000 is the SRID (Coordinate system) number of GDM2000

Create new feature table, associate and register feature tables with the topology and add topology geometry layers to the new feature table using the command:

```
EXECUTE SDO_TOPO.ADD_GEOMETRY_LAYERS ('MPC_PRO,
'MPCNDCDB_MARKES','FEATURES','POINT')
```

As a result Oracle Spatial database will generate a unique TG_LAYER_ID for each layer in the topology metadata in User_Sdo_Topo_Metadata.

Then inserting data from the spatial tables

```
BEGIN
 FOR PARCEL_rec IN (SELECT
UPII,STATE,DISTRICT,SUBDISTRICT,SECTION,PARCEL,NOLANDOFF
ICE,NOFSURVEY,S_AREA,LANDUSECODE,CP,
   APDATE,UPDATE_DATE,GEOM FROM MPCNDCDB_PARCEL_GEOM)
LOOP

   INSERT INTO MPCNDCDB_PARCEL VALUES(PARCEL_rec.UPII,
PARCEL_rec.STATE,
PARCEL_rec.DISTRICT,PARCEL_rec.SUBDISTRICT,

PARCEL_rec.SECTION,PARCEL_rec.PARCEL,PARCEL_rec.NOLANDOF
FICE,PARCEL_rec.NOFSURVEY,PARCEL_rec.S_AREA,

PARCEL_rec.LANDUSECODE,PARCEL_rec.CP,PARCEL_rec.APDATE,
PARCEL_rec.UPDATE_DATE,

     SDO_TOPO_MAP.CREATE_FEATURE('MPC_PRO',
'MPCNDCDB_PARCEL', 'FEATURE',PARCEL_rec.GEOM));

  END LOOP;
   END;
   /
```

and using SDO_TOPO_MAP.CREATE_FEATURE creates a memory cache for subsequent data updating.

The final database based on topology is showed in **Figure 4-9**.

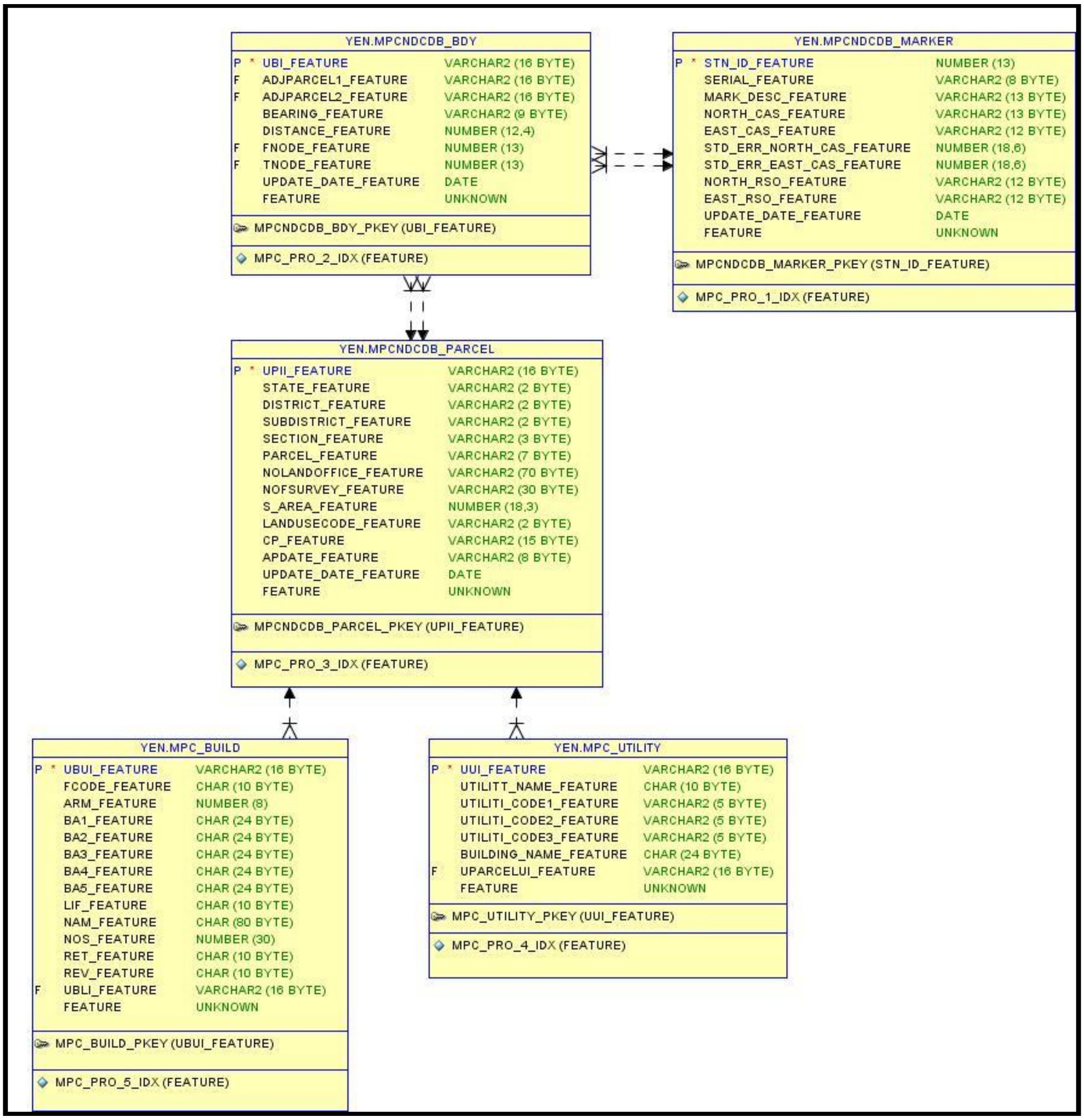


Figure 4-9 The final topology model database

4.4.9 Data security

The security of the database is managed by user restrictions and privileged user access control. An example of security imposed when a user is created is as follows:

Create user ‘yen’ identified by password

```
DEFAULT TABLESPACE users
TEMPORARY TABLESPACE temp
QUOTA 500K ON users;
grant connect, resource to yen;
```

The user ‘yen’ is granted access to the database and can modify the database. In the MPC database, data providers and users should be granted appropriate privileges.

4.4.10 Render map in XML format

Mapviewer can be used to render a map in XML format. This is particularly useful because Mapviewer can be enabled for the geospatial data available via web services. XML is a fundamental way to publish standard data, leading towards a SOA system as shown in **Figure 4-10**.

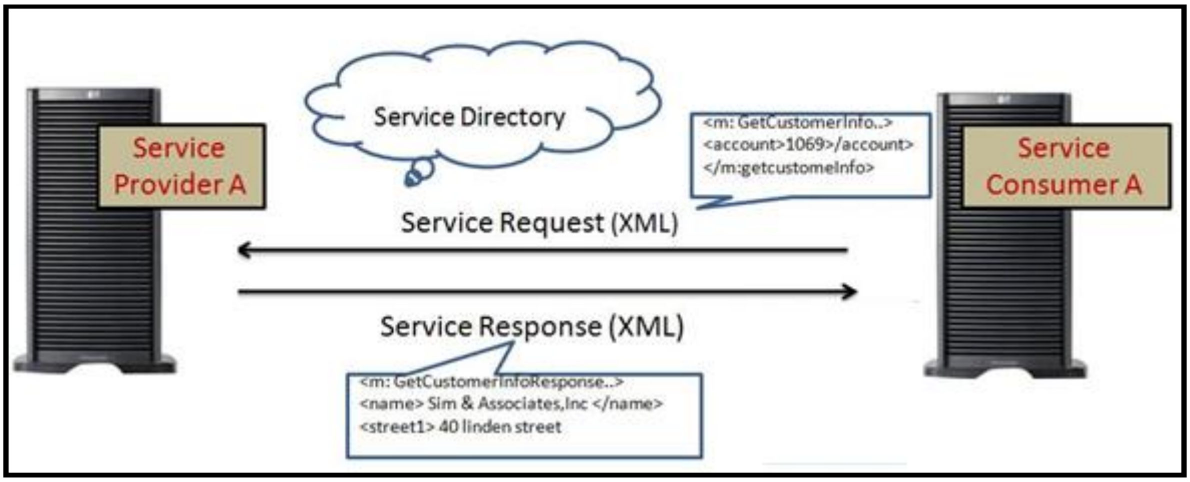


Figure 4-10 The principle Operation of SOA and XML

The following sample XML message (**Table 4-2**) is a user request to retrieve the base map in mapviewer by using Jclient, with the response message from the service provider as shown in **Table 4-2**.

Request Message by Client	**Response message by Provider**
<?xml version="1.0" standalone="yes"?>	<?xml version="1.0" encoding="UTF-8"?>
<map_request	<map_response>
basemap="MPC_database"	<map_image>
datasource="yen" width="500" height="375" bgcolor="#a6caf0" antialiase="false" format="GIF_URL" > <center size="300.0"> <geoFeature> <geometricProperty typeName="center"> <Point> <coordinates>408267.0,325268.0</coordinates> </Point>	<map_content> url="http://localhost:8888/mapviewer/images/omsmap20_4.gif?refresh=7773236016136416484" /> <box srsName="sdo:32647"> <coordinates> 408067.0,325118.0 408467.0,325418.0 </coordinates> </box>
</geometricProperty> </geoFeature>	<themes> <theme name="UTILITY_THEME" /> <theme name="PARCEL_THEME" /> <theme name="BUILD_THEME" /> <theme name="EASEMENT_BUFFER" />
</center>	</themes> <xfm matrix="0.8 0.0 0.0 -0.8 408067.0 325418.0" /> <WMTException version="1.0.0" error_code="SUCCESS"> </WMTException> </map_image>
</map_request>	</map_response>

Table 4-2 The request and response message in Mapviewer

4.5 Data quality validation

Referring to ISO 19113: 2002 there are 5 criteria which need to be fulfilled in spatial data validation, thus it can be suggested that a further four, over and above positional accuracy, need considering, namely: Logical Consistency (Geometry Validation) is an object of this, Domain Consistency (data format, datum), Completeness (presence or absence of features), Temporal Consistency (in periods required by the user) and attribute accuracy.

4.5.1 Logical consistency

The importance of logical consistency checking is that it can (among other things) support valid geometry. The data structure should follow topological rules, the data that are built using Oracle spatial can be checked systematically using validating and debugging methods provided by Oracle. There are two validation functions available in the Oracle Spatial Package, which are:

- Validate_Geometry_with_context: determines whether a geometry is valid

- Validate_Layer_with_context: determines whether geometries in a layer are valid.

  For each invalid geometry, this returns the first error encountered, also the coordinates where the geometry is invalid. Using these functions, the parcels table that was previously run through ‘check in’ for import into the database is validated.

- Sdo_util_Getvertices

  Return the coordinates of the vertices of the input geometry to find the vertex that is causing a geometry to be invalid.

- Sdo_Util_rectify_geometry

This function fixes the following problems with the input geometry and returns a valid geometry: duplicate vertices; self crossing polygons; and incorrect orientation of the outer and inner rings in a polygon.

4.5.2 Strategy for geometry validation

The following is a proposed strategy for geometry validation:

a) create a validation_results table and run the validate_layer_with_context function;

b) for each type of error, create a table and isolate the invalid geometries;

c) remove the invalid geometries from the spatial layer;

d) run the SDO_UTIL.RECTIFY_GEOMETERY function on the new table containing the invalid geometries;

e) validate the geometries again;

f) insert the fixed geometries back into the original table; and,

g) repeat the process for each type of validation error.

4.5.2.1 Create a validation_results table and run the validate_layer_with_context function

Data with error needs to be isolated into a different table, called Validation_results. The validation function provided by Oracle Spatial validate_layer_with_context will validate the data and store the bad data in Validation_results. In SQL developer an operator can view the error in a list which contains the id number of the object and the error code, as is shown in **Figure 4-11** and **Figure 4-12**.

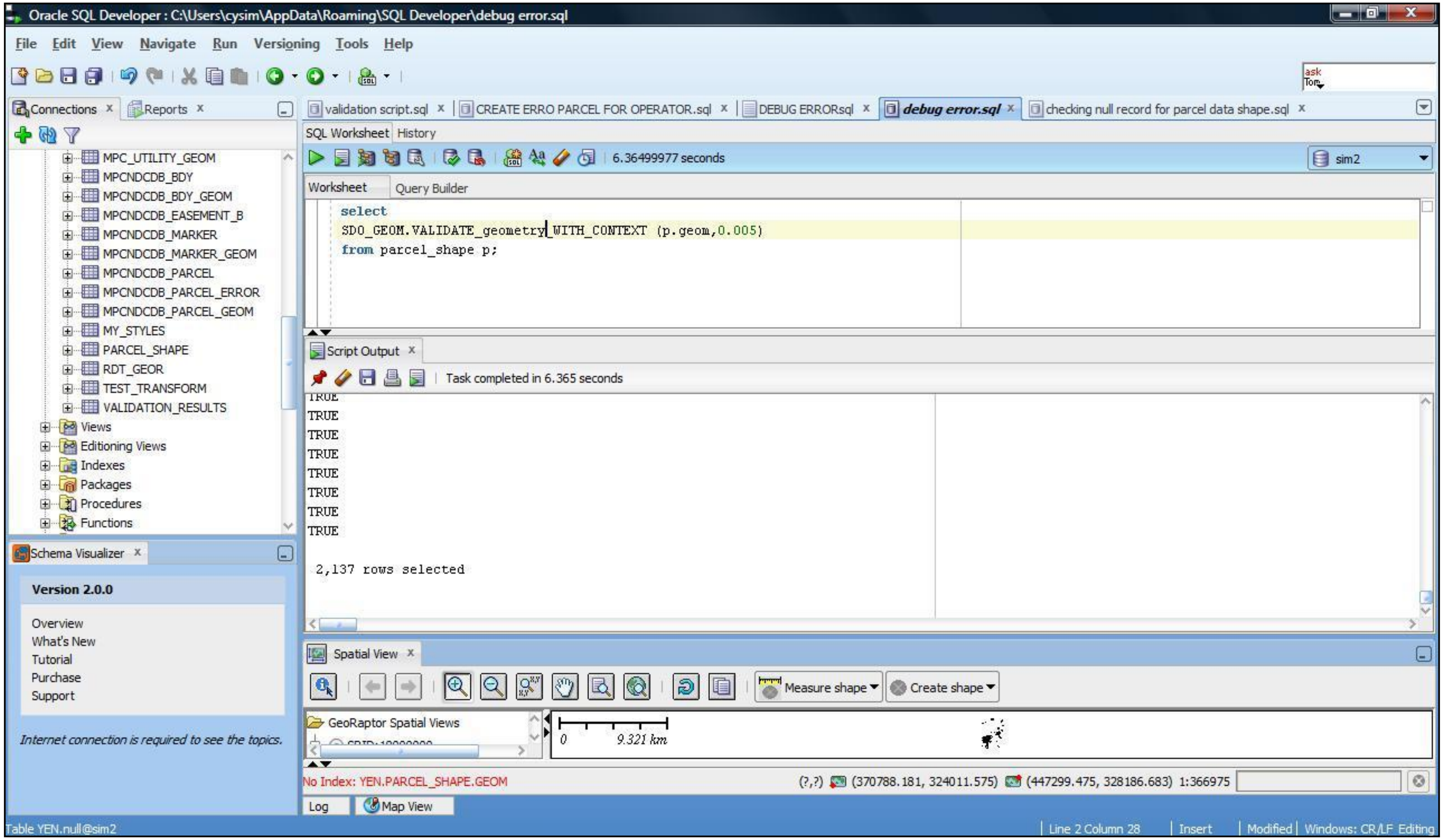


Figure 4-11 The use of Validate_Geometry_with_context
(to view the error in SQL Developer)

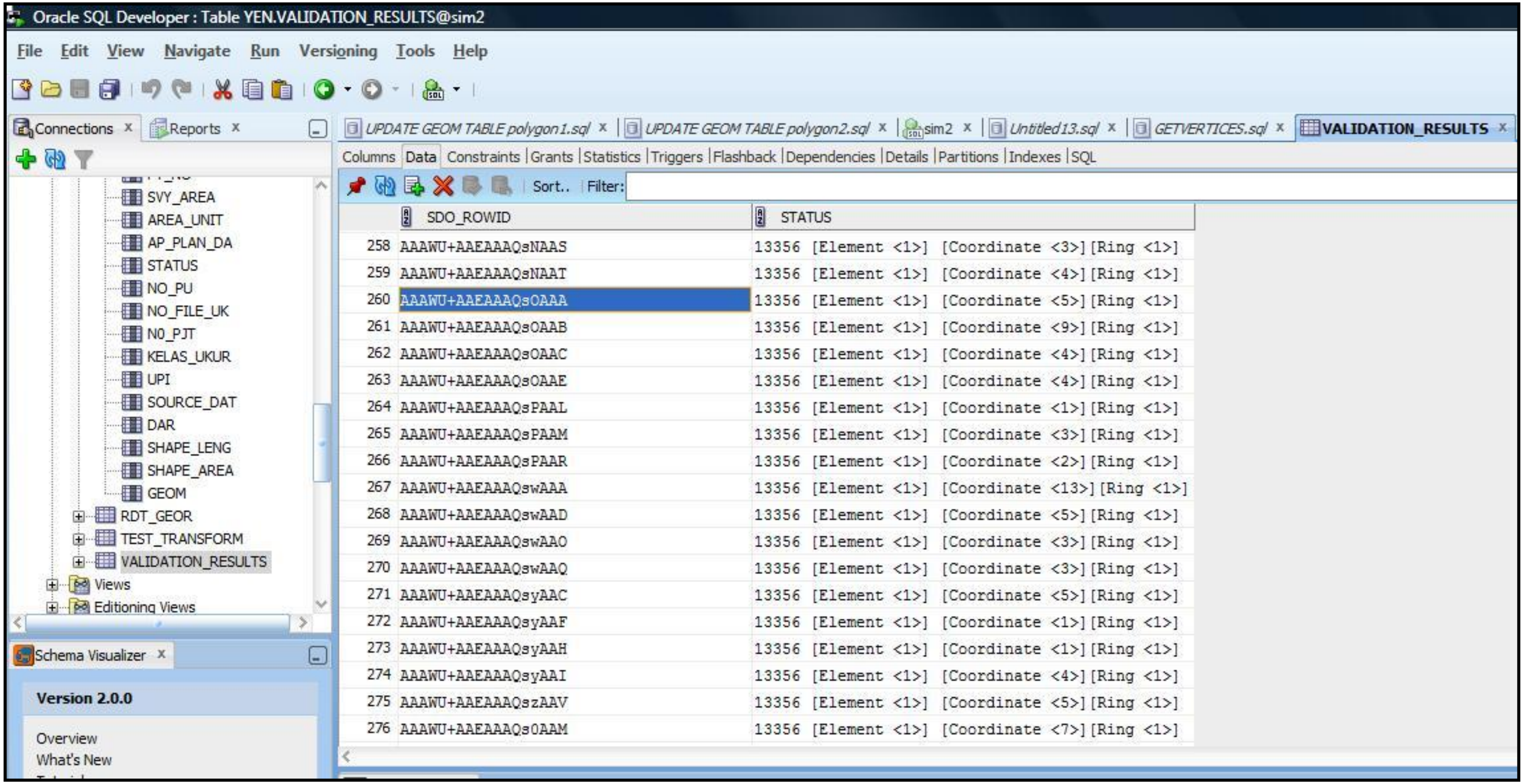


Figure 4-12 The Use of Validate_Layer_with_context
(to create validation error table)

The validation table is created using the syntax below:

```
DROP TABLE MPCNDCDB_PARCEL_ERROR PURGE;

CREATE TABLE MPCNDCDB_PARCEL_ERROR

AS (SELECT S. UPI, V. SDO_ROWID, S. GEOM

FROM PARCEL_SHAPE  S,  validation_results V

WHERE S.ROWID = V.SDO_ROWID) ;

DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME =
'MPCNDCDB_PARCEL_ERROR' AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME, DIMINFO,
SRID)

VALUES ('MPCNDCDB_PARCEL_ERROR', 'GEOM',

SDO_DIM_ARRAY

(SDO_DIM_ELEMENT('X', -1000000, 1000000, 0.05),

SDO_DIM_ELEMENT('Y', -1000000, 1000000, 0.05)

), 18000000

);
```

For the purpose of visualizing the error, the operator can overlay the Validation_results table with the table that contains all the data. By using Mapviewer the operator can view the error with a different colour display, as shown in **figure 4-13**.

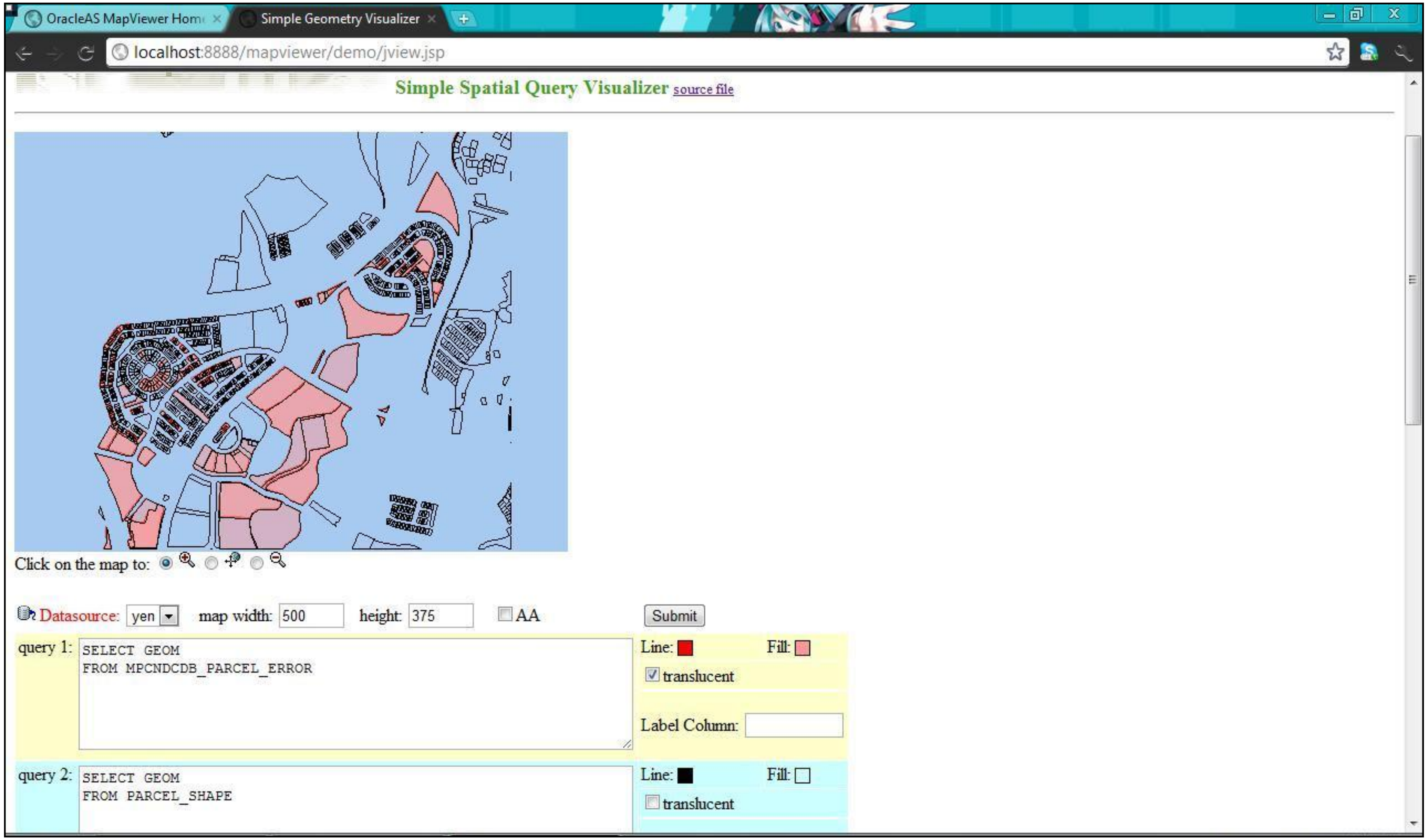


Figure 4-13 Mapviewer overlay process
(Using MapViewer to overlay tables to view parcel with geometry error)

4.5.2.2 Remove the invalid geometries from spatial layer.

An operator can identify the particular error by querying the parcel by its UPI number or ID number, and then the particular parcel with the error can be detected in Mapviewer as shown in **figures 4-14 and 4-15**. In this example (**Figure 4-15**) the error code is 13356, meaning the geometry contains redundant data.

In this case, it is actually that two polygons exist for this geometry. One polygon may be the result of a previous survey of parcels and the other is a new surveyed parcel as shown in query **Figure 4-14, Figure 4-15** and **Figure 4-16**. The topology rule where parcel polygons should not overlie each other should be applied to avoid this type of error.

Validation has detected 2 errors that have to be fixed:

a. Polygon that has a geometry error such as a redundant point.

b. Polygon that overlie each other, in this case 2 polygons overlie each other and have the same UPI number = 160140009538

- Polygon 1 which has ROWID: AAAWU+AAEAAAQsOAAA

- Polygon 1 which has ROWID: AAAWU+AAEAAAQt2AAK

4.5.2.3 Run the SDO_UTIL.RECTIFY_GEOMETRY function on the new table containing the invalid geometries

The operator can recall the coordinates of these 2 polygons by using the function sdo_util_getVertiges, as shown in **Figure 4-17**. The operator can fix the problem by the command SDO_UTIL.RECTIFY_GEOMETRY as shown in **Figure 4.18**.

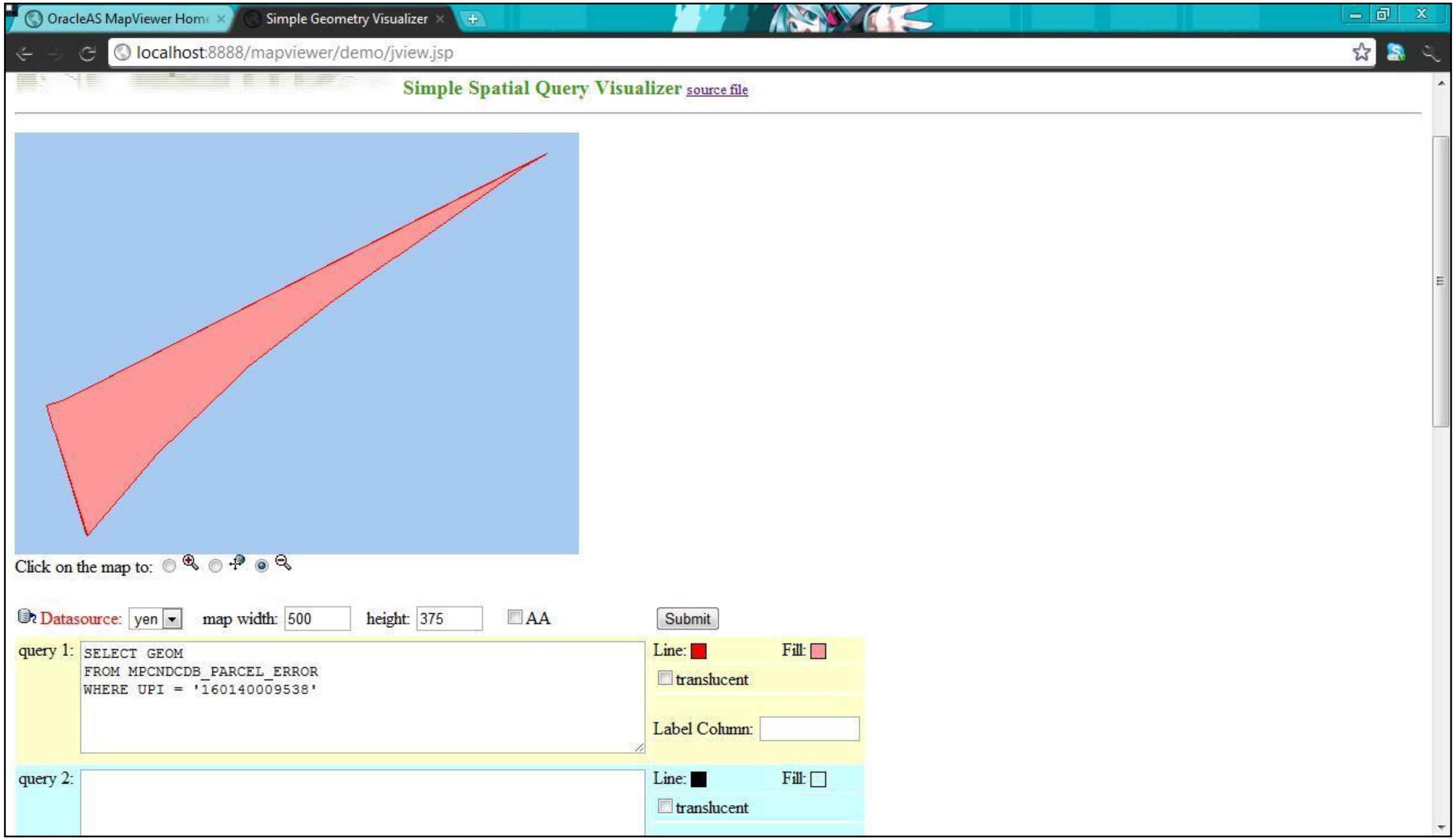


Figure 4-14 View error in Mapviewer
(using MapViewer to view particular parcel with geometry error)

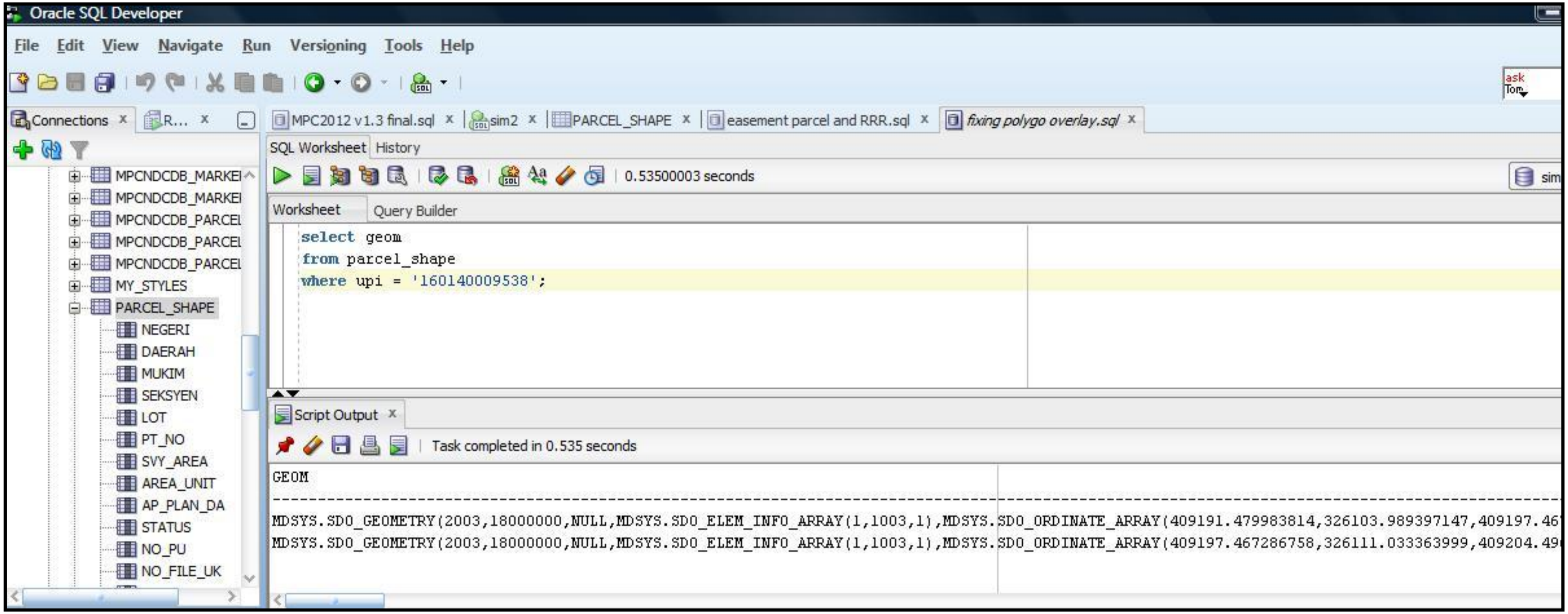


Figure 4-15 Parcel query in SQL developer
(The query of Parcel 1601400009538 return 2 polygons)

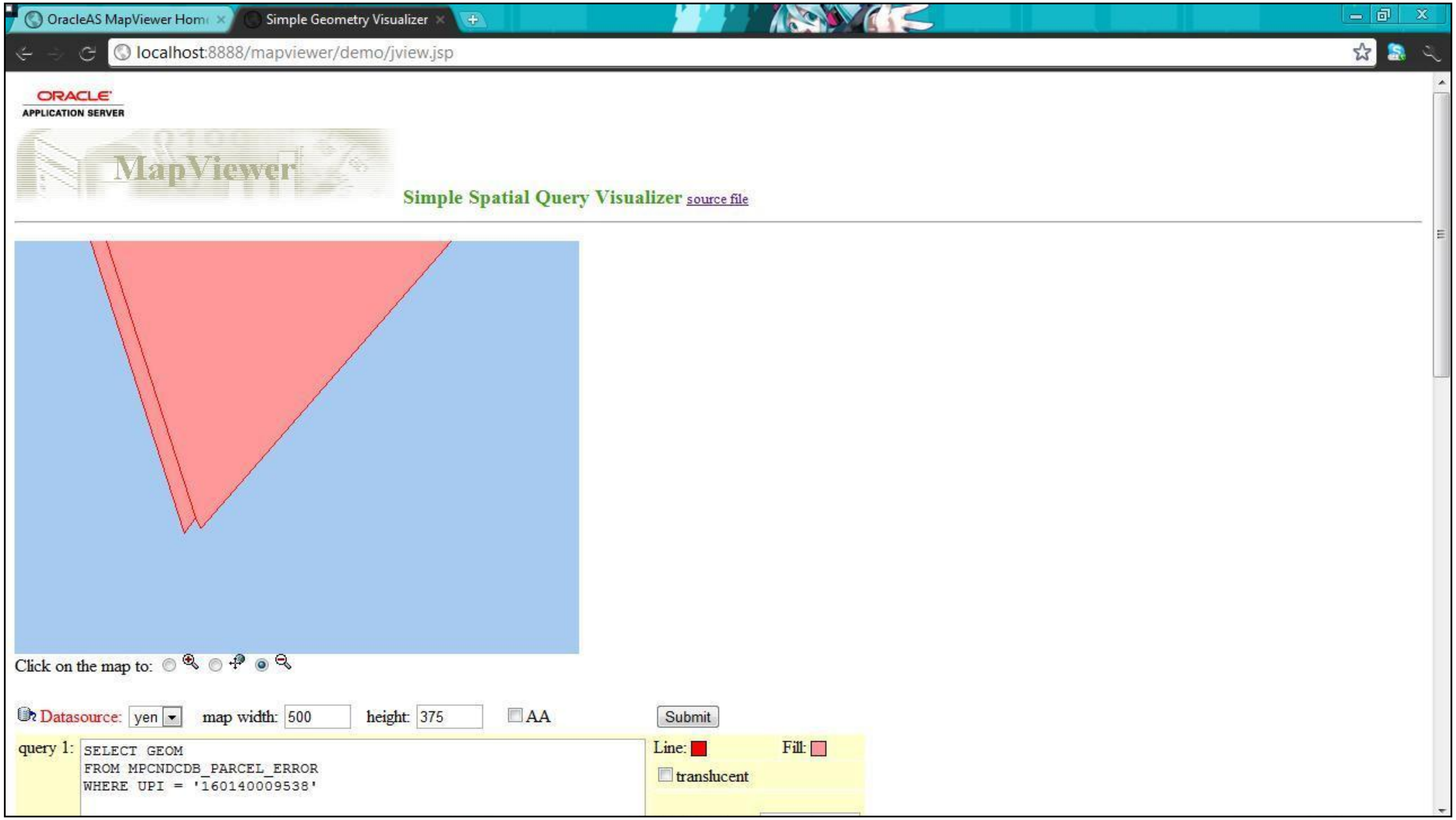


Figure 4-16 Geometry error shown in MapViewer

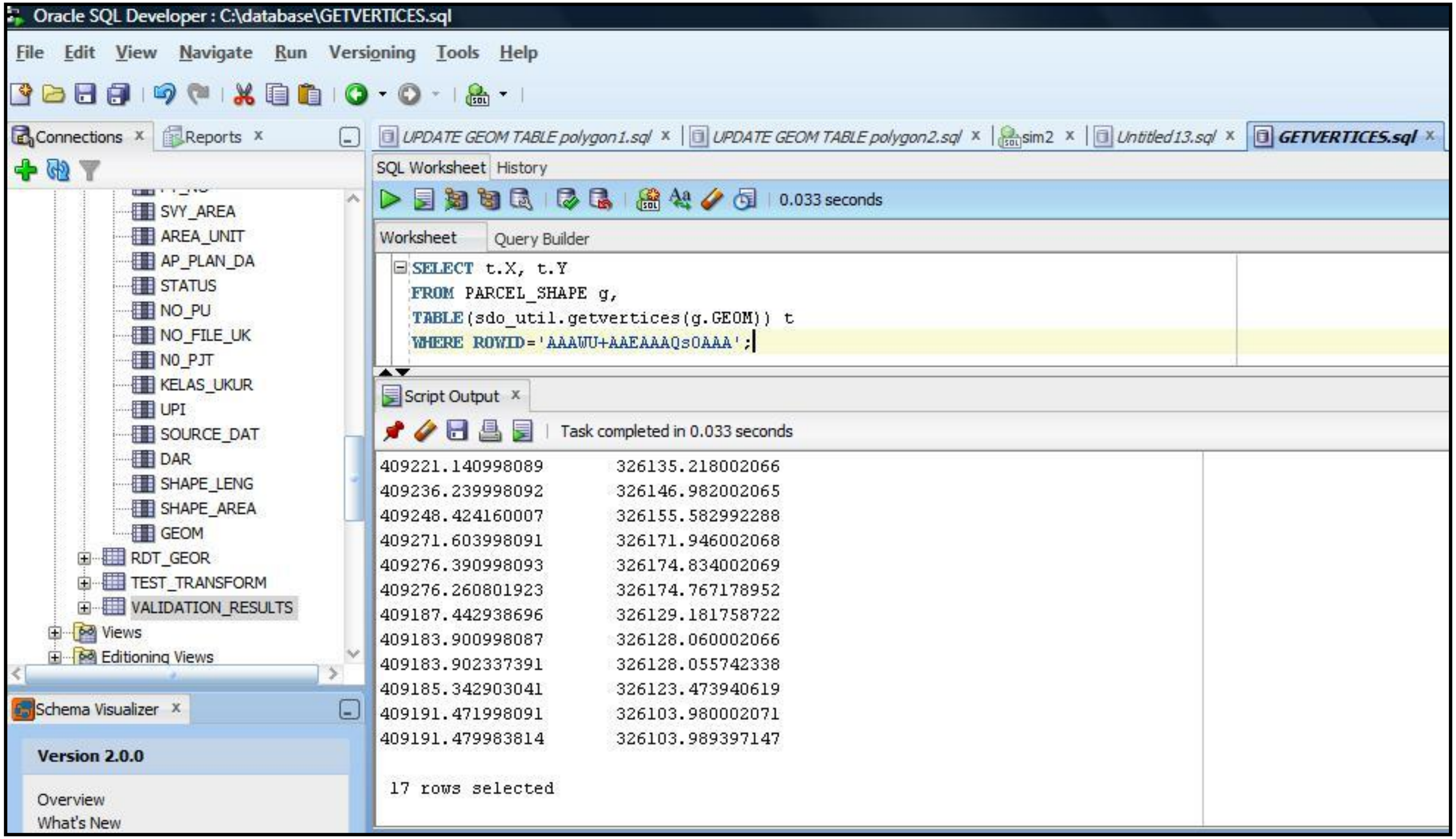


Figure 4-17 The use of sdo_util_getVertices
(to recall the coordinates)

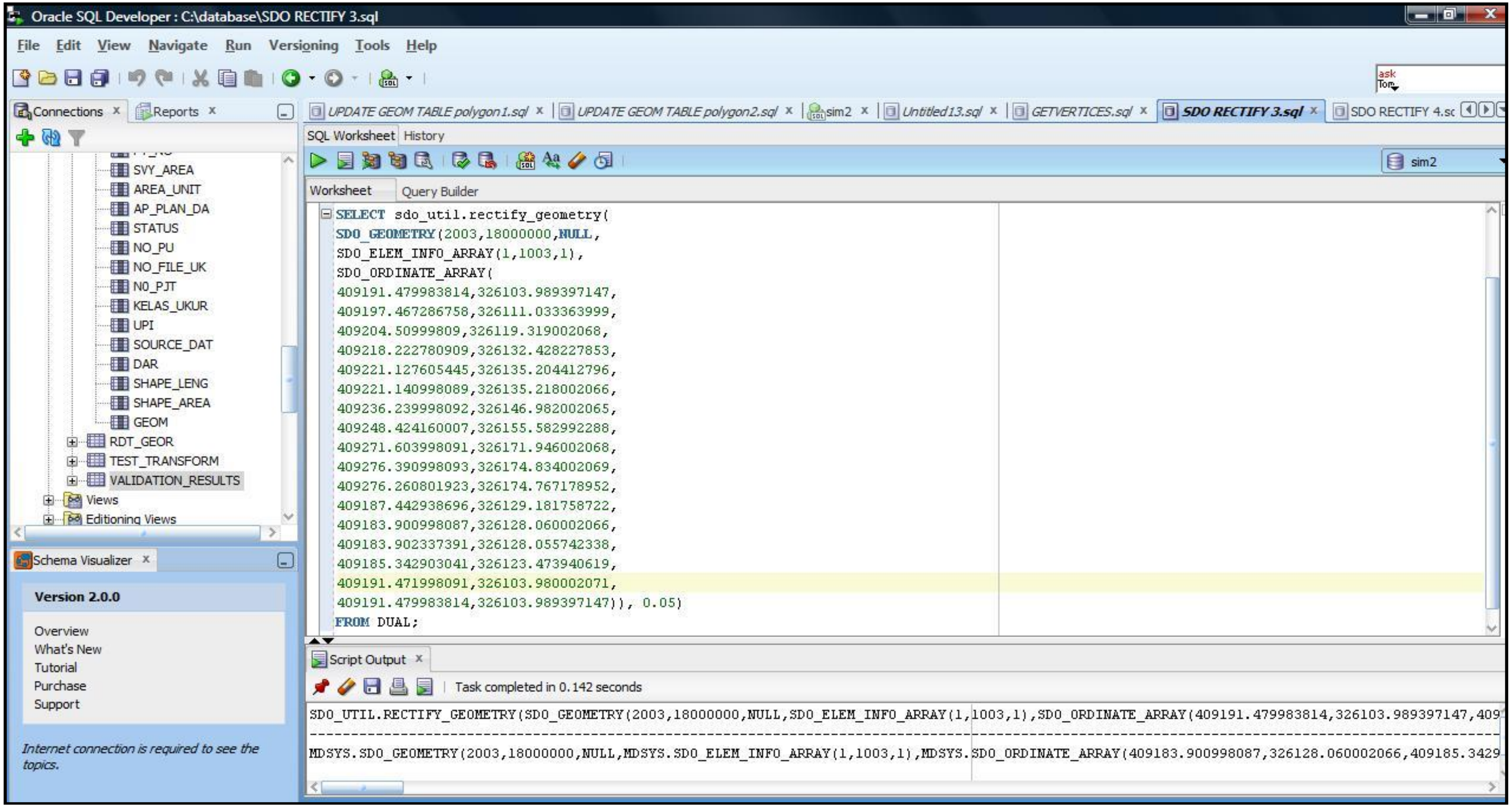


Figure 4-18 The use of Sdo_util_rectify_geometry
(to fix the error)

The result of recall geometry for polygon ROWID: AAAWU+AAEAAAQsOAAA is as follows:

Before validation:

X	*Y*
409191.479983814	*326103.989397147*
409197.467286758	*326111.033363999*
409204.50999809	*326119.319002068*
409218.222780909	*326132.428227853*
409221.127605445	***326135.204412796***
409221.140998089	***326135.218002066***
409236.239998092	*326146.982002065*
409248.424160007	*326155.582992288*
409271.603998091	*326171.946002068*
409276.390998093	*326174.834002069*
409276.260801923	*326174.767178952*
409187.442938696	*326129.181758722*
409183.900998087	***326128.060002066***
409183.902337391	***326128.055742338***
409185.342903041	*326123.473940619*
409191.471998091	***326103.980002071***
409191.479983814	***326103.989397147***

These pair of points considered as duplicated based on the tolerance 0.05

17 rows selected

After Validation:

X	*Y*
409183.900998087	*326128.060002066*
409185.342903041	*326123.473940619*
409191.479983814	*326103.989397147*
409197.467286758	*326111.033363999*
409204.50999809	*326119.319002068*
409218.222780909	*326132.428227853*
409221.127605445	*326135.204412796*
409236.239998092	*326146.982002065*
409248.424160007	*326155.582992288*
409271.603998091	*326171.946002068*
409276.260801923	*326174.767178952*
409187.442938696	*326129.181758722*
409183.900998087	*326128.060002066*

13 rows selected

The result of recall geometry for polygon: ROWID: AAAWU+AAEAAAQt2AAK is as follows:

Before Validation:

X	*Y*
409197.467286758	*326111.033363999*
409204.496998091	*326119.314002066*
409218.222780909	*326132.428227853*
409221.127605445	*326135.204412796*
409236.233998087	*326146.969002073*
409248.424160007	*326155.582992288*
409271.578998088	*326171.945002065*
409276.260801923	*326174.767178952*
409276.369998088	*326174.833002066*
409187.442938696	***326129.181758722***
409187.413998088	***326129.167002069***
409183.902337391	***326128.055742338***
409183.899998091	***326128.055002071***
409185.342903041	*326123.473940619*
409191.479983814	***326103.989397147***
409191.481998088	***326103.983002066***
409197.467286758	*326111.033363999*

The pair of points considered as duplicated based on the tolerance 0.05

17 rows selected

After Validation:

X	*Y*
409183.902337391	*326128.055742338*
409185.342903041	*326123.473940619*
409191.479983814	*326103.989397147*
409197.467286758	*326111.033363999*
409204.496998091	*326119.314002066*
409218.222780909	*326132.428227853*
409221.127605445	*326135.204412796*
409236.233998087	*326146.969002073*
409248.424160007	*326155.582992288*
409271.578998088	*326171.945002065*
409276.260801923	*326174.767178952*
409187.442938696	*326129.181758722*
409183.902337391	*326128.055742338*

13 rows selected

The command sdo_util_rectify_geometry fixes the error as follows:

- removes the point that is considered redundant according to the tolerance set 0.05;
- retains the first coordinate set after the correction; and
- only solves self polygon overlay.

4.5.2.4 Validate the geometries again and Insert the fixed geometries back into the original table.

It is suggested that the operator should only insert the correct data after a thorough investigation has been done of the error (**Figure 4-19**). The operator can recall the coordinate after the validation as **Figure 4-20**.

The operator can again use Mapviewer to view the particular parcel and see whether it is corrected.

To make all the steps more user friendly, each step needs to be compiled using the application developer Oracle Jdeveloper. Jdeveloper will be discussed in the chapter 5, one of two which focus on SOA.

This will insert back the correct geometry for both polygons into the database, but the two polygons that have same parcel number will still exist; this will requires investigation by operator to decide which polygon is valid and current.

An operator can use Sdo_util_rectify_geometry to remove redundant data (in **Figure 4.17**). According to the tolerance set in the database (i.e. 0.05m), Oracle will consider two points to be in same location if the distance difference between the coordinates is less that the tolerance. Oracle will automatically remove one of the point’s coordinates and form the new polygon.

This function should not be used automatically because the operator should decide which parcel polygon is correct before conducting this operation. This 'validation' could modify the boundaries and have legal implications.

This function (SDO_UTIL.RECTIFY_GEOMETERY) is useful to query errors and detect errors in the database. To fix errors in legal boundaries, a manual process should be used in the investigation, including field observations and allowing the operator to manually clean the database. It is advisable to impose topology tests at the beginning of data 'check in'.

Temporal data attributes such as date and time can the help operator decide which polygon is supposed to be the final data.

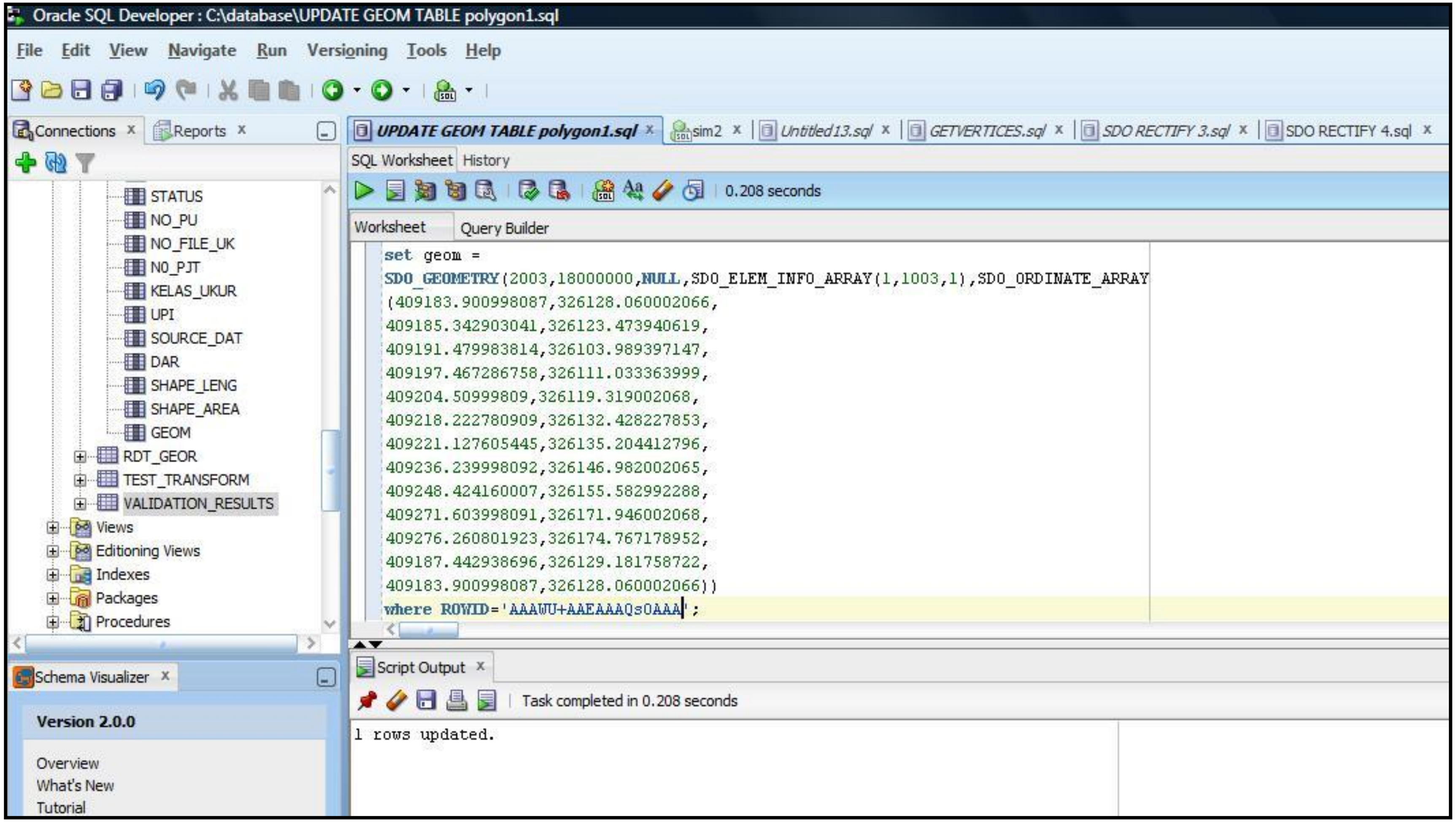


Figure 4-19 Updating the database
(Update the corrected geometry into the database)

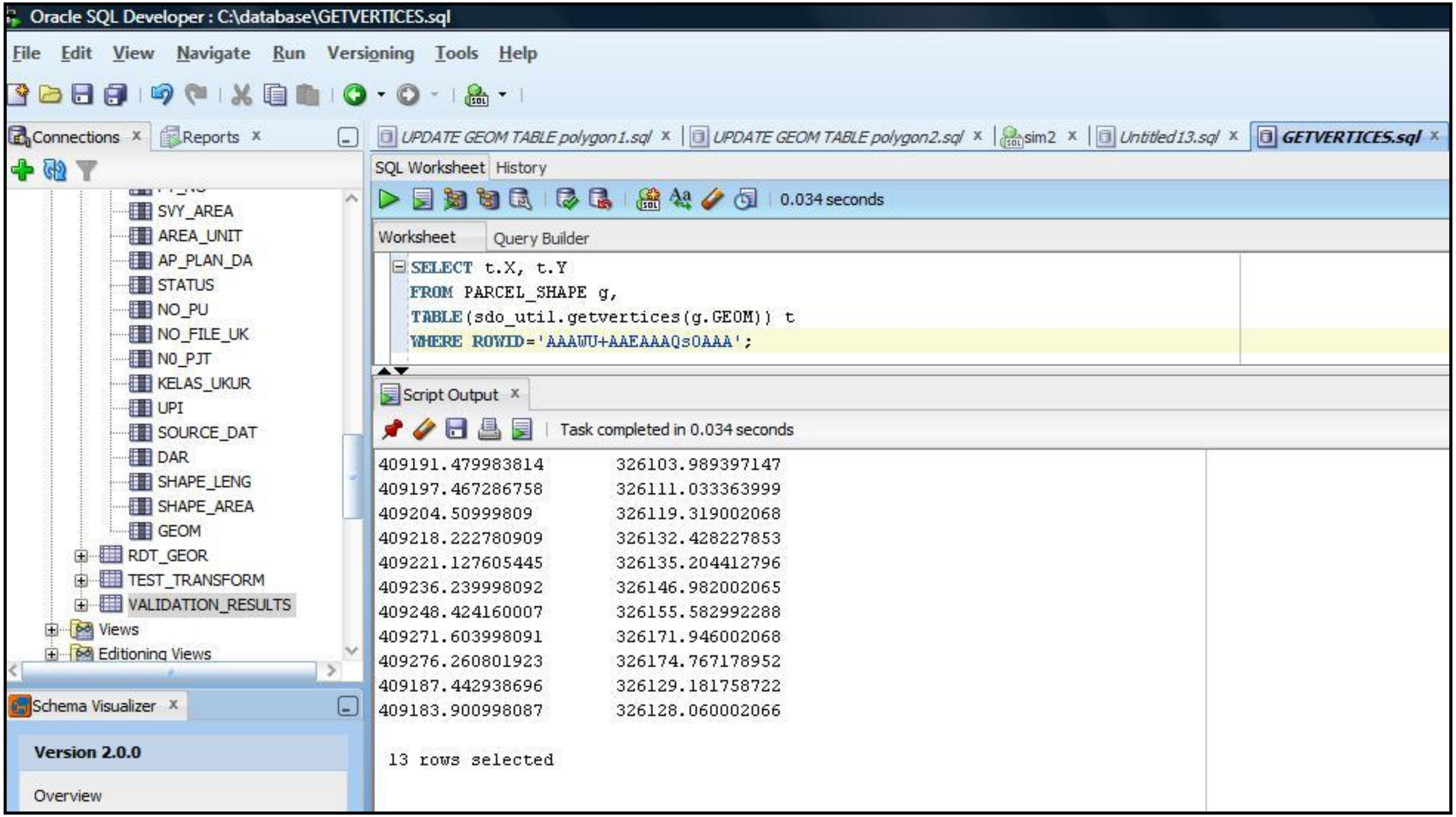


Figure 4-20 The use of sdo_util_getVertices
(to recall the coordinates after validation)

4.5.3 Domain consistency

To ensure the consistency of the datum and the coordinate system when data have come from different providers, the Malaysia Geocentric Datum (GDM2000), which was launched in 2002, is used to produce new geocentric coordinates, aiding migration from the old coordinate system to the new homogeneous coordinate system.

Oracle Spatial stores coordinate systems in SDO_COORD_SYS, which can be queried using the syntax below:

```
SELECT

COORD_SYS_ID,

COORD_SYS_NAME,COORD_SYS_TYPE,DIMENSION

FROM SDO_COORD_SYS;
```

Oracle Spatial is supporting the projections, datums and ellipsoids that are used in Malaysia as follows:

a) Projections

- Cassini-Soldner
- Hotine Oblique Mercator

b) Datums

- Kertau
- Timbalai 1948
- WGS 84
- IERS Terrestrial Reference Frame 2000

c) Ellipsoid

- WGS 84
- GRS 1980
- Everest (Kertau)
- Everest (Timbalai)

In 2009, the Director General of Survey and Mapping Circular no 3-2009 published guidelines for projections and coordinate transformation systems which are shown in **Figure 4-21**. The transformation and projection parameters in the black box were provided by JUPEM. Operators can use a simple script file to run the coordinate transformation as shown in the script file below:

```
select sdo_cs.transform  (geom, 18000000)

from Test_transform

where id=1;
```

Oracle Spatial is currently not supporting GDM2000, but this researcher has created script files for a new GDM2000 coordinate system with SRID number 18000000 in the system which are attached in the **Appendix D.**

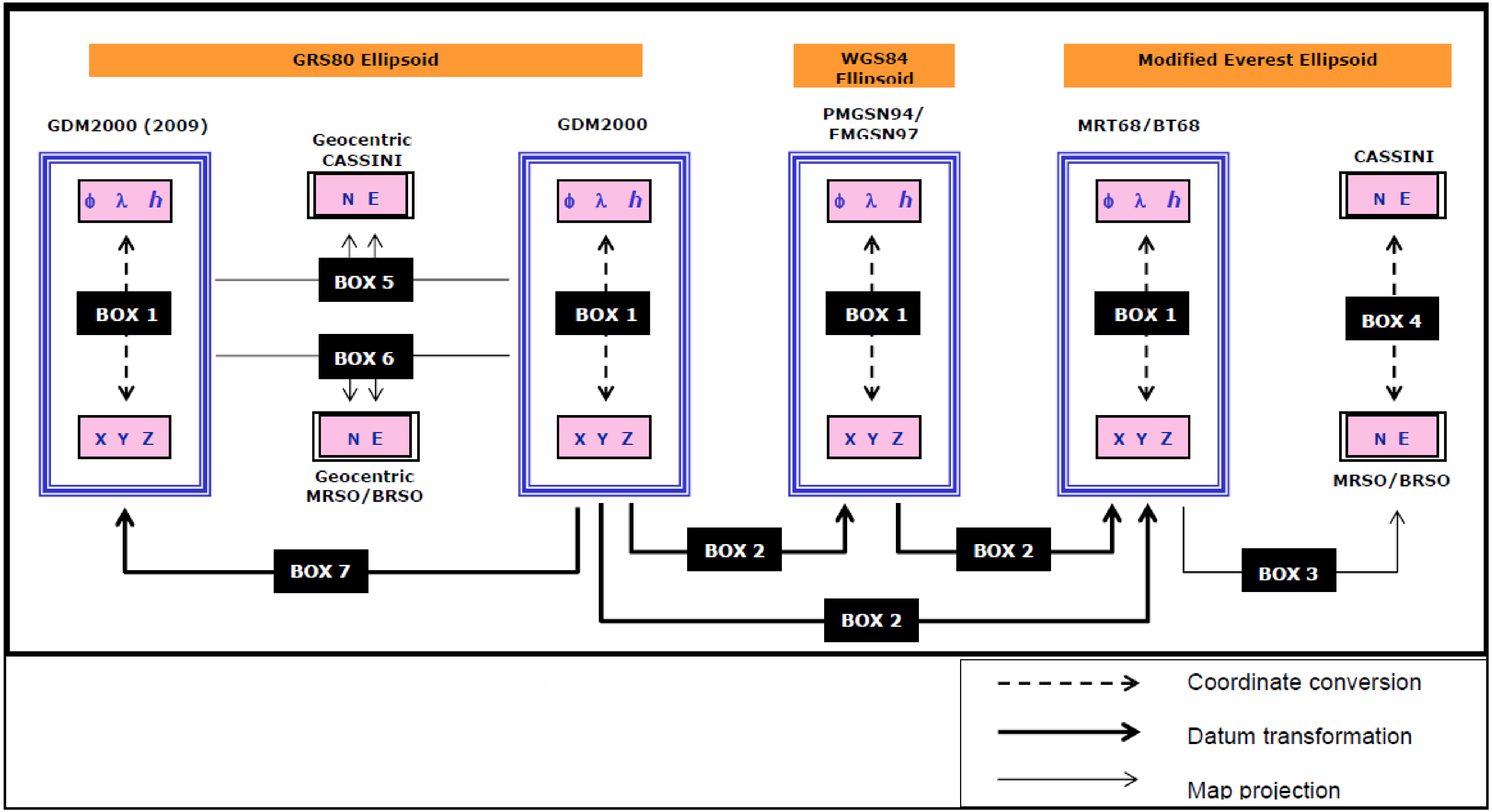


Figure 4-21 **Relationship of coordinate systems in Malaysia**
(The Department of Survey and Mapping of Malaysia, 2009)

Box 1: Coordinate conversion between geographical coordinates and Cartesian coordinates

Box 2: Transformation between various datums using the Bursa-Wolf formula

Box 3: Projection of MRT68BT68 geographical coordinates to Rectified Skew Orthomorphic (RSO) plane coordinates

Box 4: Coordinate transformation from RSO to Cassini using polynomial function

Box 5: Map projection of GDM2000 geographical coordinates to Geocentric Cassini plane coordinates

Box 6: Map projection of GDM2000 geographical coordinates to Geocentric RSO plane coordinates

Box 7: Datum transformation from GDM2000 to GDM2000 (2009) using a multiple regression model

(The Department of Survey and Mapping of Malaysia, 2009)

In the Box 7, JUPEM produced multiple regression parameters to move from the ITRF epoch 2000 to epoch 2009. Referred to in the Director General of Survey and Mapping Circular no 1-2009 this is due to the major Sumatran earthquakes in 2004, 2005 and 2007 which caused significant seismic motion with magnitudes ranging from 1.0 to 25.8 cm.

Currently the NDCDB is still based on GDM2000 epoch 2000, because the migration to epoch 2009 will cause two versions of the geometry in the database. In future the database needs to able to adopt a dynamic coordinate transformation which has ways to deal with changes faster.

4.5.4 Data format

An ESRI Shapefile is commonly used in GIS, and it can be suggested that it be used widely by the data provider, exploiting functions supplied by ESRI as discussed, and which allows the data to undergo ‘check in’ easily.

In order to work towards an open source system, the XML and GML format should be widely encouraged for use by MPC system providers. Oracle can import xml and GML data using GML.fromNodeToGeometry(), a utility of oracle.spatial.util.GML.

4.6 Attribute accuracy and completeness

Attribute validation can be supported by the SQL developer. The operator can check whether any attribute contains Null records as showed in **Figure 4-22**. (But it is easier if it is compulsory for attributes to be constrained to ‘not null’ at the beginning of database creation.)

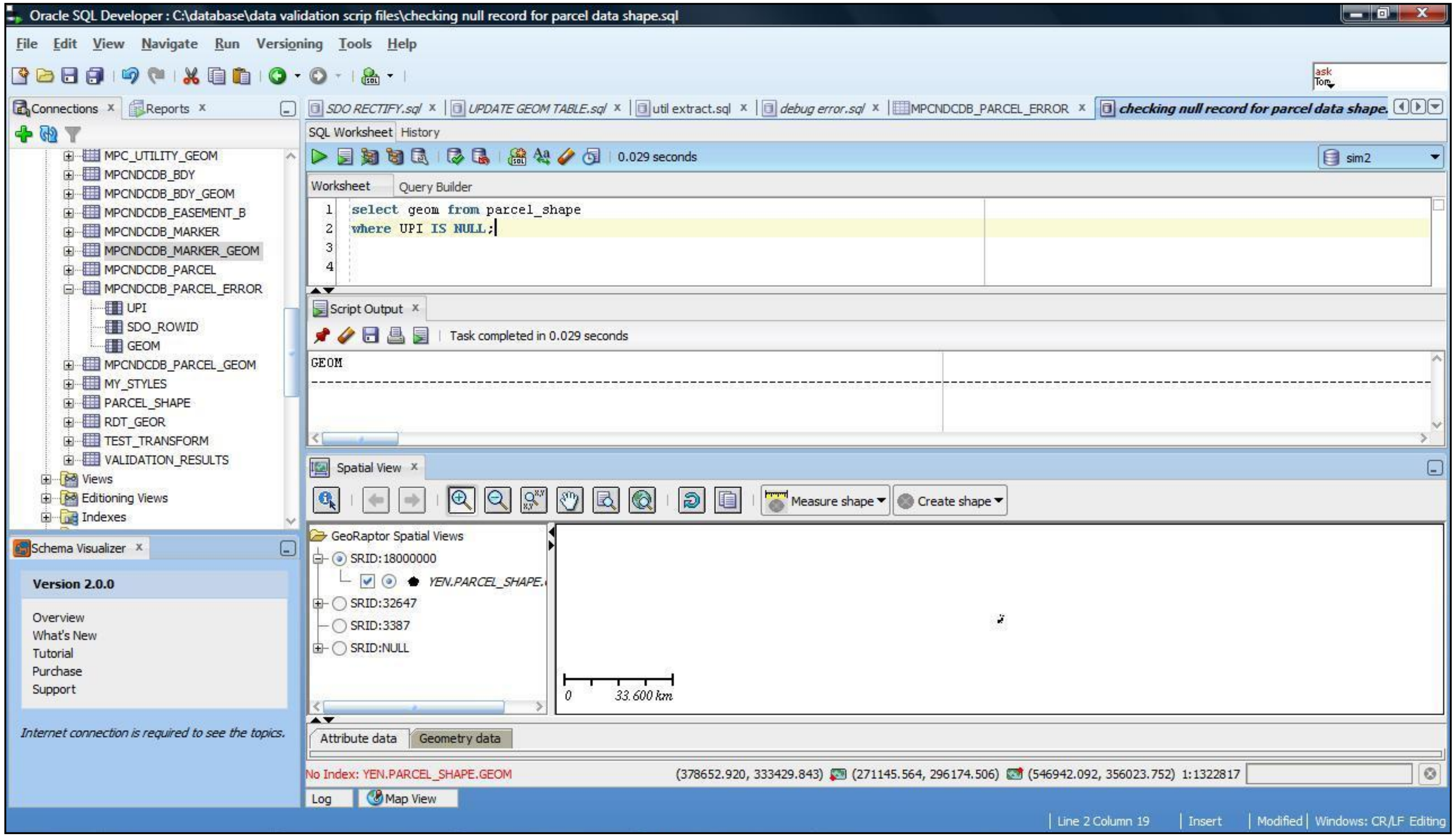


Figure 4-22 Checking null record of attribute

4.7 Case study – easement

In order to test the application right, restriction and responsibility (RRR) of the MPC database, a case study is conducted which considers how the database can generate an easement for utility data such as a gas pipeline. In this case study, features of parcel data and utility data were used to perform the easement query.

This query generates an easement line output file as follows (**Figure 4-24** and **Figure 4-25** are related):

```
MDSYS.SDO_GEOMETRY(2006,18000000,NULL,MDSYS.SDO_ELEM_INFO_ARRAY(1,
2,1,17,2,1),

MDSYS.SDO_ORDINATE_ARRAY

(408291.239900944,325379.71671719,408279.059,325332.834,408236.736
,325319.922,408238.842,325274.202,408309.116,325201.6,408344.676,3
25214.3,408364.361,325232.292,408365.30795244,325231.516109936,408
326.018269794,325176.088141342,408298.956,325152.917,408303.953398
458,325147.466522777))
```

The easement can be buffered to form a polygon to be overlaid with the parcel polygon.

```
Select sdo_geom.sdo_intersection (P.geom,
sdo_geom.sdo_buffer(l.geom,10,0.005),0.005) as easement

   from MPC_UTILITY_GEOM l,

        MPCNDCDB_PARCEL_GEOM p

  where sdo_anyinteract( p.g2eom,l.geom) = 'TRUE';

  DROP TABLE MPCNDCDB_EASEMENT_B PURGE;

CREATE TABLE MPCNDCDB_EASEMENT_B  (

   UEASEMENT VARCHAR2 (16),
```

```
   GEOM SDO_GEOMETRY

   );

DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME =
'MPCNDCDB_EASEMENT_B' AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME,
DIMINFO, SRID)

VALUES ('MPCNDCDB_EASEMENT_B', 'GEOM',

SDO_DIM_ARRAY

(SDO_DIM_ELEMENT ('X', -1000000, 1000000, 0.05),

SDO_DIM_ELEMENT ('Y', -1000000, 1000000, 0.05)

), 32647

);
```

This query is to make an easement buffer zone to get the intersection geometry

The output of the intersection can be inserted into a new legal object table called MPCNDCDB_EASEMENT, to store the easement.

```
INSERT INTO MPCNDCDB_EASEMENT_B VALUES (

'16014009380',

SDO_GEOMETRY(2003, 32647, Null,
SDO_ELEM_INFO_ARRAY(1,1005,12,1,2,2,5,2,1,7,2,2,11,2,1,13,

2,2,17,2,1,21,2,2,25,2,1,33,2,2,37,2,1,47,2,2,51,2,1),

SDO_ORDINATE_ARRAY   (408233.817,325329.486,

408228.563489257,325325.685275956,408226.746,325319.461,408228.852
,325273.741,
```

```
408229.661017261,325270.237960024,408231.656,325267.247,408301.93,
325194.645,

408306.842018428,325191.860995697,408312.479,325192.182,408341.577
,325202.574,

408292.452,325160.513,408288.974022794,325153.519377516,408291.585
,325146.158,

408297.756418652,325139.427062477,408365.385,325227.152,408365.253
,325234.628,

408359.915719219,325241.249545291,408358.7096093,325240.541936805,

408357.614,325239.673,408339.416,325223.04,408311.82,325213.184,

408248.657,325278.439,408247.082,325312.623,408281.977,325323.269,

408286.276401077,325325.912418258,408288.737,325330.319,

408301.155201115,325378.115054955,408294.716,325378.74,

408281.609634004,325382.418867143,408270.787,325340.765,

                     408233.817,325329.486)));

CREATE INDEX MPCNDCDB_EASEMENT_B_GI ON MPCNDCDB_EASEMENT_B(GEOM)
INDEXTYPE IS MDSYS.SPATIAL_INDEX;
```

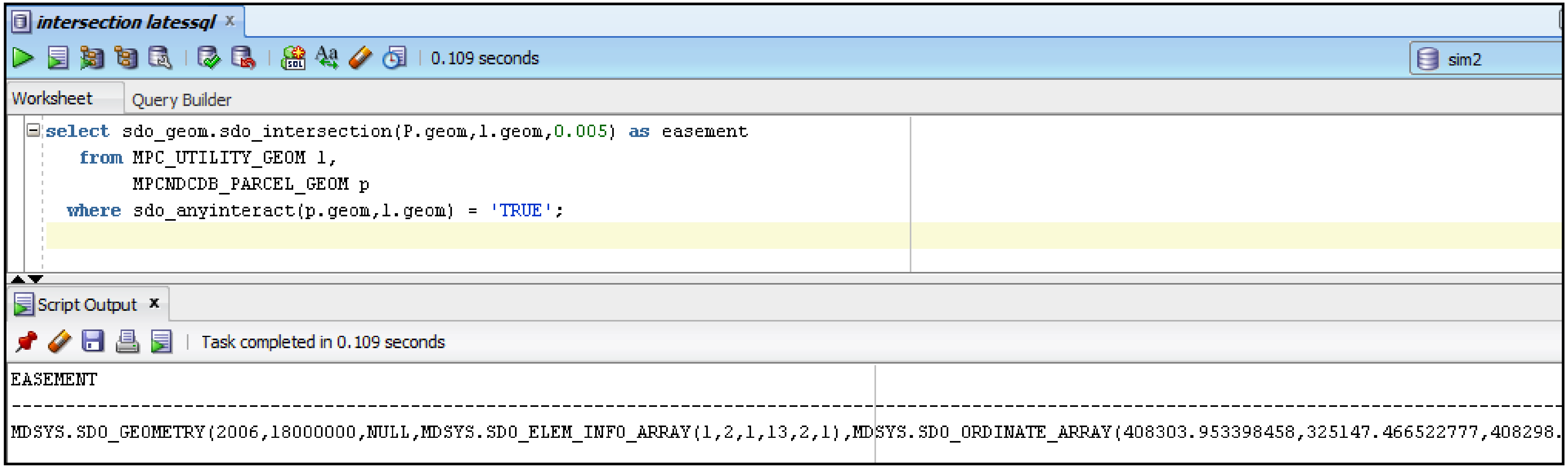


Figure 4-23 The intersection query
(The query to show intersection between the pipeline and parcel boundary)

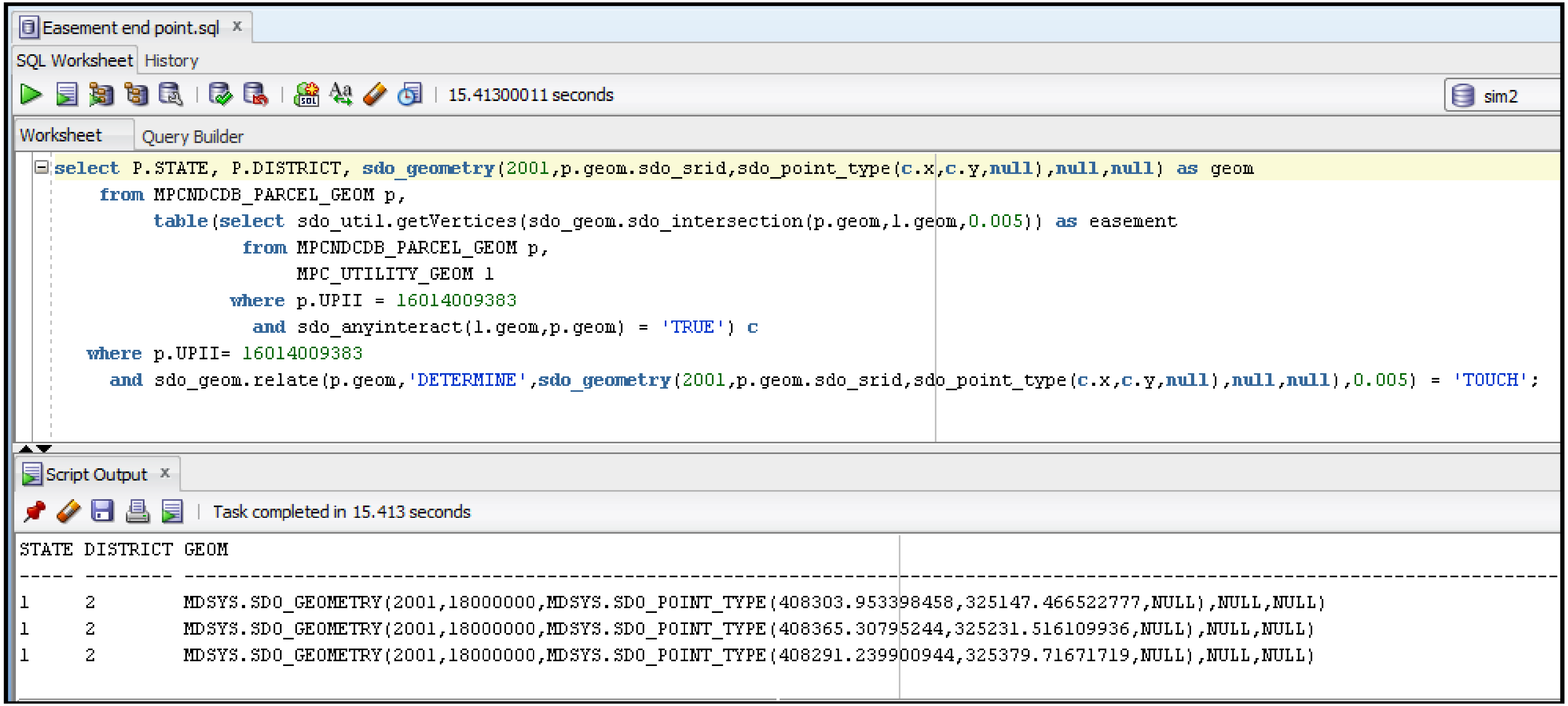


Figure 4-24 The intersection point query
(The query to show intersection point between the pipeline and parcel boundary)

The operator can view the easement in the mapviewer by querying the parcel table and easement table as shown in **Figure 4-25**.

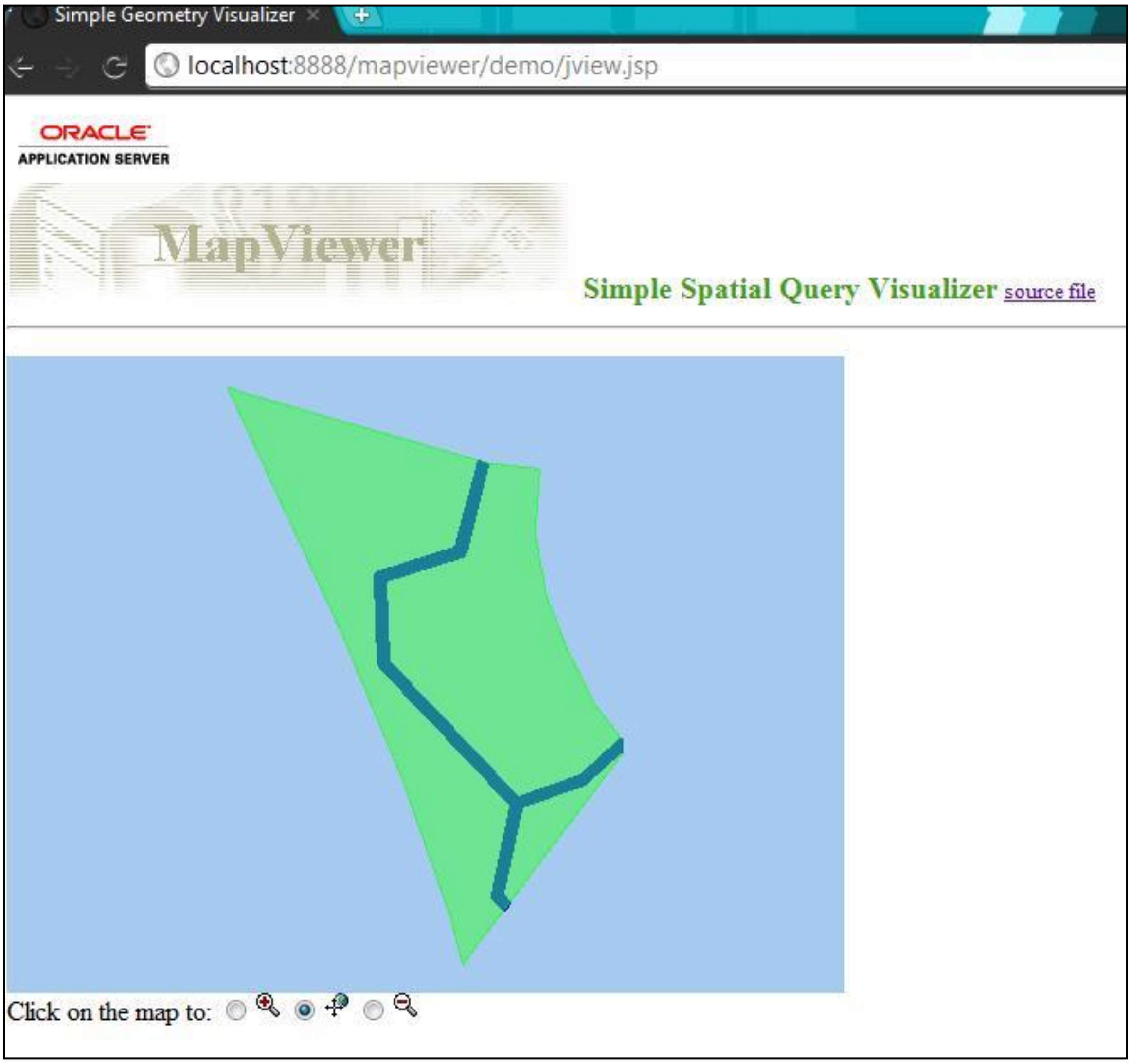


Figure 4-25 Query of easement in Mapviewer

In the right, restriction and responsibility (RRR) concept, the database layout can be expanded as in **Figure 4-26**.

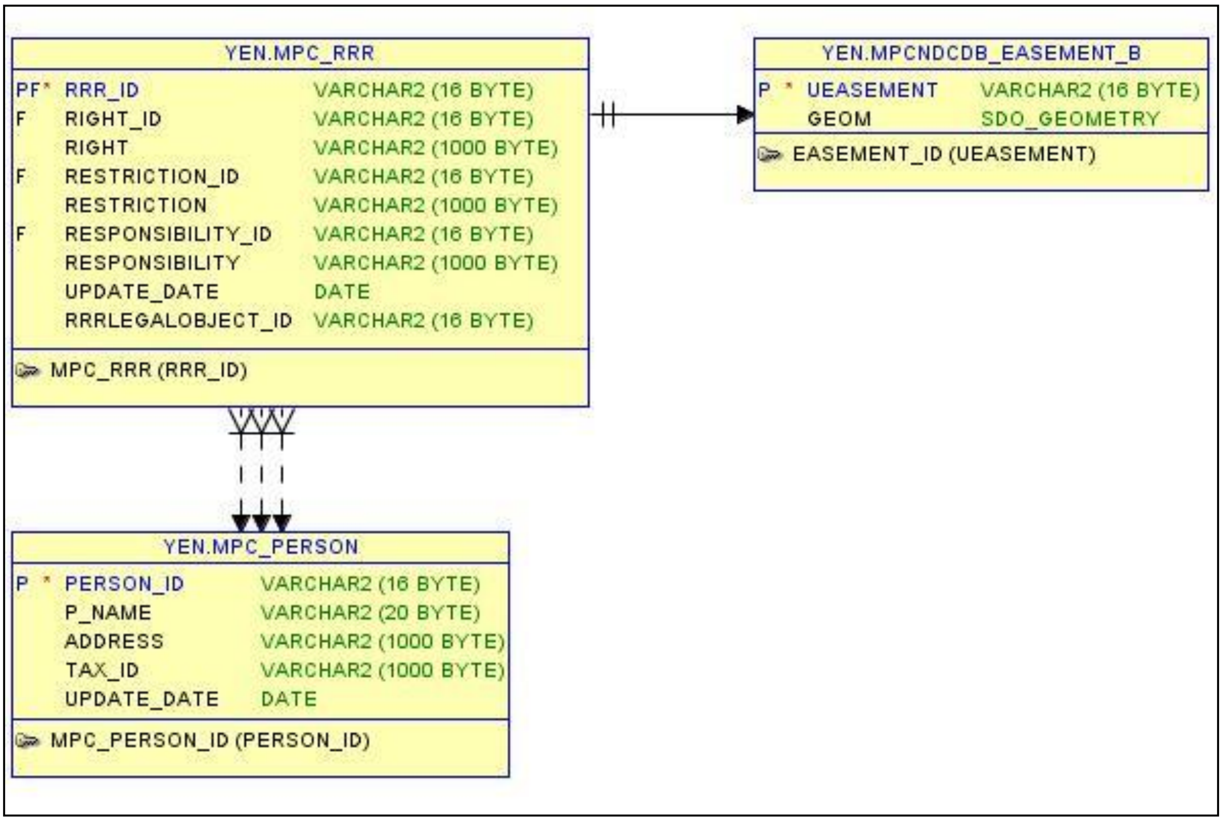


Figure 4-26 The relationship of legal object (easement), RRR and person (proprietor)

The objective is achieved by showing the complete legal situation of a parcel compared to the previous system where the user had to manually search for legal documents and deal with the ambiguous locations of legal objects.

4.8 Summary of chapter 4

This chapter has discussed how to form the object relational database in Oracle database for MPC to be practised. The parcel data and utility can be integrated and data validation can be done in SQL language.

The next two chapters will discuss how to make the MPC database available as a web service and the implementation of SOA to create a more advanced data model.

Chapter 5: Application of service oriented architecture in multipurpose cadastre

5.1 Chapter introduction

This chapter reports on an investigation into how to apply the concept of Service Oriented Architecture (SOA) in the proposed new Malaysian multipurpose cadastre (MPC) system. SOA may present a new work flow for the exchange of data between the private sector, government agencies and the public who will now become either data providers or data consumers in this new system. This researcher's study of SOA driven MPC systems using the Oracle platform will be considered in this chapter.

5.1.1 Definition of service oriented architecture (SOA)

According to the Organization for the Advancement of Structured Information Standards (OASIS), "SOA is defined as a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations" (OASIS, 2006).

5.1.2 The purpose of SOA

The purposes of SOA, according to the Organization for the Advancement of Structured Information Standards (OASIS) 2006 are listed below.

i. To solve the complexity of IT systems by rearranging the applications according to business processes.

ii. To reduce maintenance and development costs by enabling new applications to reuse information provided by previous applications.

iii. To link services by a loose coupling within a semantic framework, using an intermediate destination which ensures that consumer and producer operate independently.

5.2 History of IT architecture

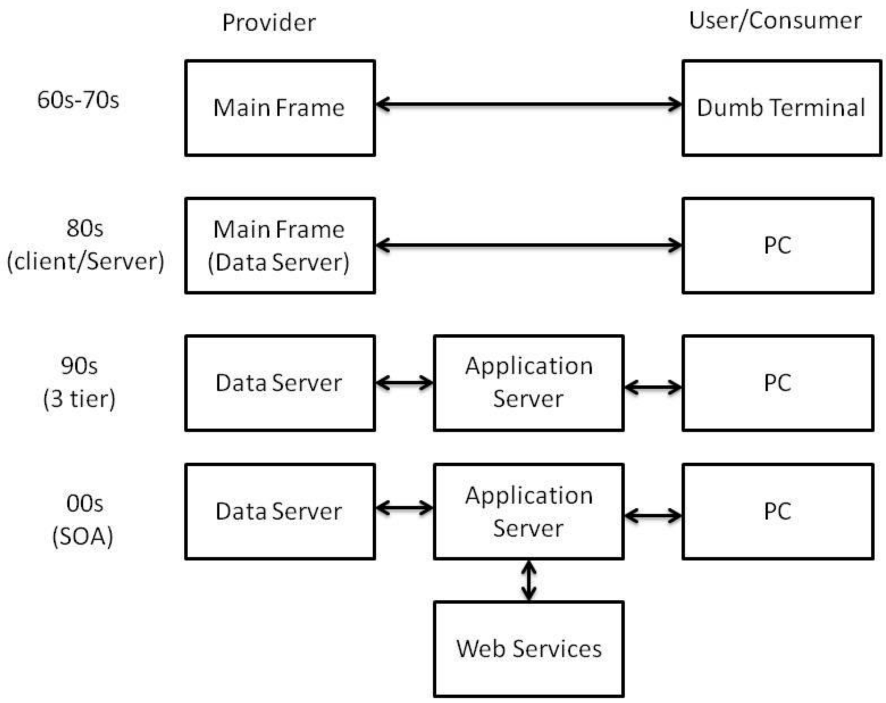


Figure 5-1 The development of the architecture of IT

Referring to **Figure 5-1**, between the 60s and 70s, the conventional architecture of IT consisted of a main frame and dumb terminals, with all functions running in the main frame - such as business logic, presentation and other applications. A dumb terminal only needed to access the information in the mainframe. The design was simple, but a lack of scalability meant it was not able to expand or contract its resource pools to accommodate heavier or lighter loads or input. This ability needed to use when more users and new applications occurred in the main frame.

In the 80s, personal computers (PCs) were used to browse the mainframe, with various functions and presentation performed in the PC. It solved the problem of scalability but such a system was not easy to maintain. When the providers needed to update the applications, they needed to ensure that all the PCs were updated to remain compatible with the main frame system.

During this time the Object Oriented database model was widely used, and the concept of bundling all the data together in one server was popular.

To solve the problem of maintenance, an application server was designed as a middle tier between provider and user. This system was called 3 tier or N tier; tier implied a processing boundary, the applications could be updated more easily. It also ensured the consistency and standard of application to be used by a PC. Such a system had the disadvantage of being too complex when there were many applications in the server. Administrators had problems even to find the applications in the server.

The data sources stored in object oriented models produce very complex data structures, which were very difficult to maintain and update.

In the decade following the new millennium the idea of SOA become more popular, applications were turned into web services. Web services can be defined as similar to a black box that contains code that can be called by an application. A web service can be recalled or reused by another application. Standard messaging, such as XML, is used between the web services to communicate. The Web Services Description Language (WSDL) is an extensible markup language, XML, which describes web services.

Using SOA, data sources can independently be separated from each other, based on their services.

5.3 List of manufacturers of SOA

There are only a few companies that provide SOA technology to users. But included technologies are: IBM Websphere; Oracle Fusion Middleware; Microsoft BizTalk Server; Red Hat JBoss Enterprise SOA Platform; Progress® Sonic® ESB; SAP NetWeaver 7.3; and, TIBCO ActiveMatrix 3.0.

5.4 Web services (web feature service (WFS) and web map service (WMS))

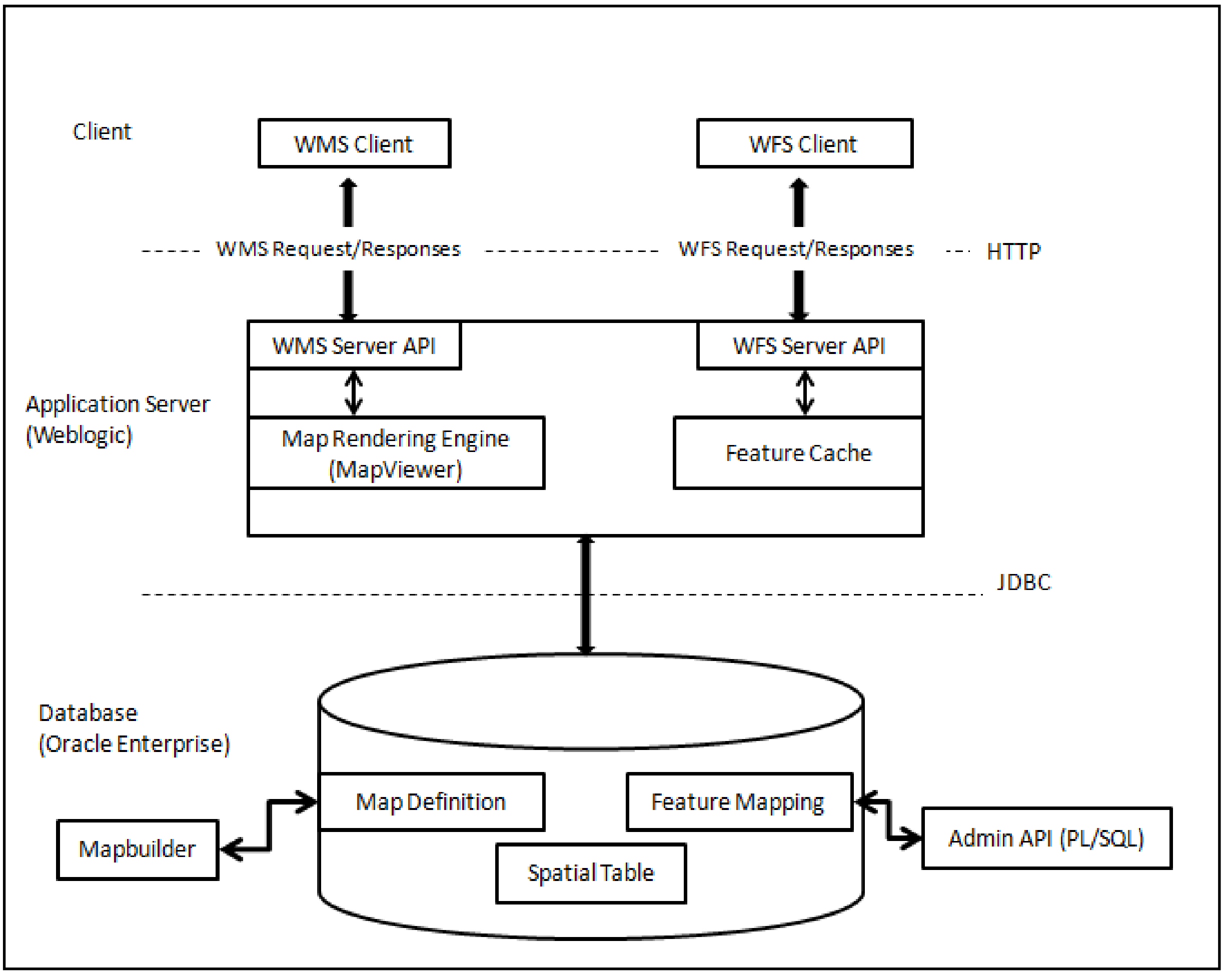


Figure 5-2 WMS and WFS in Oracle system

Figure 5-2 shows the system structure and the connectivity of database, application server and client for the flow of WMS and WFS in spatial data distribution.

Mapviewer can generate OGC WMS Compliant maps (version 1.1.1 and 1.3.0), it supports GetMAP, GetFeatureInfo and GetCapabilities. Mapviewer uses Mapclient.Jsp to request maps using the xml format.

Oracle spatial database can deploy data into an application server in GML format, the Web Feature Service is OGC conforming (version 1.0). It can process WFS requests using SOAP and XML interfaces.

There are two type of WFS which are standard WFS and transactional WFS (WFS-T). WFS-T operations include the ability to insert, delete, update, get and query features on spatial and non-spatial constraints.

The WMS can be used to distribute maps such as certified plans, by JUPEM, while WFS could be used for data updating and sharing among spatial data providers.

WMS and WFS are essential capabilities that every spatial data provider should have if they wish to move forward towards an SOA system.

5.5 Advantage of SOA in multipurpose cadastre

Service Oriented Architecture uses loosely coupled techniques to enable interoperability between applications and data sources. The data provider can provide services independently without following a standard format. This is very important because MPC needs to cater for non-standard data types.

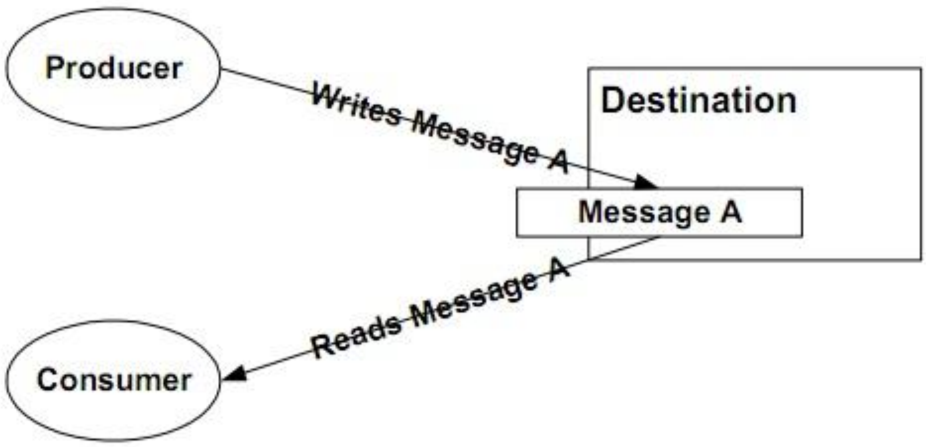


Figure 5-3 Loose coupling concept

According to Sahin and Gumusay (2008), basic operations in SOA have, conceptually, three components which are: Producer (service provider); Destination (service registry); and, Consumer (service requester) as shown in **Figure 5-3**. A producer will write message A to a destination. A consumer will read the message A from the destination. For example a service provider will publish their service to a registry so that then a consumer (client) can search and request their service from registry. A service registry helps service providers and service requesters to find each other by acting as a record of the services.

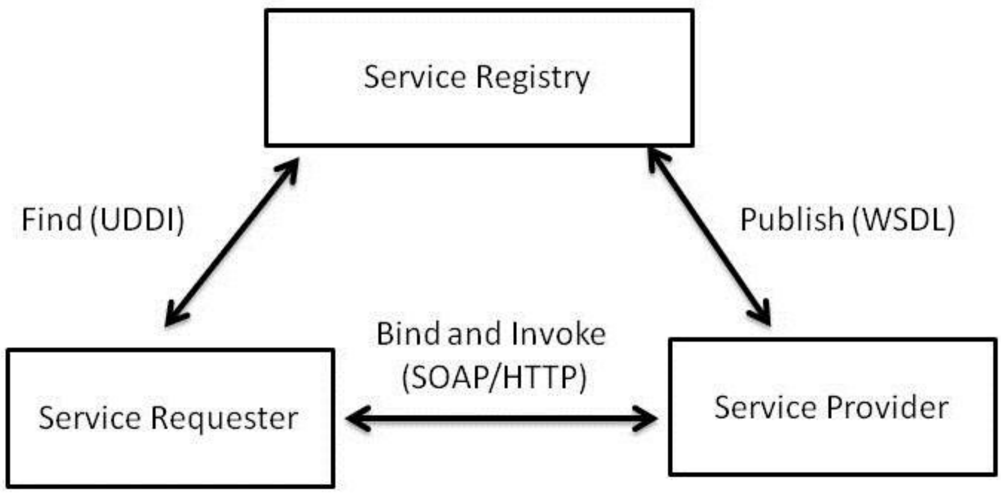


Figure 5-4 The operation of services in SOA

Figure 5-4 shows some important protocols that support transfers and searches (Sahin and Gumusay, 2008)

A Transport Protocol is responsible for transporting messages between network applications. HTTP (HyperText Transfer Protocol) is the low-level protocol used by the Internet for transfers.

A Messaging Protocol is responsible for encoding messages in a common XML format so that they can be understood at both ends of a network connection.

The Simple Object Access Protocol (SOAP) is the specific format for exchanging Web Services data over HTTP.

A Description Protocol is used for describing the public interface to a specific web service.

The Web Service Definition Language (WSDL) is used to describe what type of message a Web Service accepts and generates.

A Discovery Protocol centralizes services into a common registry. The Universal Description, Discovery and Integration (UDDI) specification can be used by the service providers to advertise the existence of their services and by requesters to search and discover already registered services.

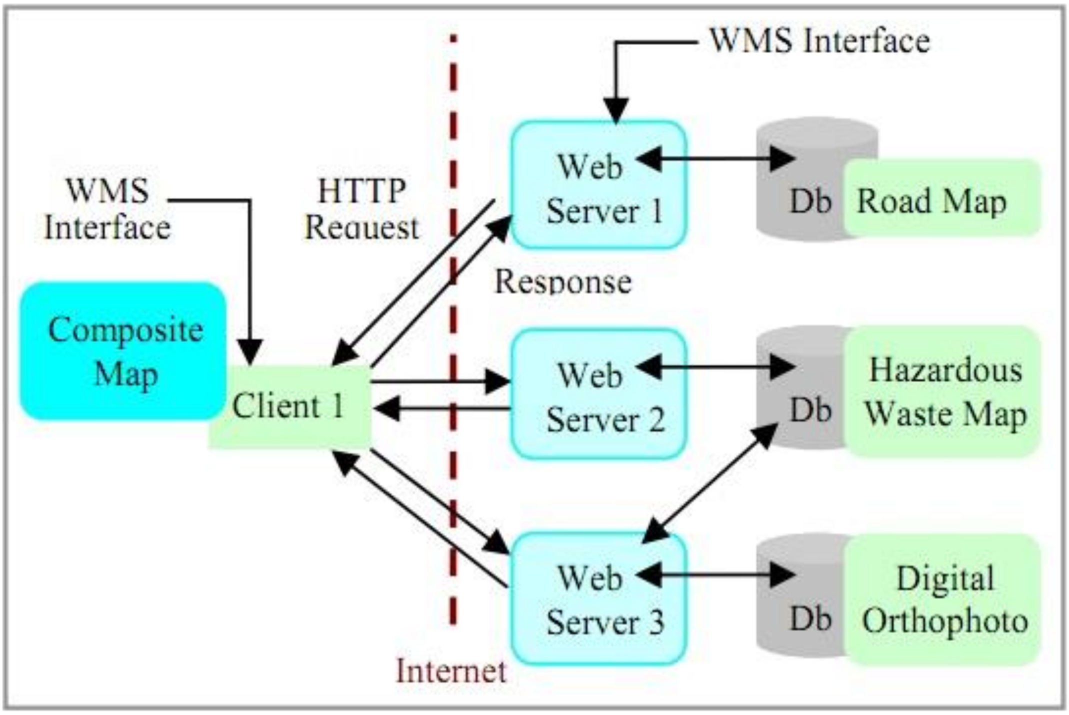


Figure 5-5 Interoperable, distributed mapping systems
(The portrayal of the concept of interoperable, distributed mapping systems in which the user runs a single Web client to access all the capabilities of each server (Sahin and Gumusay, 2008))

With OpenGIS standards-based interoperable Web mapping, each map server implements a common interface for accepting requests and returning responses. Now, the same client 1 (Web Client) in **Figure 5-5** has Web access to potentially all available map servers and multiple data sources, in which each web server 1, web server 2 and web server 3 is accessed by the same Web client through the common interface which is in this case the Web Map Services (WMS). **Figure 5-5** portrays this concept of interoperable, distributed mapping systems. The result is one composite map instead of three separate ones. This approach allows, among other things, the user to run a single Web client that accesses all the capabilities of each server (Sahin and Gumusay, 2008)

Different geospatial services provided by various agencies are available over the internet in Malaysia. However it is not possible for individual standalone services to meet all the service requirements of many users. As the number of geospatial services has increased rapidly, an emerging need has also appeared for methodologies to locate desired services that provide access and data mining capabilities to geospatial data. A Service Oriented Architecture (SOA) recognizes this and tries to construct a distributed, dynamic, flexible and reconfigurable service system over the Internet that can meet the information and service requirements of many different users (Aydin, 2007).

From chapter one, it can be seen that this investigator has proposed three data models that possibly can be used in the MPC system in Malaysia, as follows:

Type 1: Spatially-referenced data model based on Legal Land Objects, processed in independent layers (see **figure 5-6**);

Type 2: Land Parcel based data stored in a Relational Object oriented database with high geometric accuracy;

Type 3: Hybrid data model which integrates Type 1 and Type 2 data models.

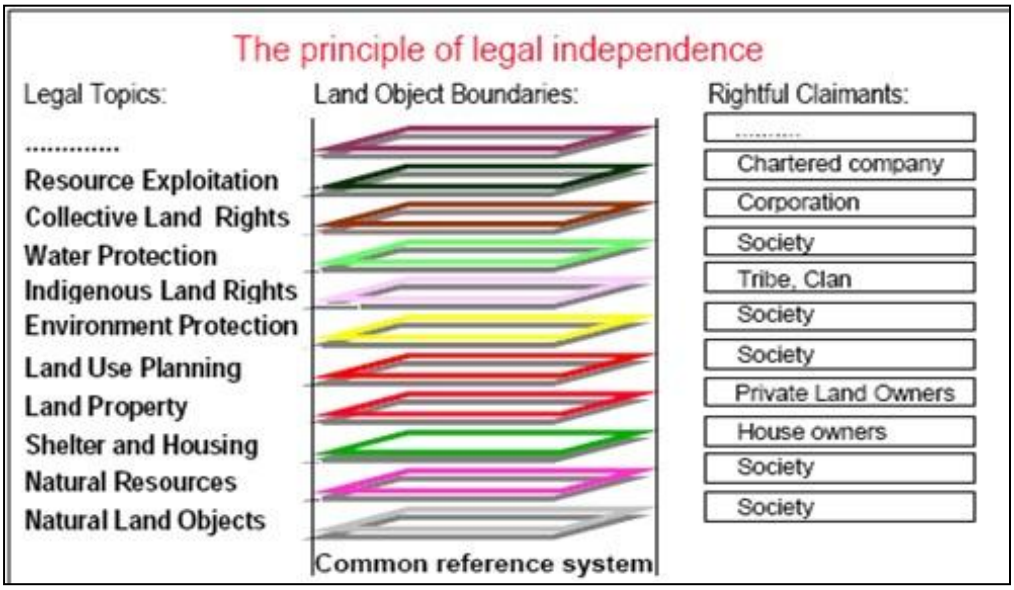


Figure 5-6 Legal land objects are processed in independent layers
(which is proposed in Cadastre 2014 (Kaufmann, 2002))

The structure of **Figure 5-6** supports the immediate adaptation of the cadastre to developments in legislation. It is not necessary to rearrange the information. A new layer of legal objects (e.g. Flood Protection Zones) can simply be added by including a further information layer. If a law is repealed, the respective layer can be removed without affecting the other layers.

The legal land objects can be based at the different services provided by various agencies in Malaysia. The merger of data or services into one database may not be an ideal considering the very different agencies under different authorities that provide data in Malaysia. SOA, using web services such as Web Feature Service (WFS), Web Feature Service-Transactional (WFS-T), Web Mapping Service (WMS) or Web Coverage Service (WCS) may be the answer.

A data layer is stored according to the business processes and according to the group of data providers who are involved in that business process.

In the case study concerning the easement of a utility pipeline developed in chapter four. The business process to produce an easement for a utility pipeline involves a few different agencies, such as JUPEM, who produce parcel data, a utility company, who produces utility data, and the Land Office, who issues easements in a particular land title.

The data model type 1 which involves storing both the utility data and the parcel data separately with WFS and WMS capability has the advantage of low cost maintenance, being business process friendly and involves different agencies.

The data model type 2 which stores both the utility data and the parcel data in one homogeneous relational database has the advantage of generating an accurate parcel base easement but has the disadvantage that the database has to be maintained and stored in the same place. The Land Office which issues easements has the authority but might not have the capability and skill to maintain spatial data.

5.6 Disadvantage of SOA in multipurpose cadastre

There are downsides to SOA however, especially for enterprise datasets. SOA is a strategy for integrating loosely-coupled independent data sources, but centralized control does not exist. Backup and restoration is complicated when information is collated at the application layer which are recalled using protocol interfaces instead of in the persistence layer stored in the hard drive of one particular server. Data Base Administrators and network managers have no single data dictionary or repository index that allows them to catalog and manage all information. This complicates, or makes impossible, the tasks of ensuring that all information is appropriate, timely, and recoverable.

To solve this problem, software vendors have created a few products that integrate work across all service providers, such as an Enterprise Service Bus. In this investigation the Oracle Service Bus will be used.

5.7 Focus on Oracle SOA

JUPEM is using an Oracle platform as a database and all data are structured and stored for an Oracle database, thus this researcher will focus discussion on the SOA Package provided by Oracle. The MPC sample database that was developed in Chapter 4 will be used by the researcher to test, practically, the Oracle SOA platform.

<table>
<tr><td colspan="2">Database</td><td>WebLogic Server</td><td>Repository Creation Utility (RCU)</td></tr>
<tr><td>SOA Suite</td><td>Oracle Service Bus</td><td>Jdeveloper</td><td>SOA Extension</td></tr>
</table>

Figure 5-7 Components provided by Oracle to support SOA
(Oracle Corporation, 2011b)

Before the installation of the SOA suite provided by Oracle, the user should have the general components listed in the **Figure 5-7**, especially an Oracle database and WebLogic Server, Repository Creation Utility (RCU), Jdeveloper and an Oracle Service Bus (Oracle Corporation, 2011b).

WebLogic is used for server partition and locates the domain for any new Oracle components such as the (Oracle) SOA Suite and the Oracle Service Bus.

The Repository Creation Utility is used to create database schema.

Enterprise Service Bus (in this case the Oracle Service Bus) manages and monitors messages between the web services. It also has a role to monitor security, manipulate data sequences and version applications.

Jdeveloper is used to develop applications in the SOA Suite such as the BPEL Process Manager.

The Oracle SOA Suite contains the components below:

a. BPEL(Business Process Execution Language) Process Manager
b. Human Workflow
c. Business Rules (BR)
d. Business Activity Monitoring (BAM)
e. Business Process Management
f. Mediator
g. B2B (Business to Business, document exchange)
h. Complex Event Processing
i. Web Services Manager
j. User Messaging Service
k. Enterprise Manager Fusion Middleware Control

BPEL (Business Process Execution Language) Process Manager is an application that links and recalls the web services using Jdeveloper. This is the main component of the SOA concept to be investigated in the next chapter. Jdeveloper has an interface that enables the designer to drag and drop code without writing the JAVA script.

Figure 5-8 shows the interface of Jdeveloper in the process of developing a BPEL process. It has 4 components which are application navigator, composite XML,drag and drop flow and component palette.

The application navigator contains project folder, deployment functions, sources navigator. The composite XML contains the XML script file that is produced by the drag and drop function. The component palette contains the function that can be dragged to design the process. For example the function of invoke is used to recall WMS or WFS.

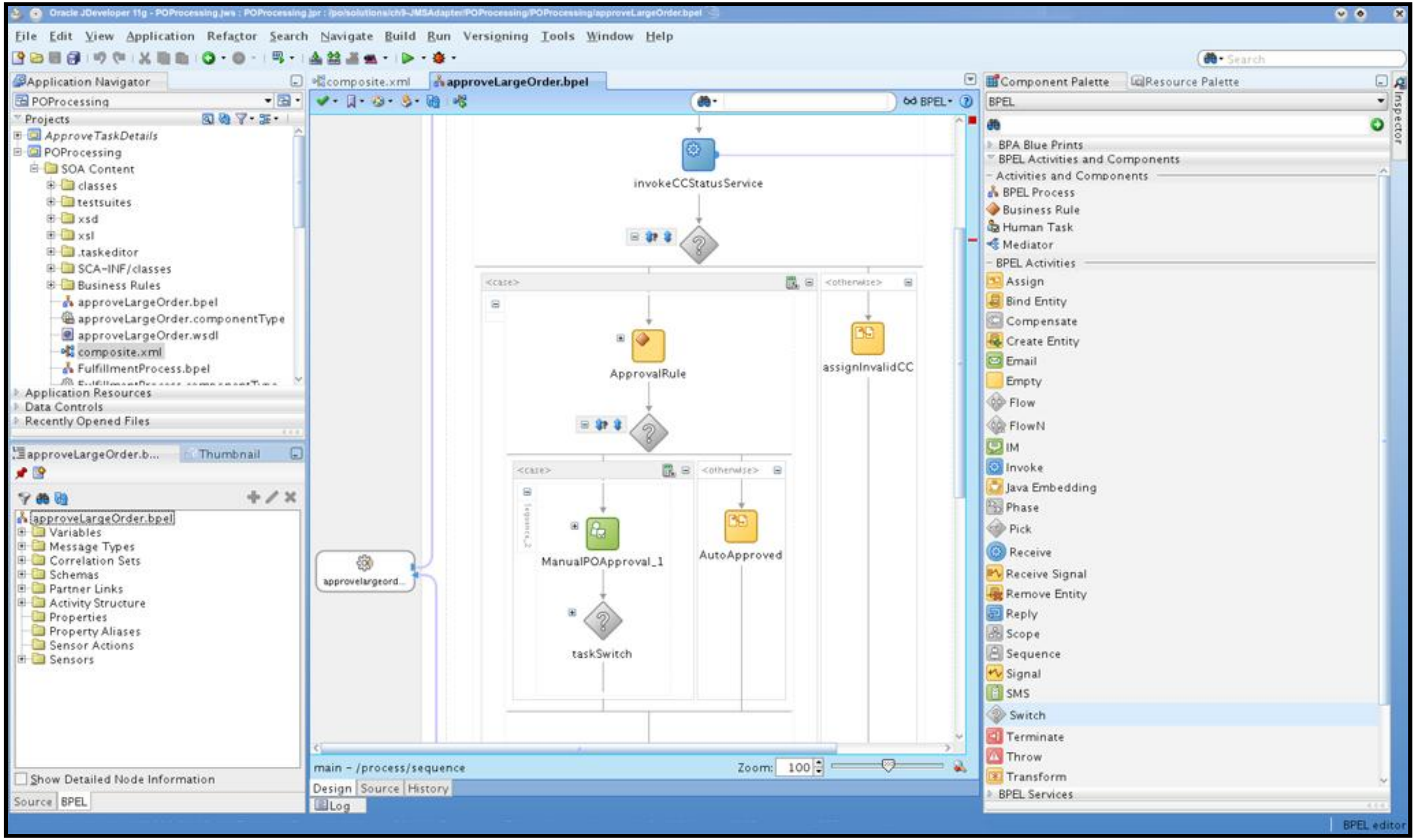


Figure 5-8 Application view of how BPEL is developed
(Oracle Corporation, 2011a)

The BPEL (Business Process Execution Language) Process Manager is also used together with other Oracle SOA components such as Human Work Flow to layout the business processes which involve people, tasks and approvals. People can connect directly to business processes and get responses through email or SMS.

Oracle SOA also includes BAM (Business Activity Monitoring) that enables business owners to collect data and reports. The BR (Business Rule) engine can store the business rules and users can change the business rules without going through any scripting.

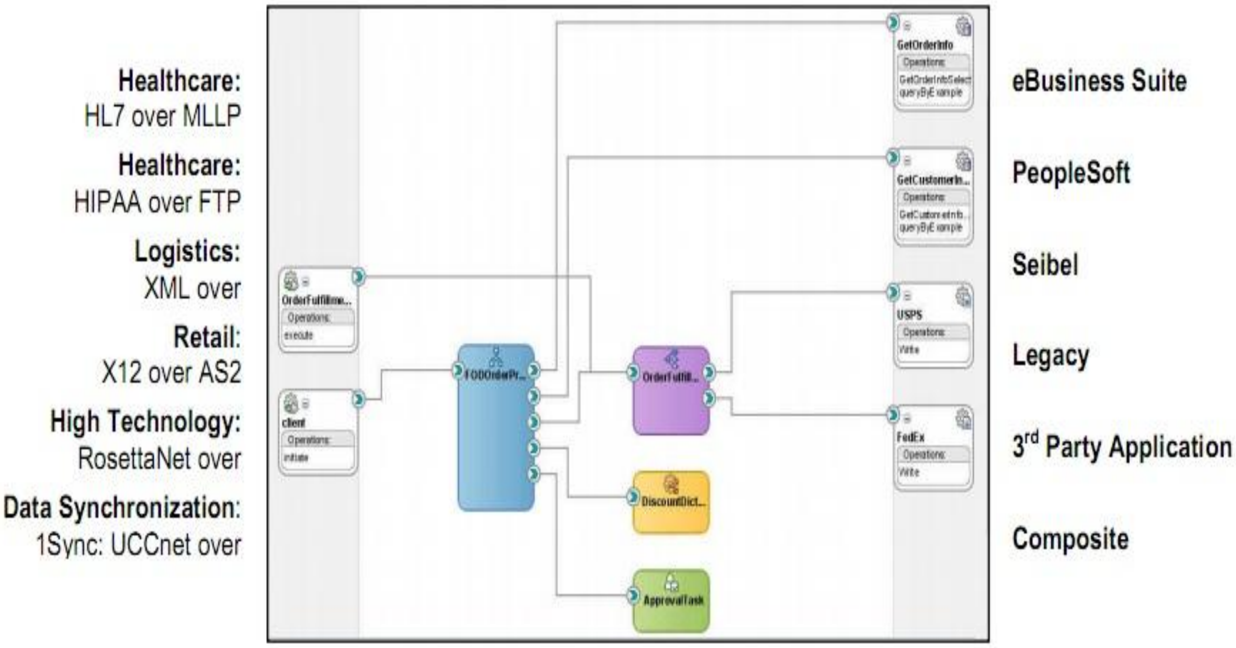


Figure 5-9 **Sample of document exchange using B2B**

As shown in **Figure 5-9**, B2B is the application that allows exchange of documents between business entities such as manufacturers, suppliers and retailers, or in the JUPEM case, between data providers.

5.8 System migration in JUPEM

JUPEM had achieved full automation of its work processes through the project eKadaster by 2011. The same project successfully integrated two main services which are survey data records and land registry records, provided by two different agencies, namely JUPEM and the Land Office which are respectively under the authority of the federal government and the states. The combination of two previously different work flows aimed to produce a land register document referred to as ‘title’.

There are various applications which have been developed by JUPEM for eKadaster as shown in **Figure 5.10**.

The eKadaster referred to chapter 1 was introduced to address the problem of the backlog of the production of ‘final title (a final document that contains a certified plan produced after a particular parcel has been surveyed by JUPEM) due to discrepancies of authority, location and staff in both agencies. The technology was developed to speed up the manual work flow but the system contains a group of complex applications. Data exchange among the applications is just a one way flow. Queries may be difficult to pass among the users. In the system, JUPEM utilizes the XML format in the submission of strata maps by licensed surveyors. The other formats used in this system are ASCII, DXF and Shape. JUPEM could use XML or GML format for all processes, and such an effort would migrate the system towards more open format across the applications. It is suggested that JUPEM could utilize the Oracle B2B as a platform to synchronize information in the eKadaster system.

Although the eKadaster project solved the interoperability problems to produce parcel data, JUPEM also provides non cadastre data such as topographic data, geodetic data and utility data which has yet to be homogenised with the parcel data. The detail of eKadaster and **Figure 5-10** can be found in **Appendix E**.

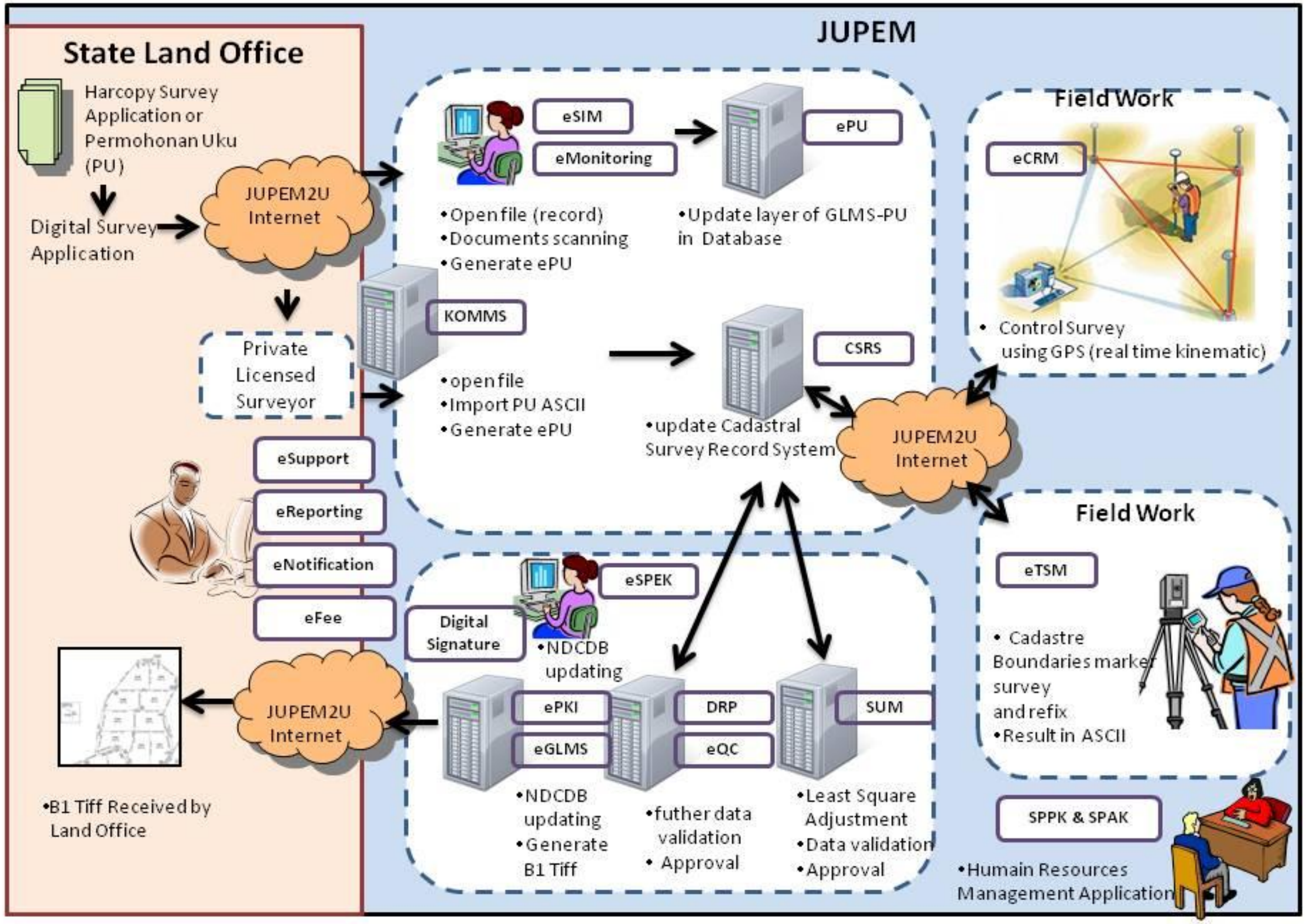


Figure 5-10 eKadaster workflow
(Introduced in 2009 by JUPEM, explained in **Appendix E**)

5.9 eKadaster internal SOA

Investigations should be done on whether it is necessary for JUPEM to migrate the applications in eKadaster to web service, to establish an internal SOA system. This may not be necessary because all the applications are directed towards one customer service.

Further investigations should be done on how to migrate JUPEM2u (the JUPEM geoportal) to Web Services. It should be able to respond to messages that need to reuse services.

5.10 SOA system sample – Danish case

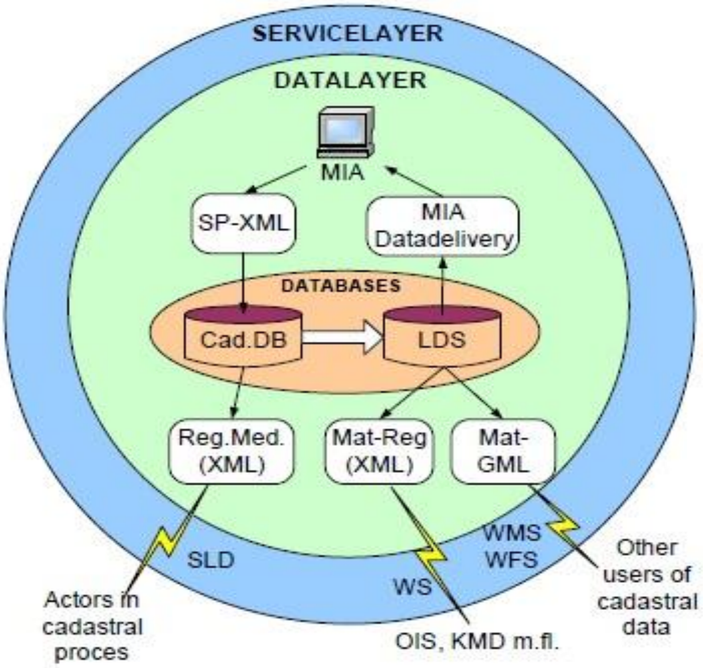


Figure 5-11 The Danish SOA cadastre system
(makes use of SOA to distribute the data to the customer (Christensen, 2009))

In the 2009, Denmark renewed its cadastre business process using the SOA technology IBM Websphere. They reformatted their register and map data into open source data formats, such as XML and GML as shown in **Figure 5-11**.

Denmark's Cadastre database is in Oracle database. After the redevelopment, they found that performance in WFS was not as good as expected, compared to direct calls in a client/server solution (a factor 2.5 slower). However, they claim it is acceptable, They claim the greatest challenge has been defining database views (Christensen, 2009). The knowledge of how to define a view in Oracle spatial is important in order to speed up the querying in Oracle.

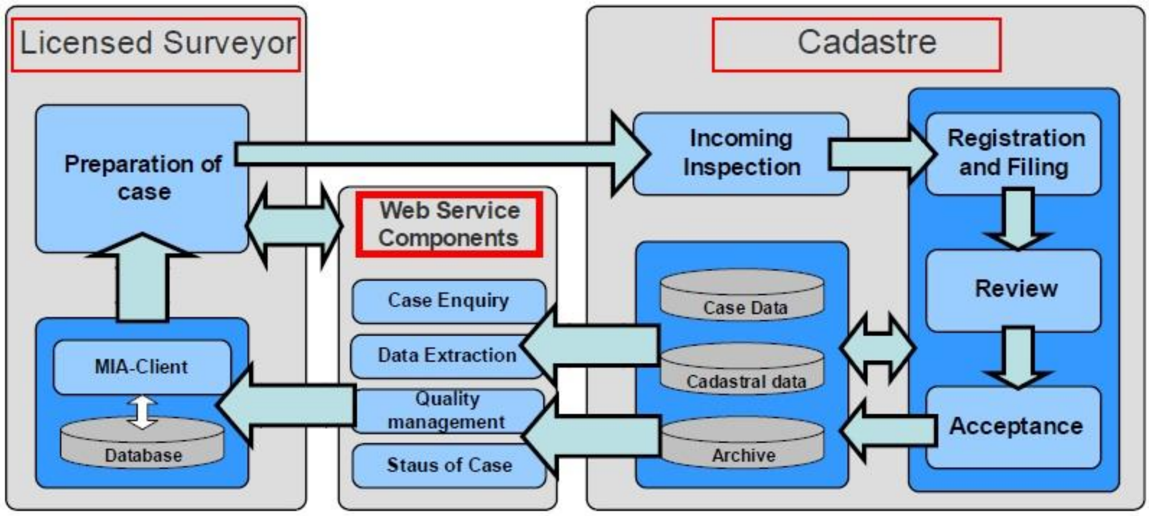


Figure 5-12 Danish cadastre data distribution
(The example of data from published using web service by Danish Cadastre (Christensen, 2009))

The idea of web service publishing just after the Licensed Surveyor has finished the work might address some of the lengthy processes in Malaysia's eKadaster. In the eKadaster system the final data produced by the Licensed Surveyor are redundantly checked in JUPEM. The SOA should function to reduce the redundancy process in the work flow. **Figure 5-12** shows that in the Danish cadastre, the final data available to users in the web service come from Licensed Surveyors. The Licensed Surveyors are in charge and responsible for maintaining the final data

If this business process model is implemented, Licensed Surveyors in Malaysia may have greater responsibilities.

5.11 Summary of Chapter 5

The technology of the internet and information exchanging through networks have provided a facility that enables humans at different locations, with different backgrounds, knowledge and skill to work together under one digital process. It is because in the real world situation, many organisations involved in a business process are not able to put that together under one roof. The modules in SOA have created a platform and standards to provide diverse and separated systems and organisations with an interoperability environment. The use of the SOA concept in the spatial sector is becoming popular especially as it is expected to bring down operating costs. An understanding of Web Feature Service (WFS), Web Feature Service-Transactional (WFS-T), Web Mapping Service (WMS) or Web Coverage Service (WCS) and BPEL process are basic to effective spatial SOA functioning. JUPEM has successfully migrated its business process from manual to fully automated, now JUPEM faces a new challenge in the MPC project: it needs to bring data out from its silo; SOA is expected to help in this process. Currently, the Danish cadastre uses SOA in its business which can be taken as a model for SOA in MPC.

Chapter 6: Multipurpose cadastre in an SOA environment

6.1 Chapter introduction

In this chapter, the researcher will describe the execution of a technical test implementing the SOA concept for multipurpose cadastre, as explained in the previous chapter. The chapter will explain, technically, how the SOA concept can support data model type 1 (Spatially-referenced data model based on Legal Land Objects, processed in independent layers). Although an unusual format for a dissertation chapter (it might, for example, be found in an appendix), it is thought that the experience has been so beneficial to the author that its place as a main chapter in justified.

The researcher will enable performance of the Web Map Service (WMS) and Web Feature Service (WFS) processes for the MPC database developed in Chapter 4. This process will use the technology of Oracle MapViewer and Oracle Spatial.

In Chapter 4, the OC4j standalone application server was used to host MapViewer. In this chapter, the WebLogic Application Server will replace OC4j. The WebLogic Application Server is a Java EE based server that can deploy more applications including MapViewer, WMS, WFS and SOA BPEL applications. It can create domains and cluster these for applications.

In this chapter, the application development tools used are as following:

Software:

- Oracle database 11g version Release 2 enterprise edition;
- Oracle Spatial Web Feature Service;
- Oracle Fusion Middleware MapViewer version 11g ps4 (11.1.1.5.1);
- Oracle SQL Developer version 3.0.04;
- Oracle Web Map Service;
- Oracle Map Builder 11g ps4 (11.1.1.5.0);
- WebLogic version 10.3;
- Oracle Suite; and,
- Jdeveloper 11g R1

Programming Languages:

- SQL programming Language; and,
- Java, XML and GML (Generated by Jdeveloper)

Hardware:

Dell N5030 Notebook (Pentium ® Dual-Core CPU,(2.3GHz), 3.00 GB RAM, 64 bit operating system, Windows 7)

The installations of the above applications were carried out according to the 'quick guide' of the SOA Suite provided by Oracle Corporation (Oracle Corporation, 2011b).

Unfortunately RAM limitations prevented a full of examination of SOA as hoped (**see 6.12.9**), however the examination considered was thorough.

6.2 Hypertext Transfer Protocol, SOAP interface and XML interface

Web Services support the HTTP protocol to transfer data. Two types of HTTP interface are as follows:

a. SOAP (Simple Object Access Protocol) and XML interface

The structure of SOAP contains the envelope, header and body as shown in the example below:

```
Post/ Http/1.1
Host: http://localhost:7001/
<?XML Version='1.0'
<SOAP: Envelope  xmlns:soap= " http://....
<SOAP: Header
<SOAP: Body>
<m:Get….. xmlns: m= "http://....
```

b. HTTP-GET and HTTP-POST

The difference between GET and POST is the message encoding to the server. Both can use SOAP or XML interface formats for the message.

GET uses the URL encoded in a query string. It is suitable for retrieving data if the message is short, such as in the GetCapabilities query.

The more suitable approach is POST, which is normally used for sending data or for data update, but a client application platform is needed for the POST message.

HTTP-GET xml example:

```
http://machine-name:port/SpatialWS-SpatialWS-context-
root/xmlwfsservlet?request
=GetCapabilities&service=WFS&version=1.0.0
```

HTTP-POST xml example:

```
<?xml version="1.0" ?>
<GetCapabilities
service="WFS"
version="1.0.0"
xmlns="http://www.opengis.net/wfs" />
```

Most of the testing in WMS uses HTTP-GET while the testing in WFS uses HTTP-POST.

6.3 The Web Map Service (WMS)

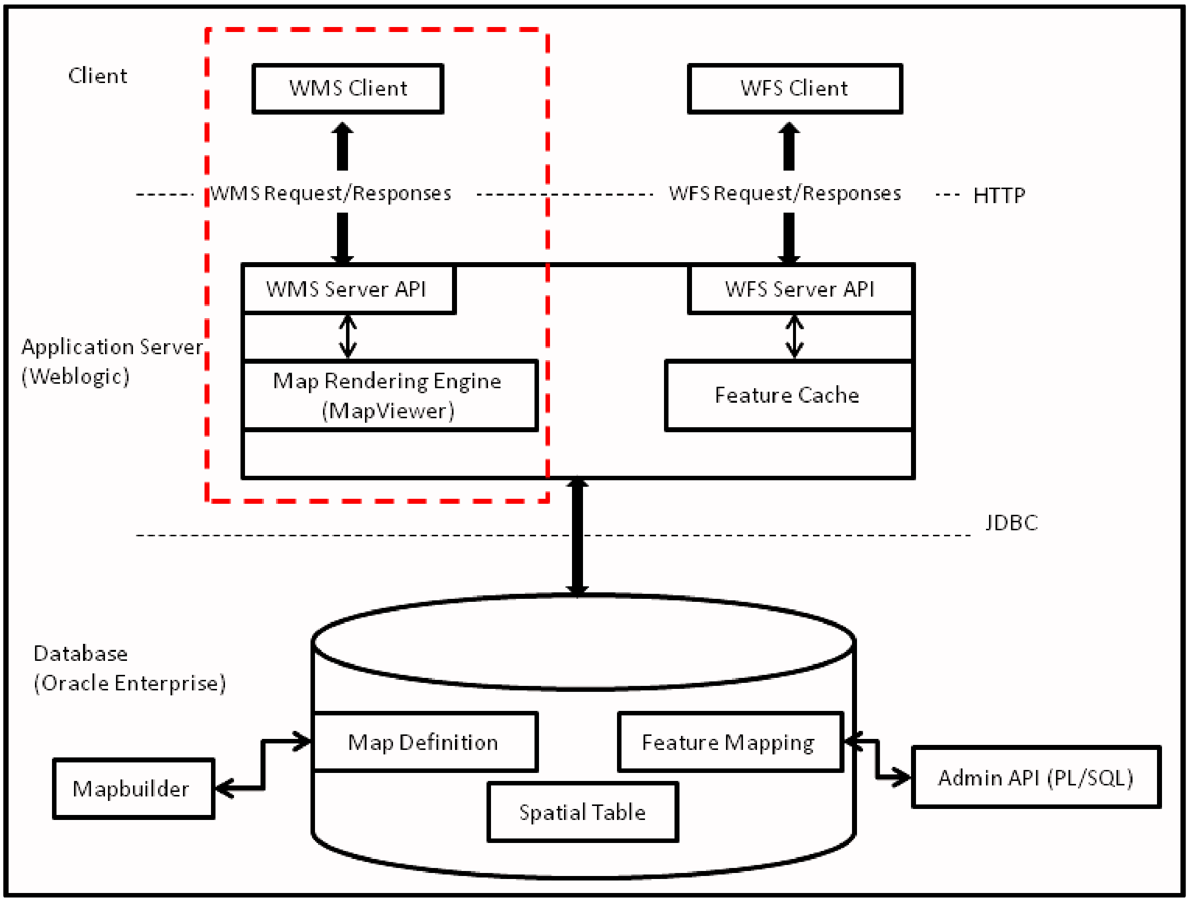


Figure 6-1 WMS in Oracle technology
(The Concept of Web Map Service (WMS) in Oracle Technology)

Figure 6-1 show the concept of Web Map Service (WMS) in Oracle technology, the Web Map Service Interface Standard (WMS) provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. WMS maps are in picture formats such as GIF or JPEG. Oracle WMS follows the specification of the Open Geospatial Consortium Standard. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc.) that can be displayed in a browser application.

A client application user will be able to combine layers coming from different map servers.

The steps described in **section 6.4** enable the Web Map Service using Web Logic.

6.4 Creating a domain in Web Logic application server

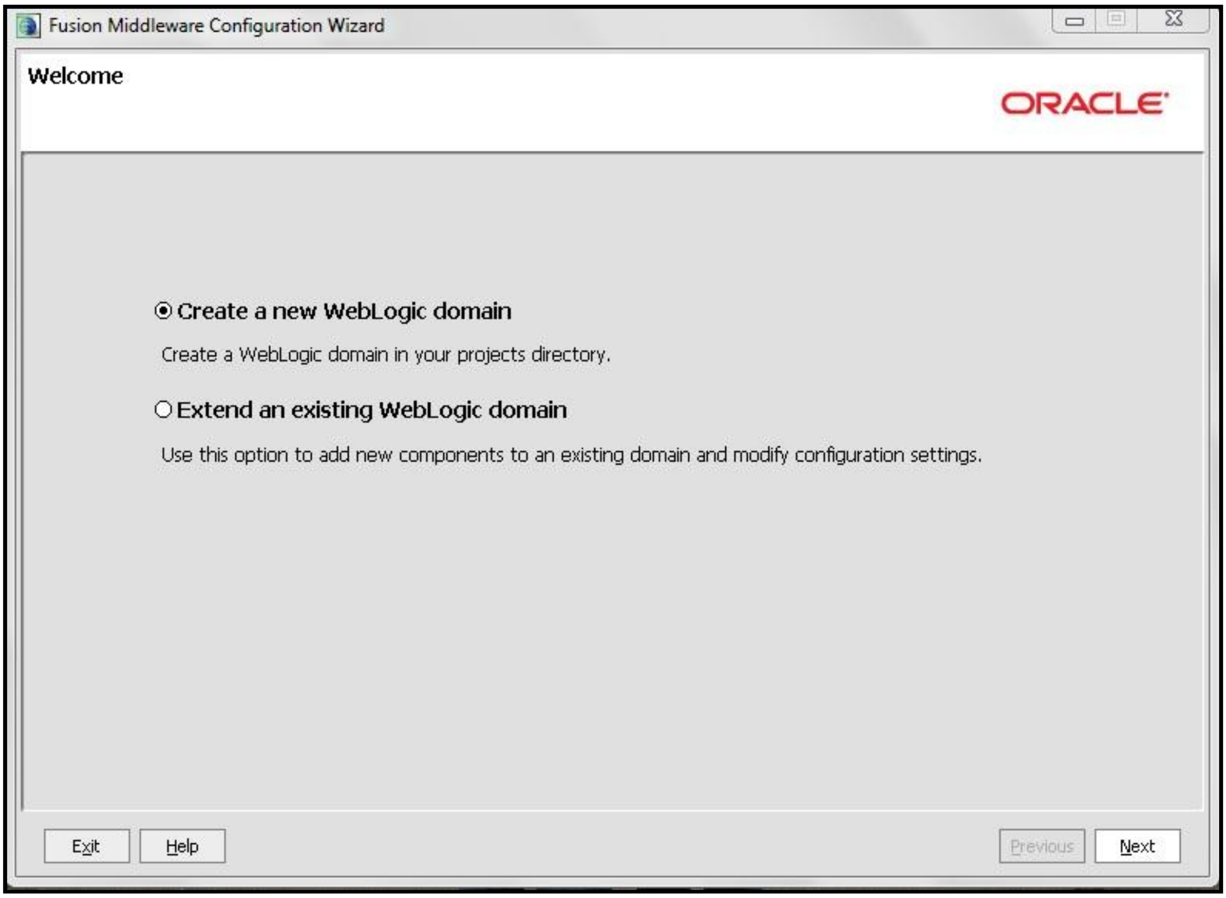


Figure 6-2 WebLogic domain
(Creating New Domain in WebLogic Application Server)

WebLogic can create a domain to host the application as shown in **Figure 6-2** and the domain can then be divided to clusters. The admin server can be a target for this domain and clusters.

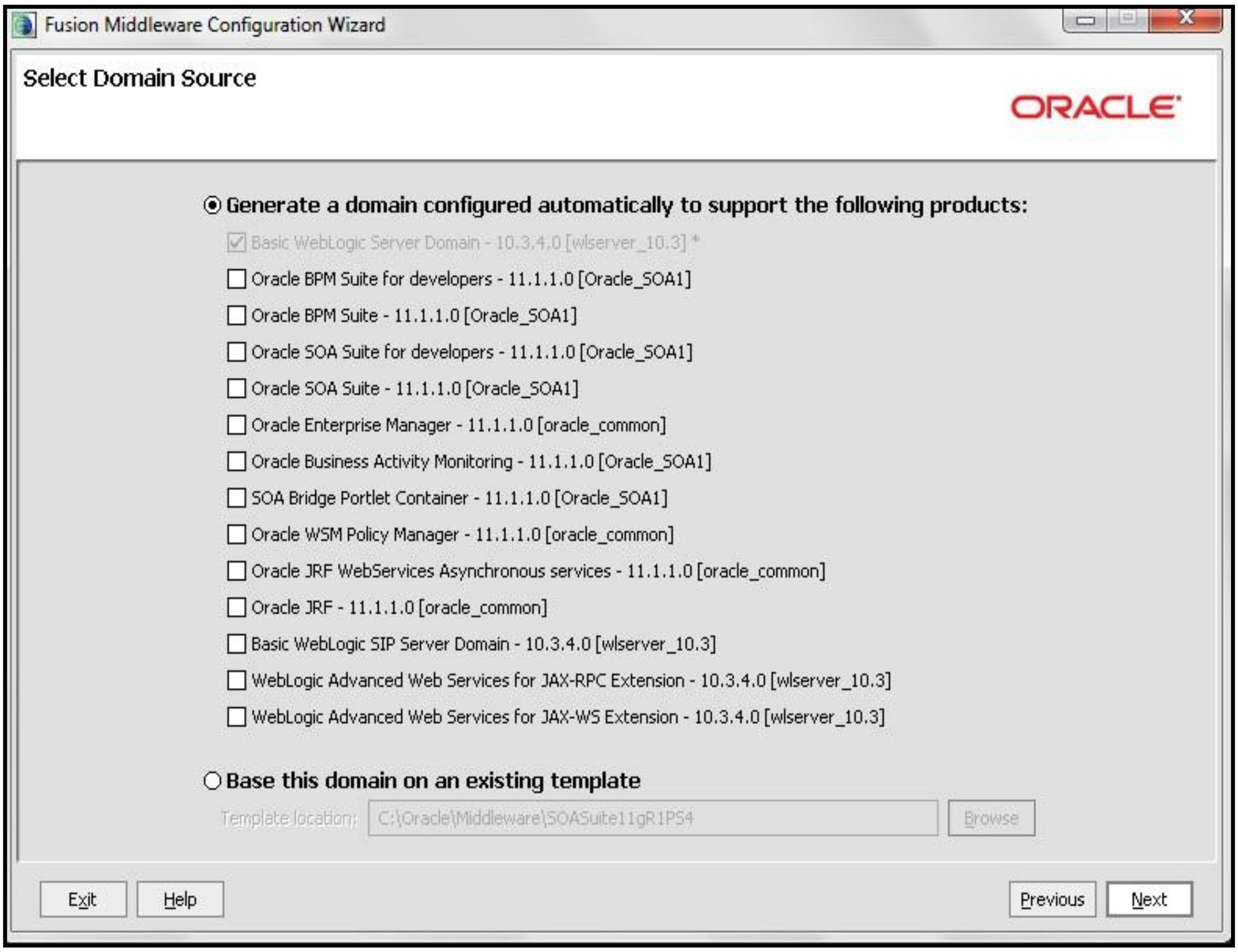


Figure 6-3 WebLogic application customization
(User to Customize the Applications for the Domain)

After the SOA suite is installed, the user can select the component of SOA to be included in the domain as shown in **Figure 6-3**. In this example, the modules selected are Oracle BPM Suite for Developers, Oracle SOA Suite for developers, Oracle Enterprise Manager, Oracle Business Activity monitoring, Oracle WSM Policy Manager and Weblogic Advanced Web Services for JAX-WS Extension.

The domain can be started using the StartWebLogic.bat which is created in the domain folder in the Weblogic Application Server as shown in **Figure 6-4**. The Weblogic is installed as the folder ‘SOAsuite11gR1p4’.

When the .bat file is started, the deployment of the application server will start running as shown in **Figure 6-5** until all the applications in the domain are ready to accept the request, as shown in **Figure 6-6**.

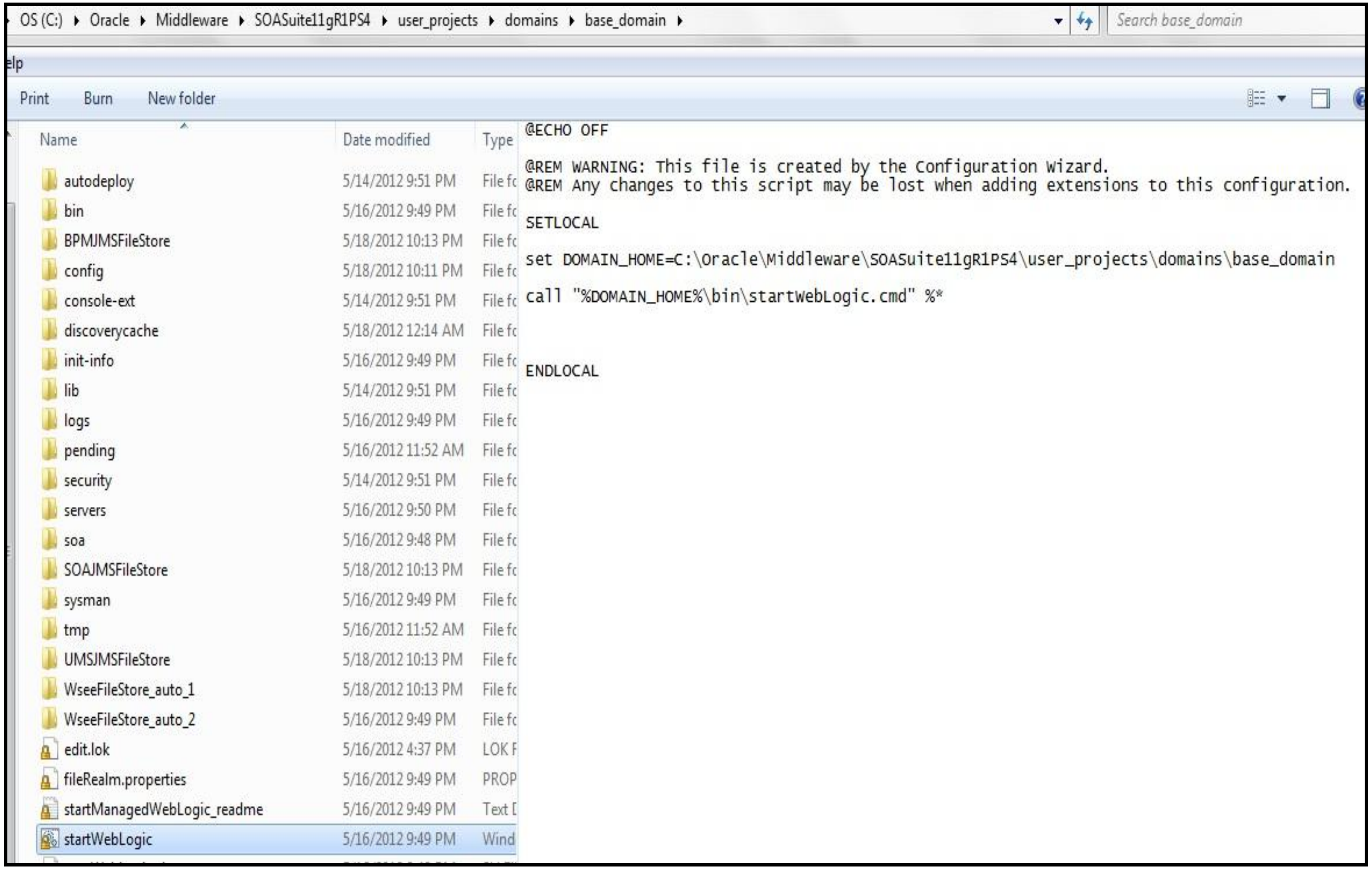


Figure 6-4 **Start the Weblogic application server domain**

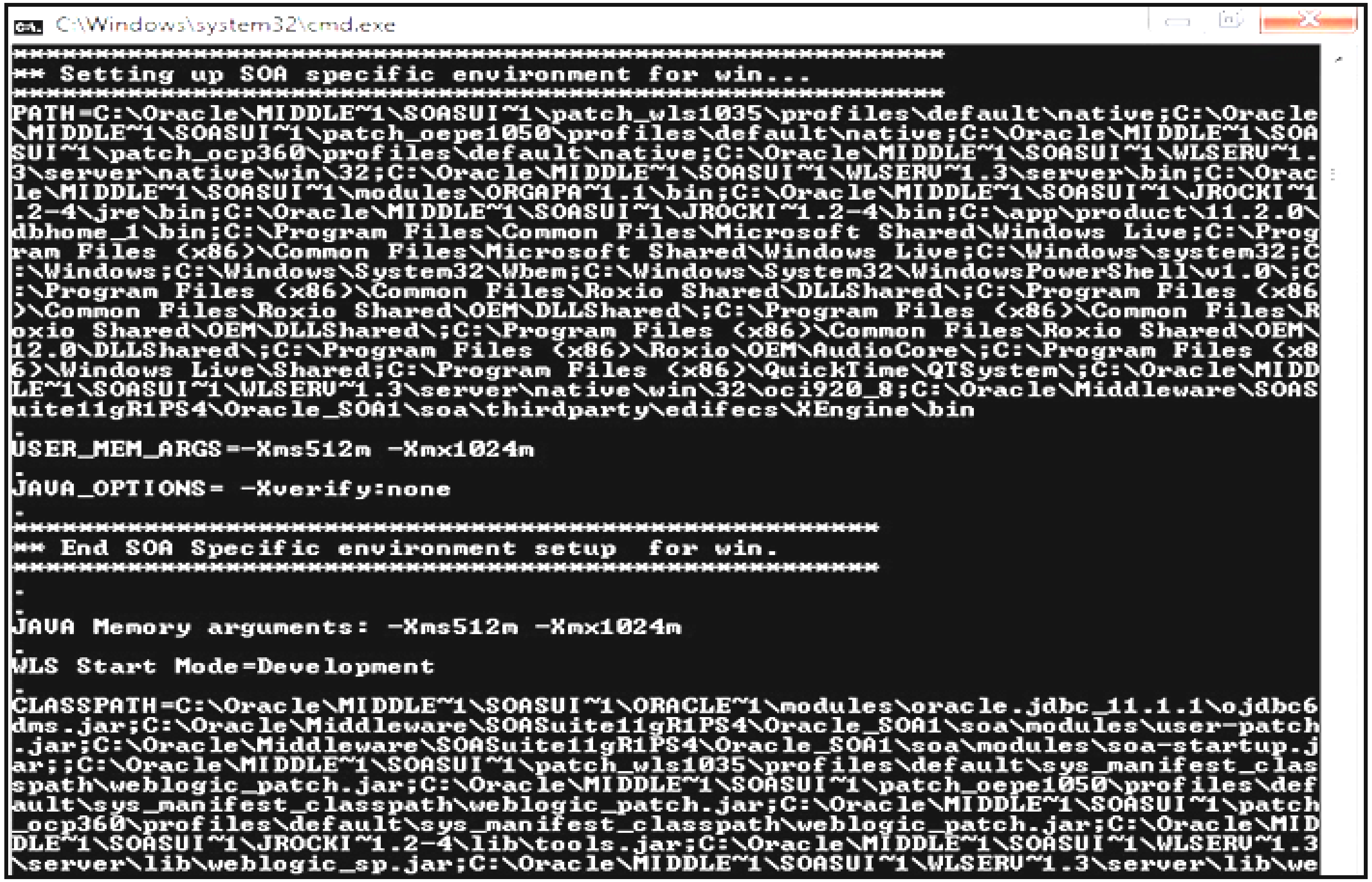


Figure 6-5 WebLogic deployment
(The deployment of the Weblogic application server based on the customized domain)

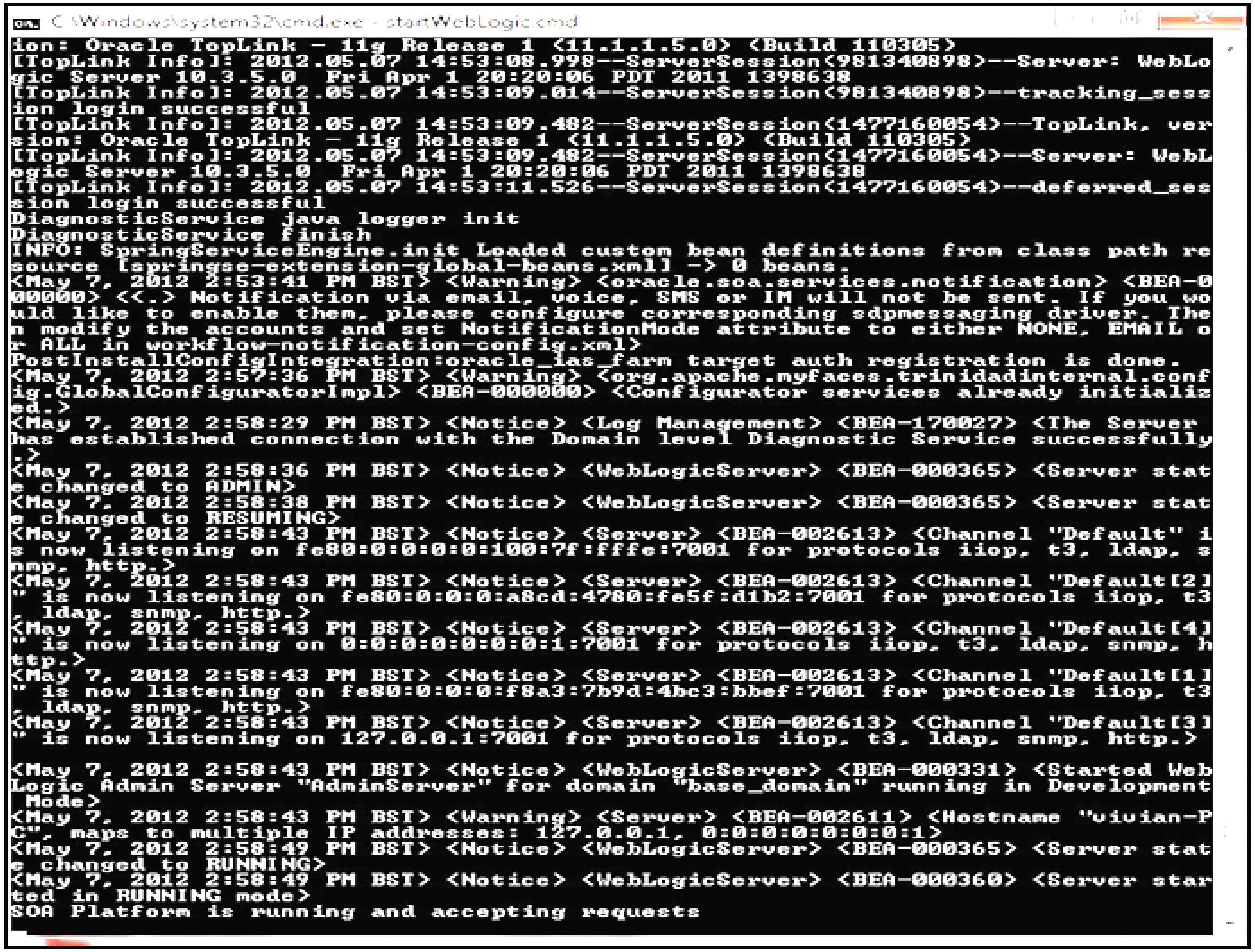


Figure 6-6 **Status of SOA in WebLogic**
(The deployment screen will show that the SOA platform is running and ready to accept request)

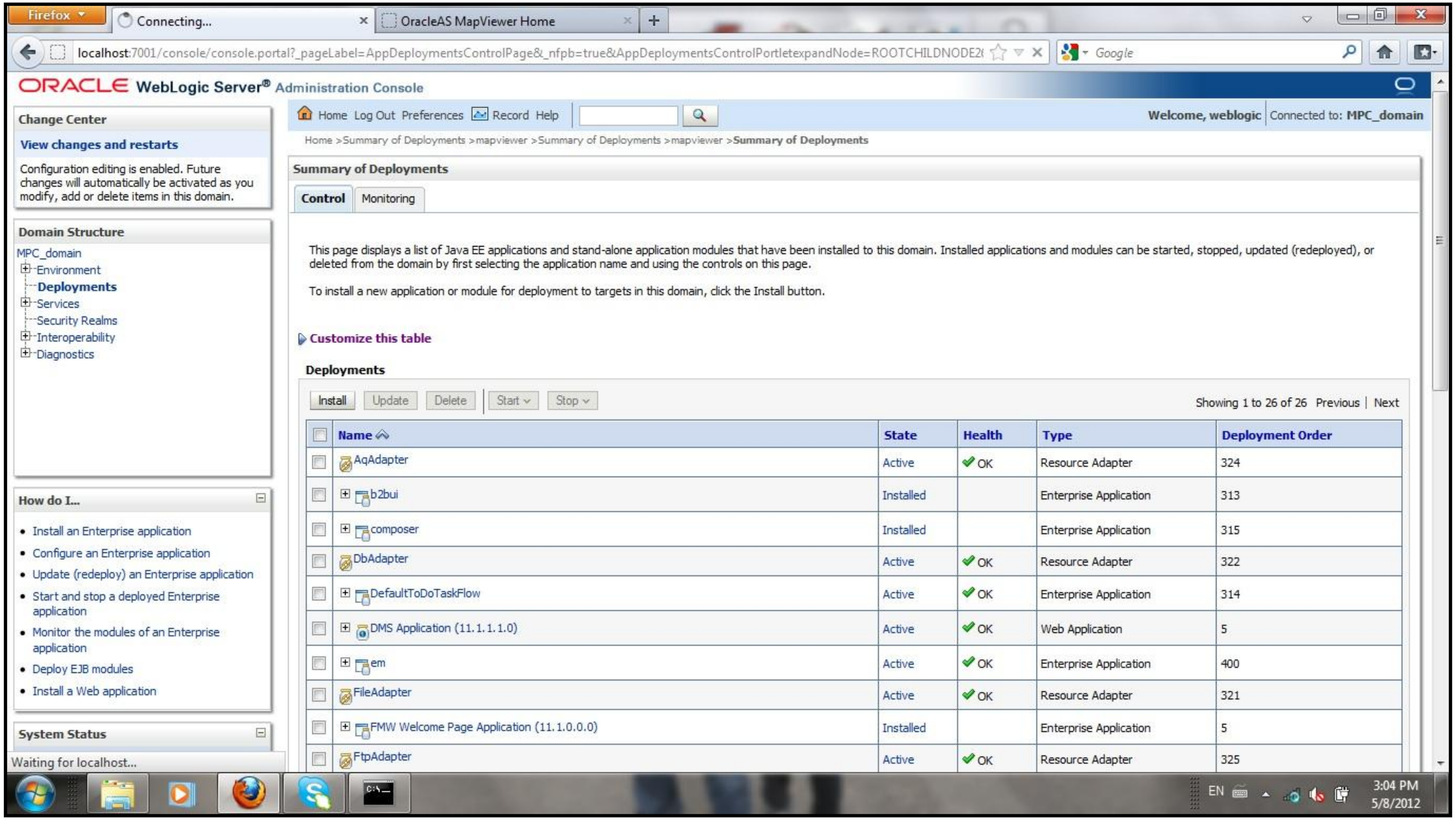


Figure 6-7 WebLogic application server console
(The WebLogic application Server Console that is used to deploy the application)

Following successful deployment, the domain can be accessed using the Oracle WebLogic Server Administration Console. In this case a user can access using the internet browser at URL http://localhost:7001/console as shown in **Figure 6-7**. The application will show the running status (active or failed).

6.5 Deploying *Mapviewer*

The new folder contains Mapviewer.ear and web.war, whose creation was discussed in the chapter 4. The user can use WebLogic to deploy the Mapviewer application from this new folder as shown in **Figure 6.8**.

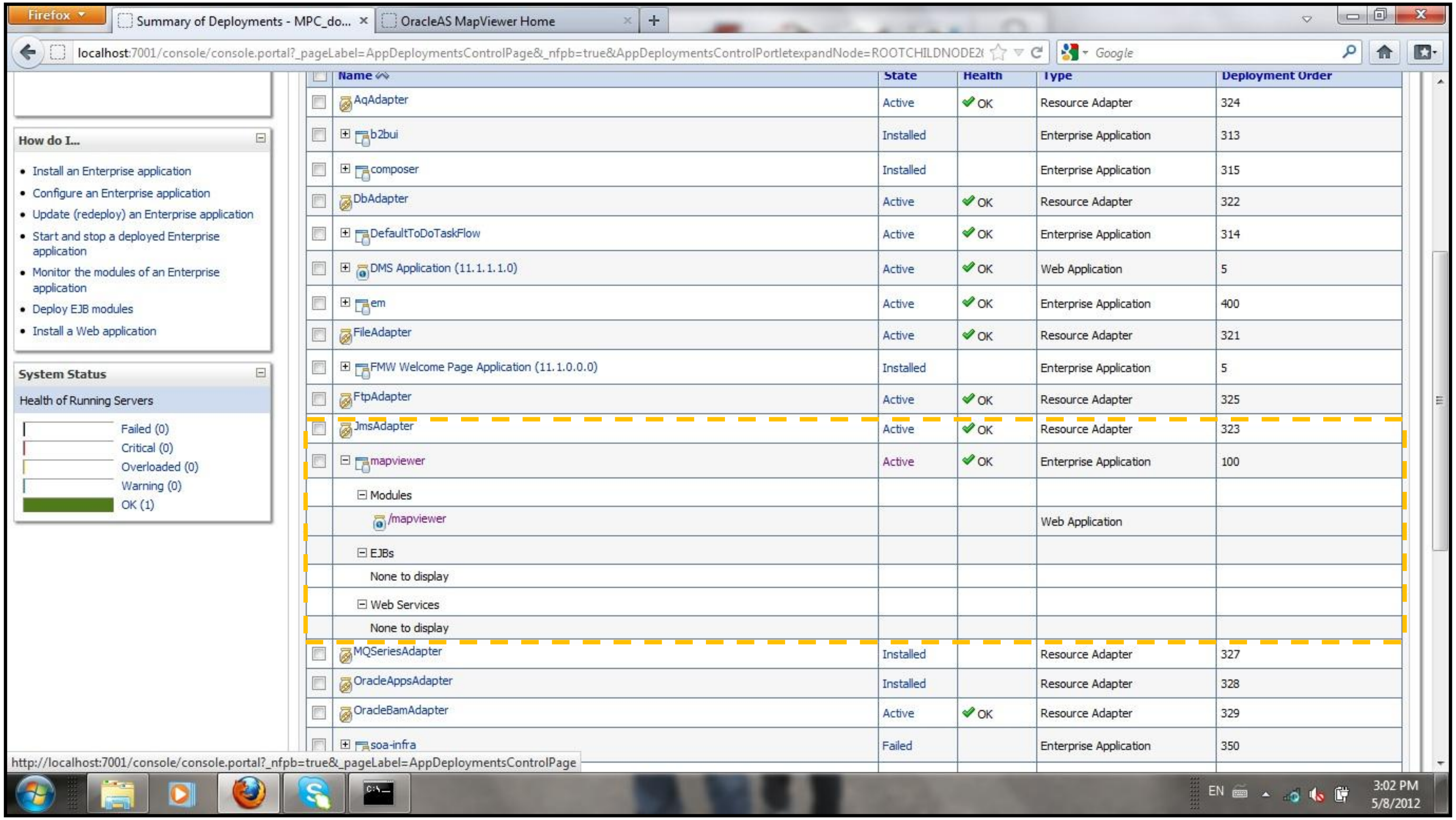


Figure 6-8 Mapviewer deployment in WebLogic

The user can access the Mapviewer application server using the address of the URL http://localhost:7001/mapviewer as shown in **Figure 6-9**.

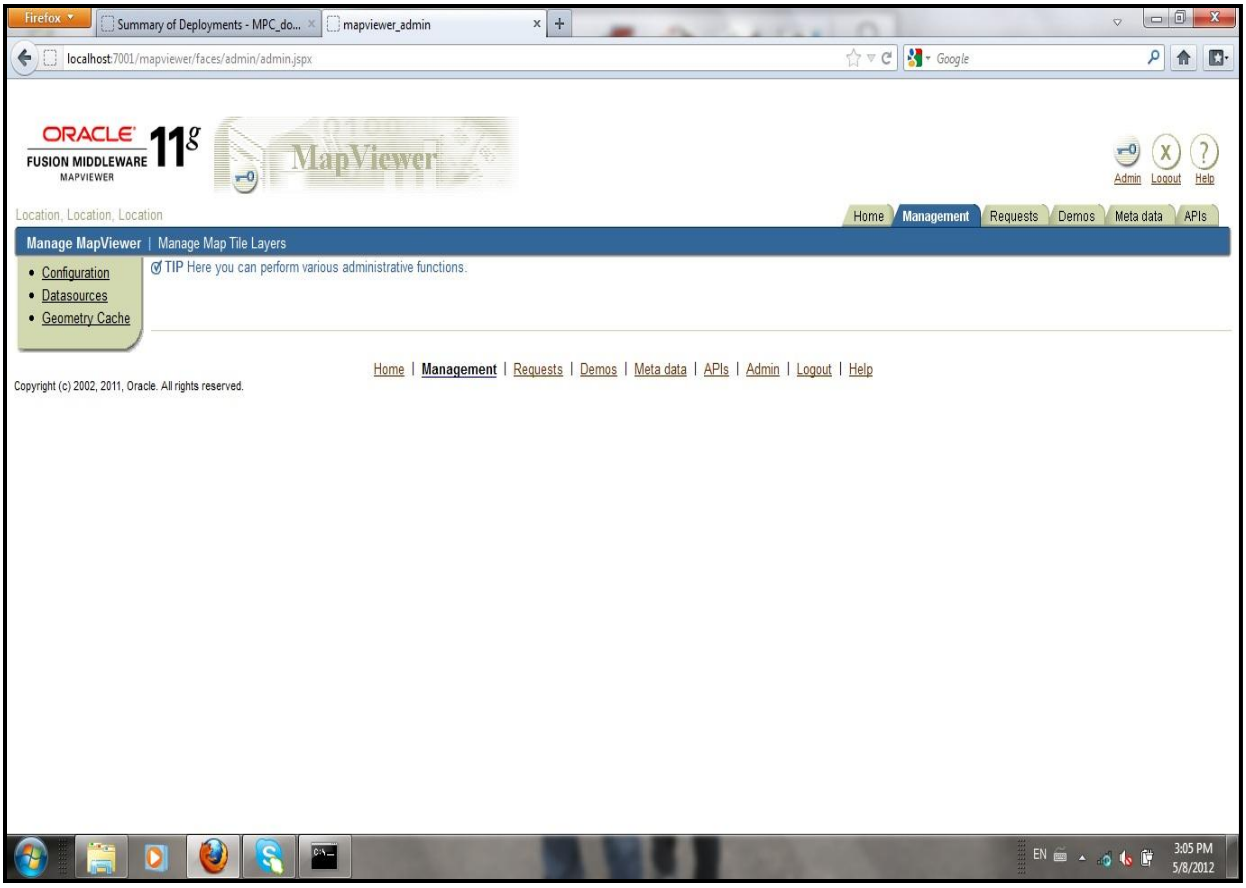


Figure 6-9 Access to Mapviewer

The deployment of Mapviewer will automatically enable the WMS (Web Map Service) capabilities. The user is then able to use WMS, which is hosted by Mapviewer.

6.6 Using *GetCapabilities*

Every WMS needs to define its capabilities in a XML file. This will provide the client server with the description of the service and the base maps (created using MapBuilder as described in Chapter 4) that are available to the public are listed in the file as shown in **Figure 6-10 and Figure 6-11**. The client can request to use HTTP Get in a normal internet browser. For GetCapabilities, in this case the client can key in the URL as given below:

> *http://localhost:7001/mapviewer/wms?VERSION=1.1.0&REQUEST=GetCapabilities&SERVICE=WMS*

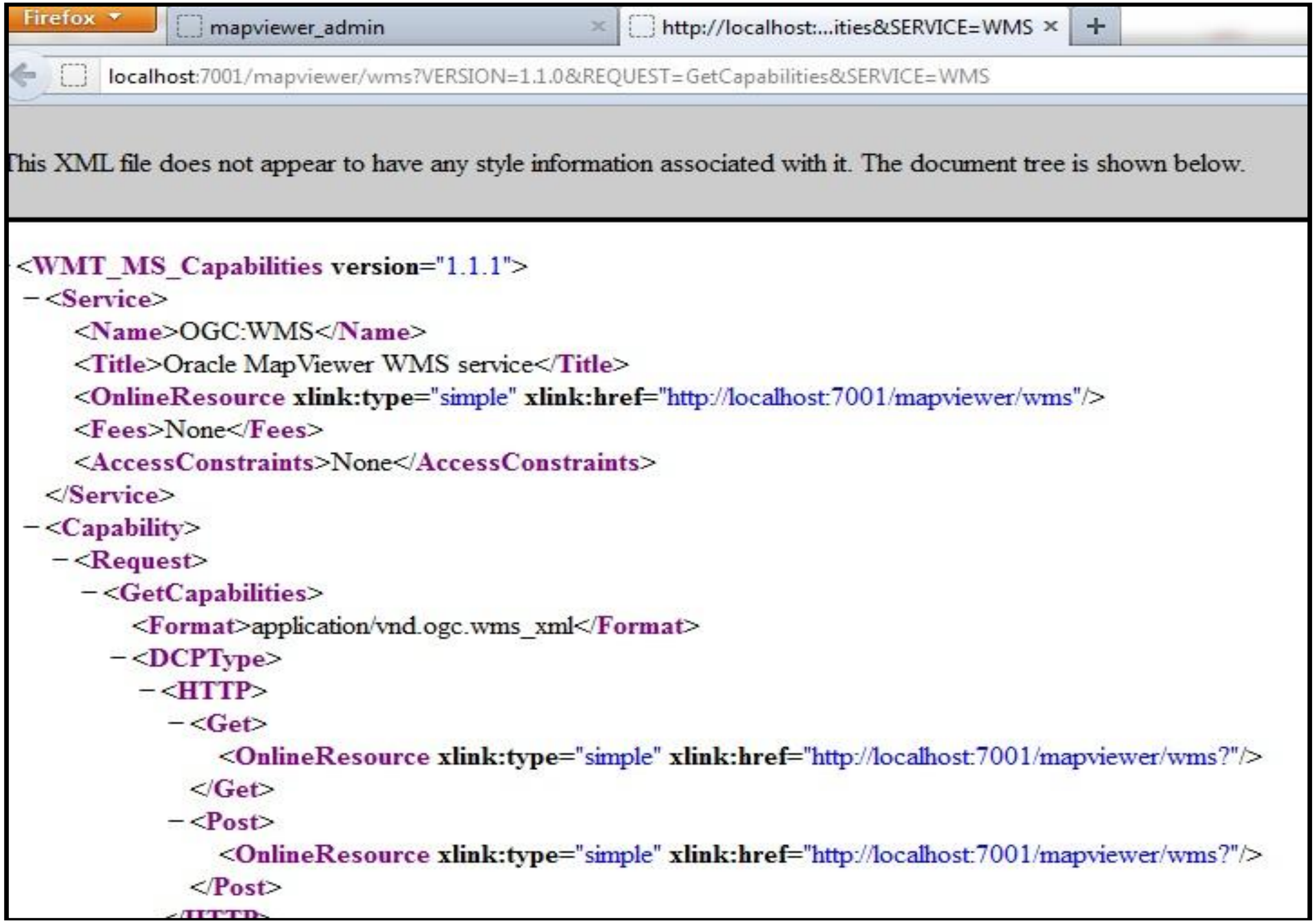


Figure 6-10 The response from WMS GetCapabilities

Figure 6-11 The feature map avalaible in GetCapabilities response file.

6.7 Using *GetMap*

The Client Server can request particular a base map that is published by mapviewer: the return image is the base map that is constructed in Map Builder. The style of map presentation is according to the definition in Map Builder. The **samples 1 and 2** below show the method for requesting the base map from the Mapviewer.

Sample 1: Easement Base Map

```
http://localhost:7001/mapviewer/wms
?VERSION=1.1.0
&REQUEST=GetMap
&FORMAT=image/jpeg
&SRS=SDO:18000000
&BBOX=408156.52499999997,325117.20599999995,408365.385,325418.77
&WIDTH=480
&HEIGHT=400
&BASEMAP=EASEMENT
&DATASOURCE=wms
&LAYERS=PARCELNDCDB,UTILITY
```

Sample 2: Building Base Map

```
http://localhost:7001/mapviewer/wms?VERSION=1.1.0
&REQUEST=GetMap
&FORMAT=image/jpeg
&SRS=EPSG:4326
&BBOX= -180.0,-90.0,180.0,90.0
&WIDTH=480
&HEIGHT=400
&DATASOURCE=wms
&LAYERS=BUILDING
```

The server is responding with the map images that are published by Mapviewer as shown in **Figure 6-12** and **Figure 6-13**. The user now can save the map images into their application.

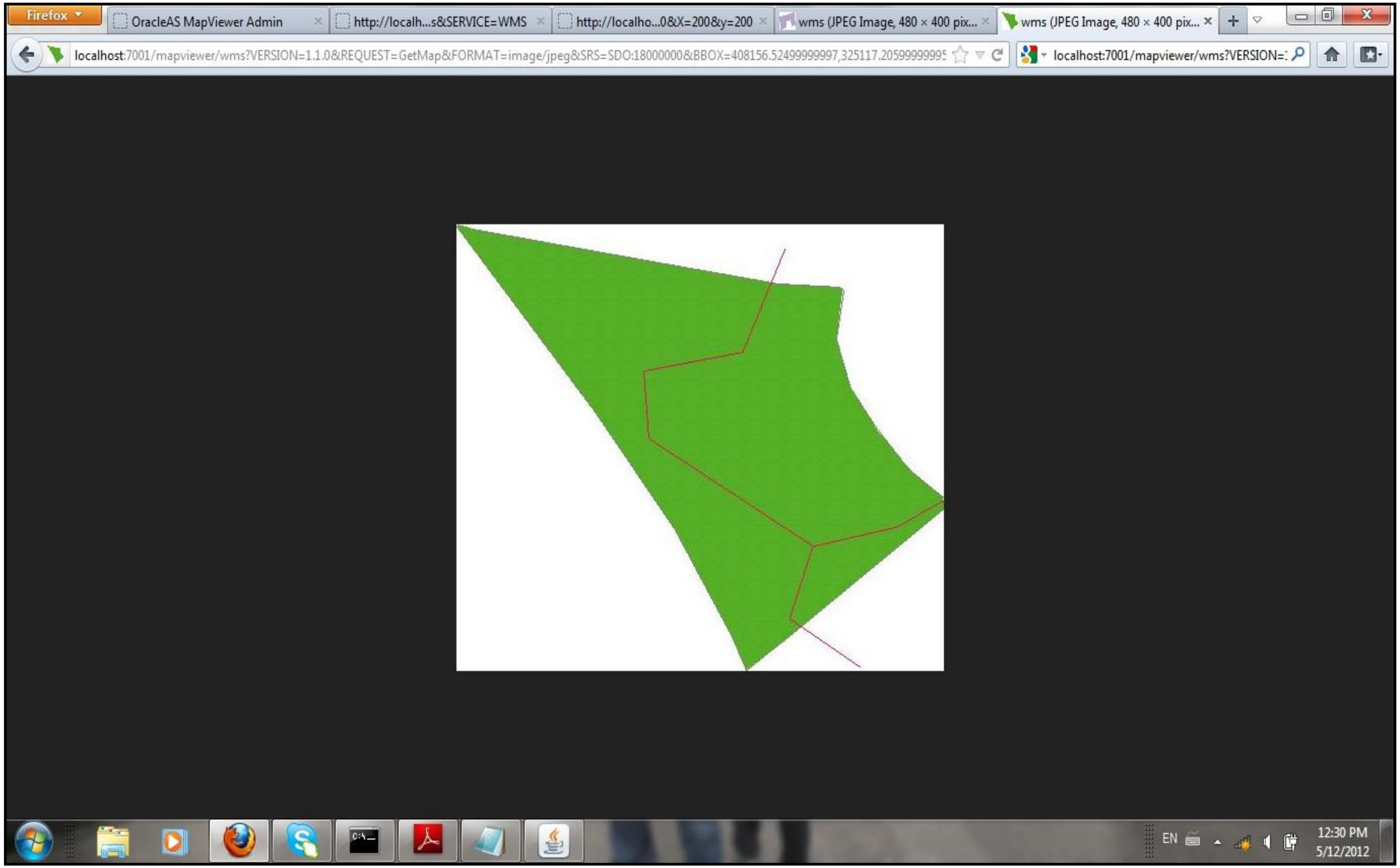


Figure 6-12 A response to GetMap sample 1

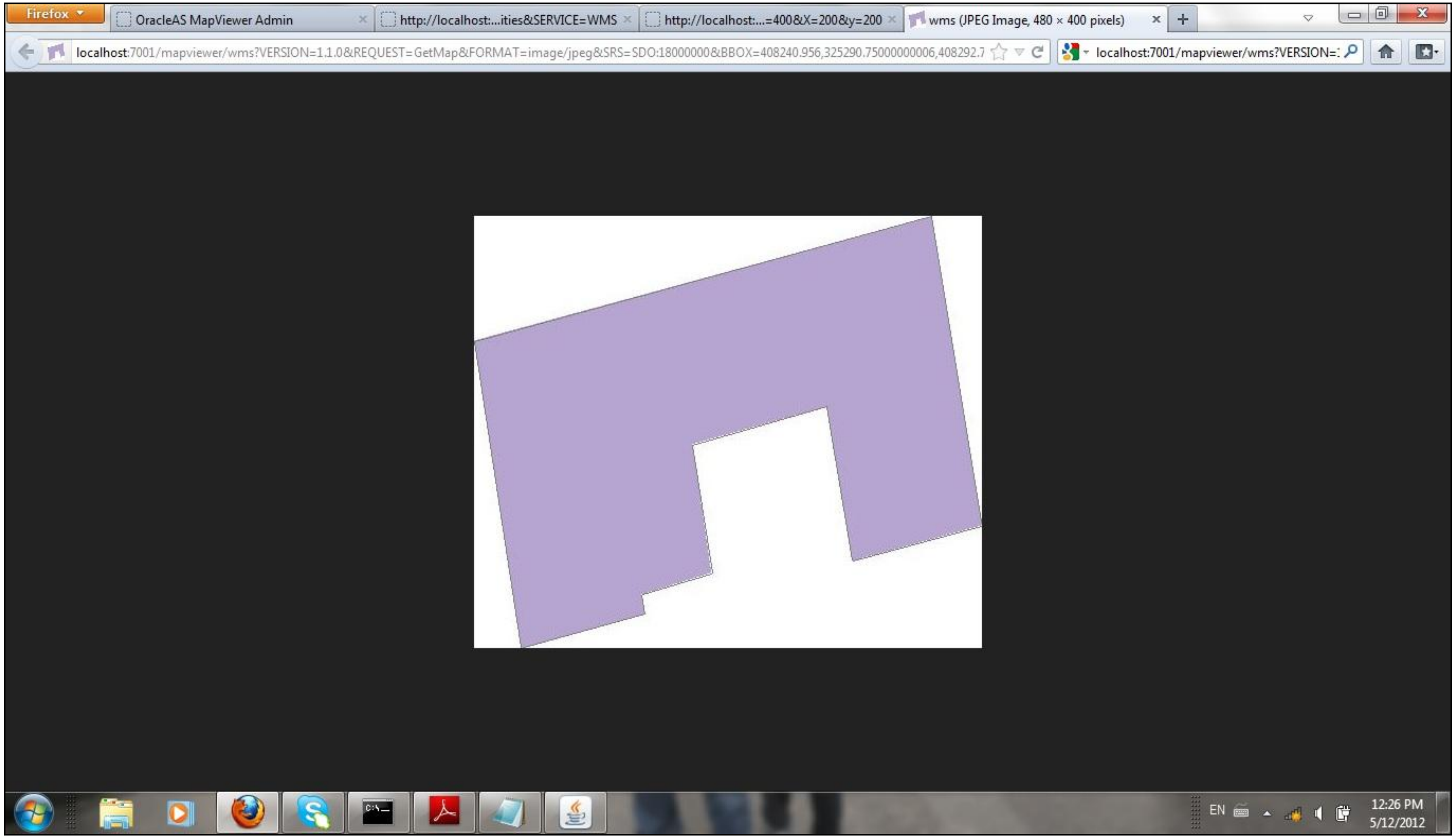


Figure 6-13 A response to GetMap sample 2

6.8 Using *GetFeatureInfo*

The Client also can request GetFeatureInfo, as presented below, for particular layers of a map.

http://localhost:7001/mapviewer/wms
?VERSION=1.1.0
&REQUEST=GetFeatureInfo
&query_Layers=BUILDING
&SRS=SDO:18000000
&BBOX=408240.956,325290.75000000006,408292.78800000006,325324.228000000
06&WIDTH=480
&HEIGHT=400
&X=200
&y=200

The response message is shown in **Figure 6-14**.

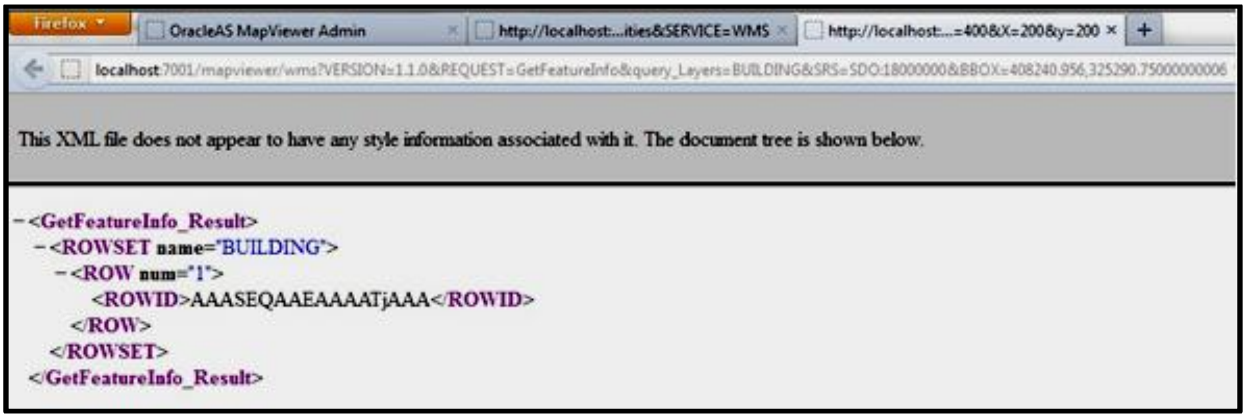


Figure 6-14 GetFeature infor for building data

6.9 The Web Feature Service (WFS)

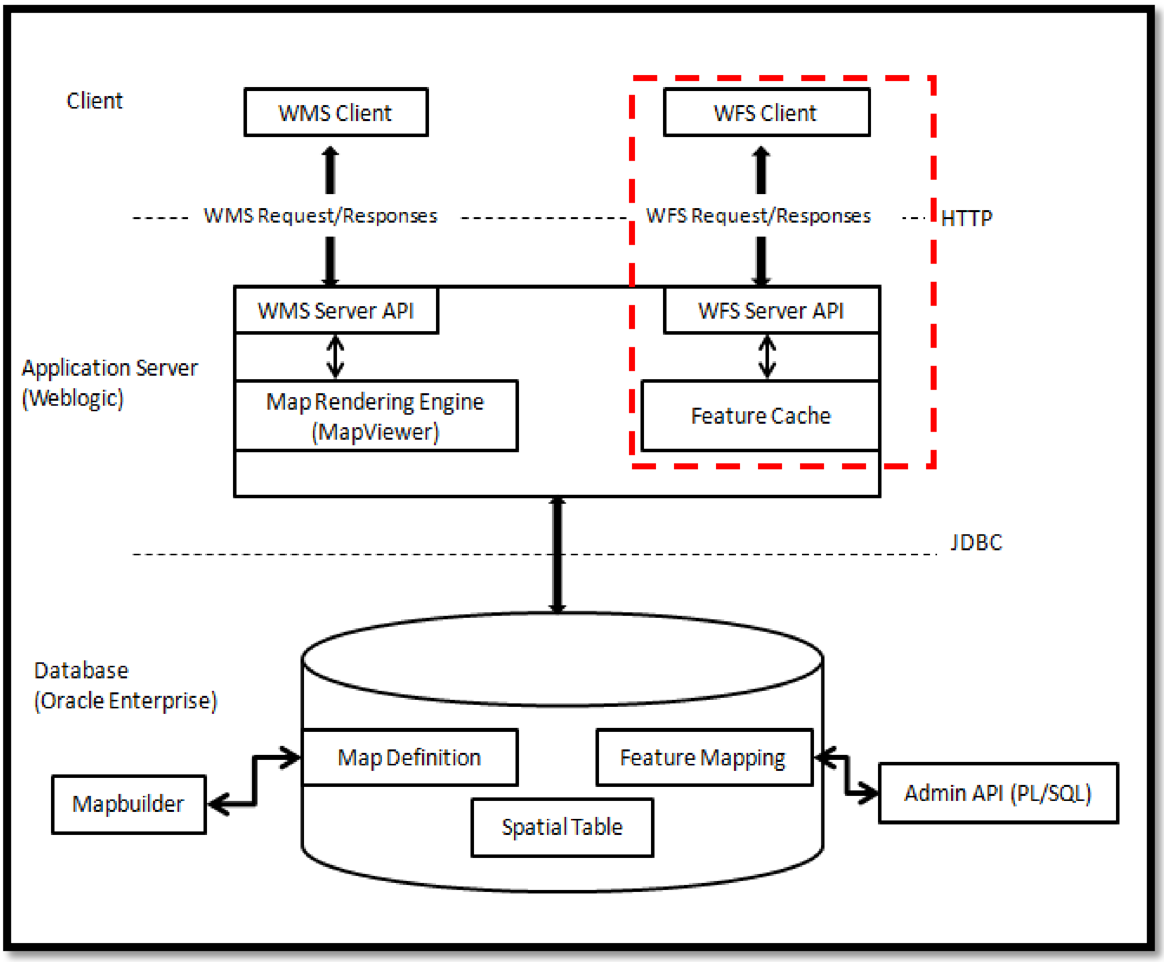


Figure 6-15 WMS concept in Oracle technology

As explained in the previous chapter, there are two types of WFS which are standard WFS and transactional WFS (WFS-T). WFS-T operations include the ability to insert, delete, update, get and query features using spatial and non-spatial constraints.

WFS responds to requests using GML and spatial data from a cache. Different from WMS, WFS allows more complex procedure to be set up. It involves Oracle SQL script programming as shows in **Figure 6.15**.

The final data response to requests follows the standard GML format and can be used for data updating in the database.

6.10 Deploying *sdows* in WebLogic

The SDO Web Feature Service application must be deployed in the WebLogic Application Server before Oracle spatial can enable the WFS for particular spatial data. A java file (sdows.ear) is expanded into the directory of %Oracle_home%/md/jlib/sdows.ear as shown in **Figure 6-16**.

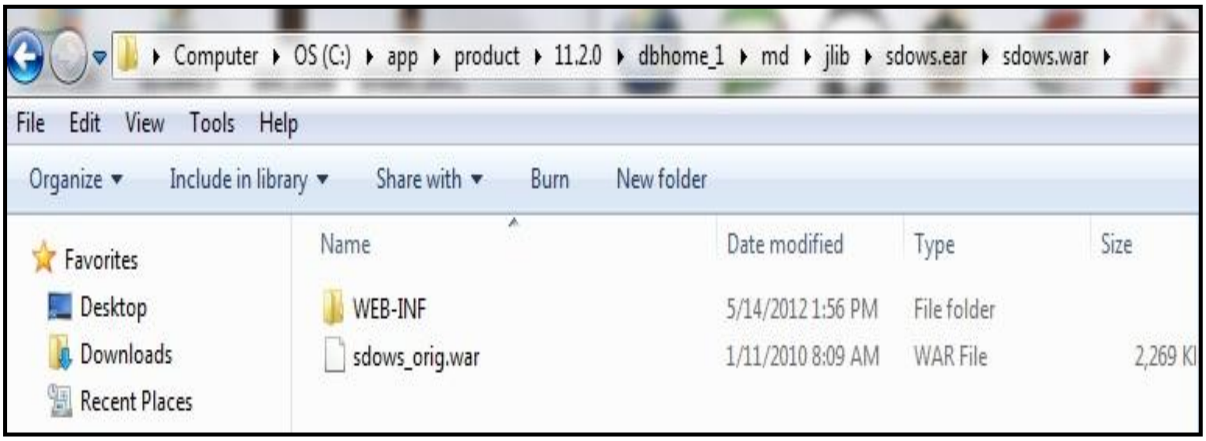


Figure 6-16 sdows.ear folder

sdows.ear is deployed in WebLogic as shown in **Figure 6-17**.

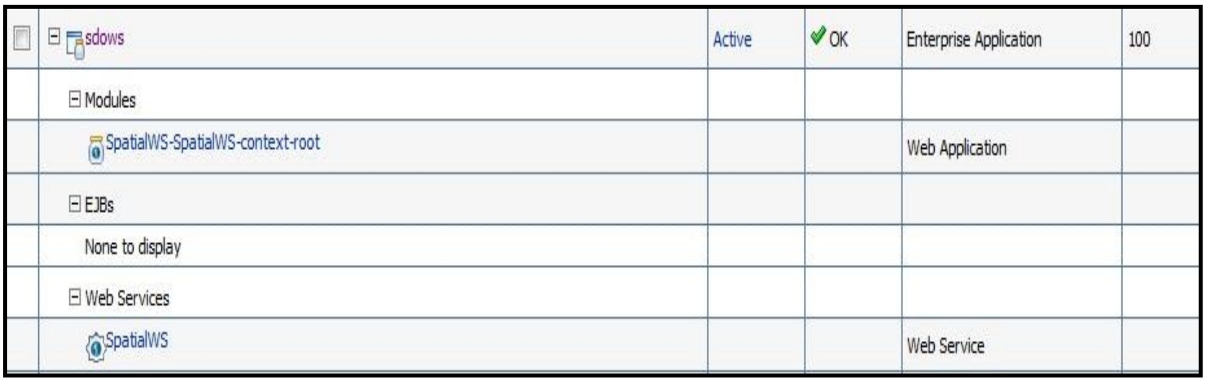
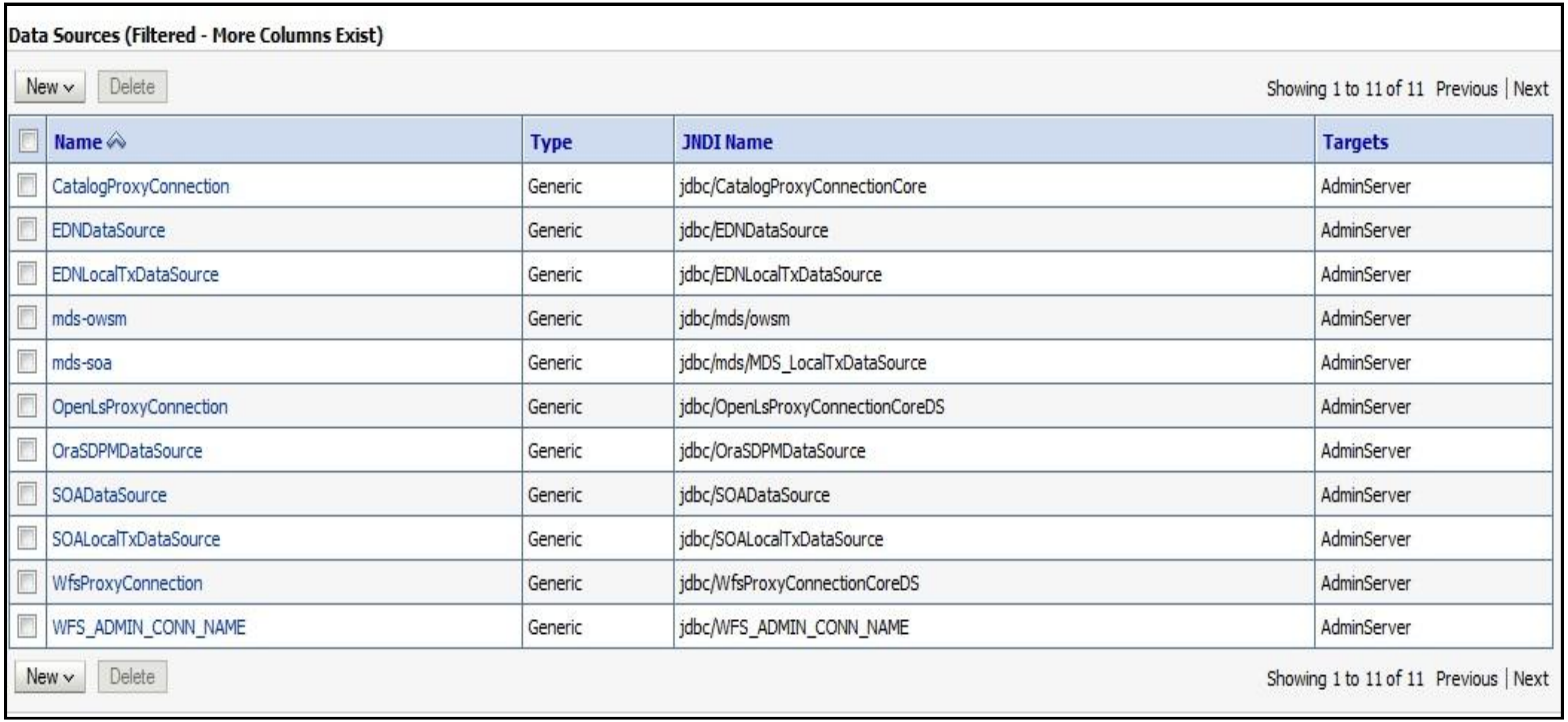


Figure 6-17 sdows application deployment in WebLogic.

After sdows.ear is deployed, four data sources and connection should be added into the sdows service as shown in **Figure 6-18**.

1. CatalogProxyConnection
2. OpenLsProxyConnection
3. WfsProxyConnection
4. WFS_Admin_CONN_NAME


Data Sources (Filtered - More Columns Exist)

New Delete Showing 1 to 11 of 11 Previous | Next

	Name	Type	JNDI Name	Targets
	CatalogProxyConnection	Generic	jdbc/CatalogProxyConnectionCore	AdminServer
	EDNDataSource	Generic	jdbc/EDNDataSource	AdminServer
	EDNLocalTxDataSource	Generic	jdbc/EDNLocalTxDataSource	AdminServer
	mds-owsm	Generic	jdbc/mds/owsm	AdminServer
	mds-soa	Generic	jdbc/mds/MDS_LocalTxDataSource	AdminServer
	OpenLsProxyConnection	Generic	jdbc/OpenLsProxyConnectionCoreDS	AdminServer
	OraSDPMDataSource	Generic	jdbc/OraSDPMDataSource	AdminServer
	SOADataSource	Generic	jdbc/SOADataSource	AdminServer
	SOALocalTxDataSource	Generic	jdbc/SOALocalTxDataSource	AdminServer
	WfsProxyConnection	Generic	jdbc/WfsProxyConnectionCoreDS	AdminServer
	WFS_ADMIN_CONN_NAME	Generic	jdbc/WFS_ADMIN_CONN_NAME	AdminServer

New Delete Showing 1 to 11 of 11 Previous | Next

Figure 6-18 Data sources created in service

6.11 Configuring the database accounts and users

Using the 'system' user account (Administrator), login into SQL Developer and perform the task below to unlock the mdsys (owner of spatial schema) and administrator account of the Web Feature Service and the catalog service. The password can be changed at this time.

```
alter user mdsys account unlock;
alter user spatial_csw_admin_usr account unlock;
alter user spatial_wfs_admin_usr account unlock;
alter user mdsys identified by oracle;
alter user spatial_csw_admin_usr identified by oracle;
alter user spatial_wfs_admin_usr identified by oracle;
```

Using the mdsys account to create a web feature user and grant a role to the user that allows access from the web application. A proxy user 'spatialwsxlmuser' is created for mdsys.

```
create user spatialwsxmluser identified by oracle;
grant create session to spatialwsxmluser;
alter user spatialwsxmluser grant connect through mdsys;
grant wfs_usr_role to spatialwsxmluser;
grant csw_usr_role to spatialwsxmluser;
alter role WFS_USR_ROLE not identified;
alter role CSW_USR_ROLE not identified;
alter role SPATIAL_WFS_ADMIN not identified;
alter role SPATIAL_CSW_ADMIN not identified;
```

6.12 Configuring the WFS

All administration steps were performed in SQL using packages of SDO_WFS_PROCESS and SDO_WFS_LOCK by following the step shown in **Figure 6-19**.

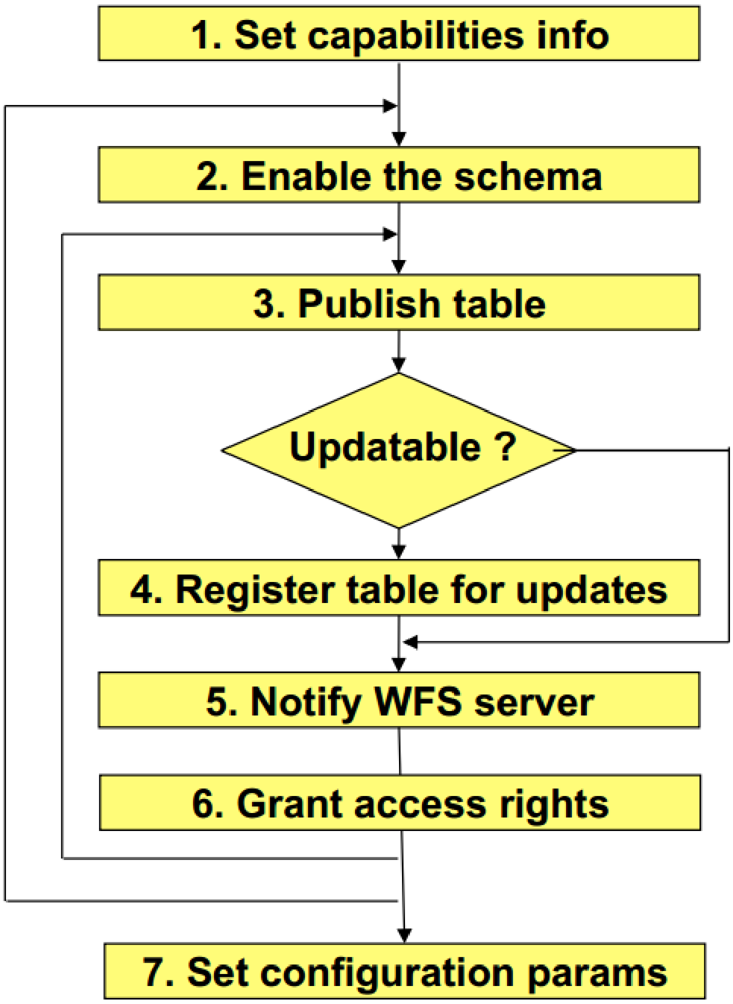


Figure 6-19 Step to set up the WFS and WFS-T

6.12.1 Setting of Capabilities Info

A WFScapabilitiesTemplate.XML is created as shown in **Appendix F** and stored in the folder $Oracle_home/ and the insert capabilities performed on this xml template. The service URLs are filled in and all the published features are listed in this xml file.

```
create or replace directory WFS_XML
as 'c:/app/product/11.2.0/dbhome_1';

begin
SDO_WFS_PROCESS.insertCapabilitiesInfo(
xmltype(
bfilename('WFS_XML', 'WFScapabilitiesTemplate.xml'),
nls_charset_id('AL32UTF8')
)
);
end;
/
commit;
```

6.12.2 Enabling the schema

This step is to make sure the sdo_wfs_process grants access to the schema 'yen', the owner of the database created in chapter 4. This allows data in those schemas to be published via WFS.

SQL> execute SDO_WFS_PROCESS.GrantMDAccessToUser('yen')

6.12.3 Publishing the (spatial data) table

The table (spatial data) that needs to be published is identified, the primary key and coordinate system of this table needs to be recognized.

```
declare
  featureDescriptorXML CLOB :=
    '<?xml version="1.0" ?>
       <FeatureType xmlns:yenns="http://www.myserver.com/yen"
         xmlns="http://www.opengis.net/wfs">
         <Name> yenns:MPCNDCDB_PARCEL_GEOM</Name>
         <Title>MPCNDCDB_PARCEL_GEOM</Title>
         <SRS>SDO:18000000</SRS>
     </FeatureType>';
begin
  SDO_WFS_PROCESS.publishFeatureType(
    dataSrc            => 'YEN.MPCNDCDB_PARCEL_GEOM',
    ftNsUrl            => 'http://www.myserver.com/YEN',
    ftName             => 'MPCNDCDB_PARCEL_GEOM',
    ftNsAlias          => 'YENons' ,
    featureDesc        => xmltype(featureDescriptorXML),
    schemaLocation     => null,
    pkeyCol            => 'UPII',
    columnInfo         => MDSYS.StringList('PointMemberType'),
    pSpatialCol        => 'GEOM',
    featureMemberNs    => null,
    featureMemberName  => null,
    srsNs              => null,
    srsNsAlias         => null
  );
end;
/
```

6.12.4 Registering the database table for updates

For the transactions in WFS-T to be effected, database tables should be registered. This will enable a user to lock the database table while updating it.

SQL>execute SDO_WFS_LOCK.registerFeatureTable('yen','MpcNdcdb_Parcel_Geom')

6.12.5 Notifing WFS server

Changes are not automatically visible when running WFS, thus notification should be sent to acknowledge the server.

SQL>executeSDO_WFS_PROCESS.InsertFtMDUpdated('http://www.myserver.com/yen','MpcNdcdb_Parcel_Geom', sysdate)

6.12.6 Granting access rights

The user of WFS will be granted select, insert, update and delete privileges (rights).

SQL> grant SELECT, INSERT, UPDATE, DELETE on cities to SpatialWsXmlUser;

6.12.7 Setting of configuration parameters

Update may be delayed in WFS, depending on the settings in wsconfig.xml.

```
WEB-INF/conf/wsconfig.xml
<wfs_cache_sync_interval>10000</wfs_cache_sync_interval>
<wfs_query_timeout>10</wfs_query_timeout>
<wfs_lock_expiry>4</wfs_lock_expiry>
<cached_feature_types>
<features_typens=http://www.myserver.com/yen name=”cities”/>
<features_type ns=http://www.myserver.com/yen name
=”’MpcNdcdb_parcel_Geom”/></cached_feature_types>
```

6.12.8 Deploying *GetCapabilities*

This is the interfaces using the URL (‘key value pairs’-KVP): the response returned will be as **Figure 6-20** and **Figure 6-21**.

All the application servers, applications and samples are running in a single machine, thus it is expected that the execution of these application will have some limitations.

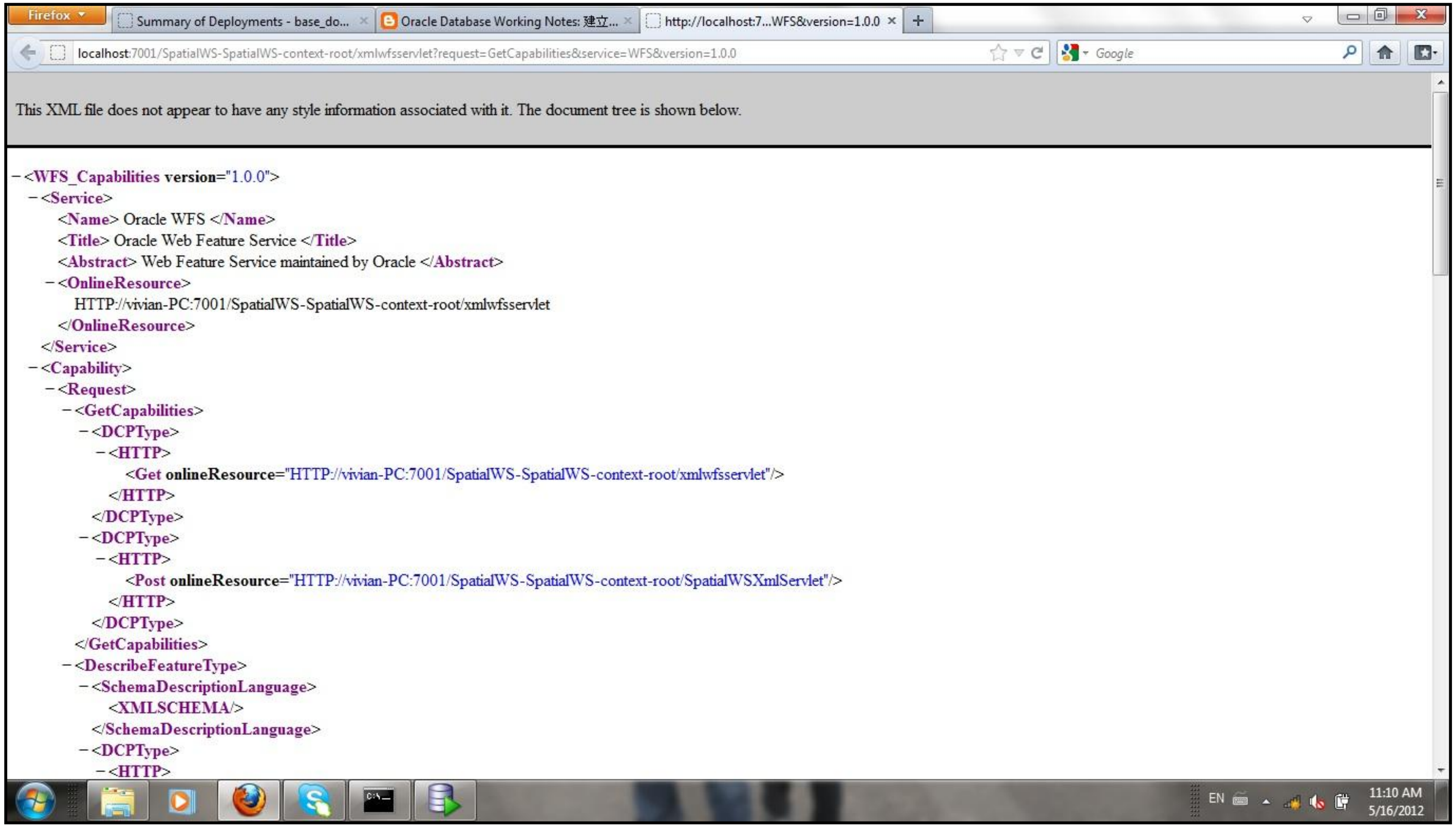


Figure 6-20 The response of WFS GetCapabilities 1
(From server showing the WFS address)

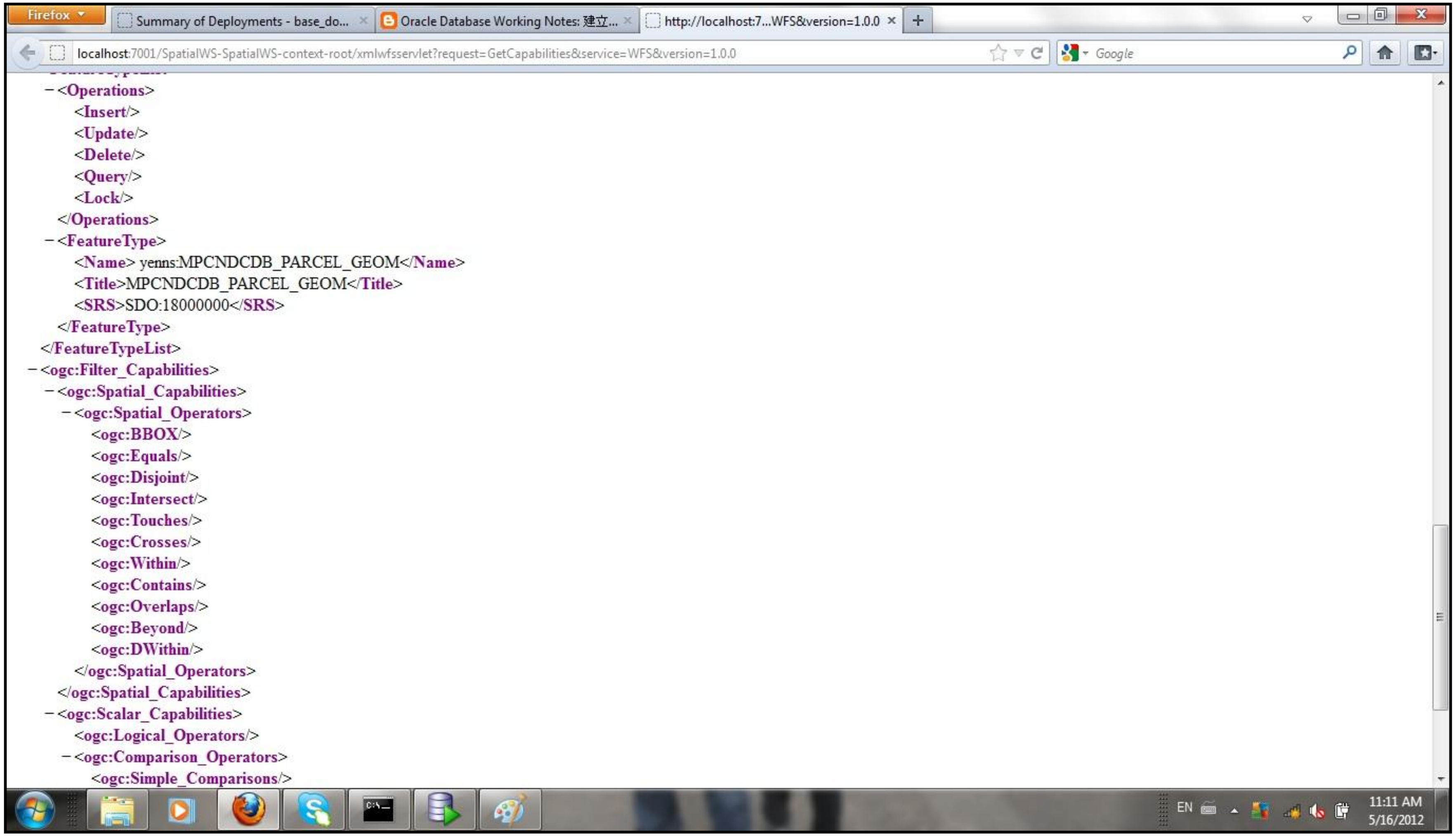


Figure 6-21 The response of WFS GetCapabilities 2
(from server showing the feature published in WFS)

6.12.9 Execute *GetFeature*

The *GetFeature* function can only be executed through an xml request using post protocol. Using the client page sample provided by Oracle as shown in **Figure 6-22**, this function can be performed.

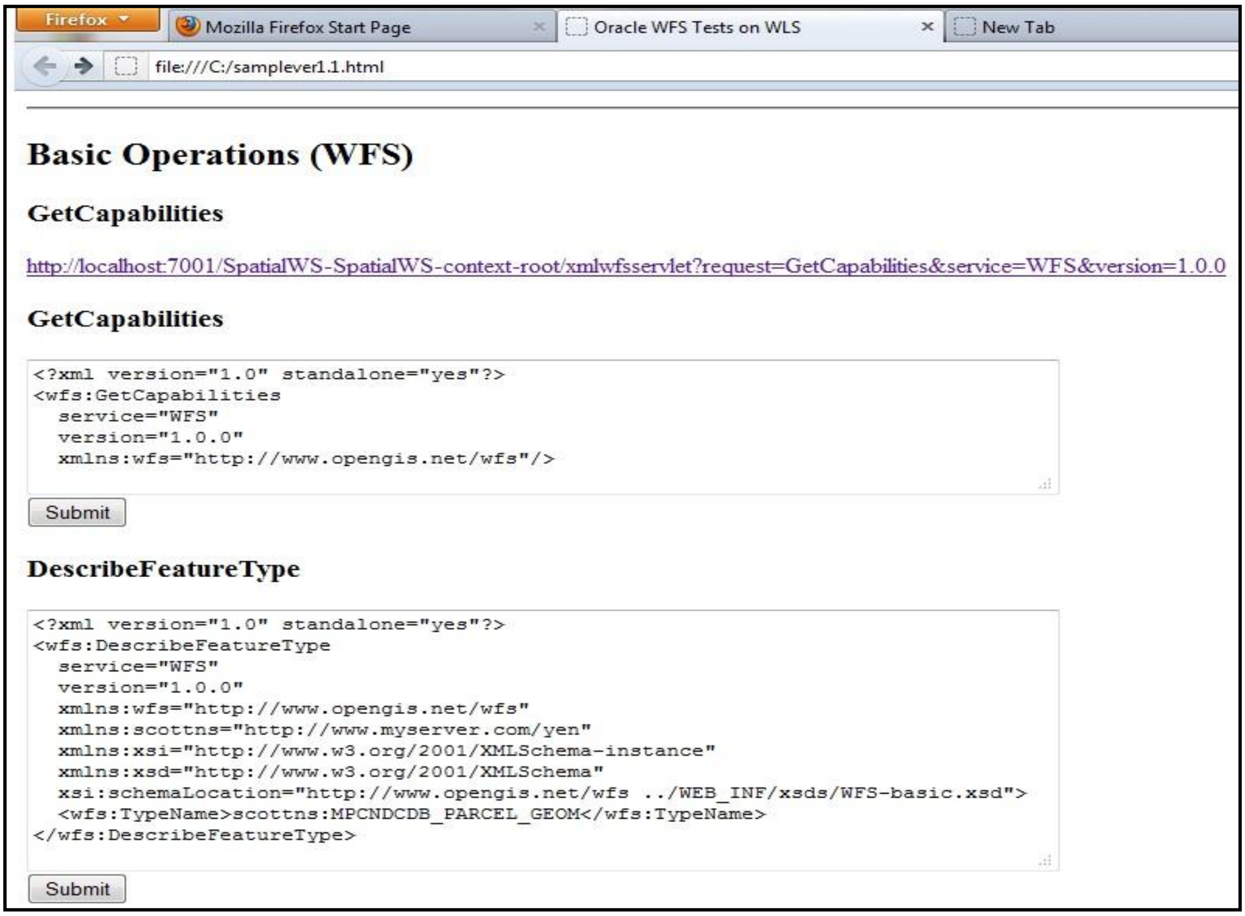


Figure 6-22 Client page example
(The sample of Client page to for xml request provided by Oracle)

This interface, used in this testing, requires high RAM machines. In this investigation the machine that was used had 3GB RAM, it was less that 3GB after deductions due to the operating system and other applications. As a result, the request message returned the message 'OutOfMemoryError'.

java.lang.OutOfMemoryError: Java heap space

Java Heap Space is the combination of the memory set for JVM (Java Virtual Machine) in –Xmx and the MaxPermSize when weblogic was deployed. The setting is as follows:

set WLS_MEM_ARGS_64BIT=-Xms256m -Xmx512m

set MEM_PERM_SIZE_64BIT=-XX:PermSize=128m

set MEM_MAX_PERM_SIZE_64BIT=-XX:MaxPermSize=512m

after using the sample.html which is provided by Oracle as a client page. The result returns an error as **Figure 6-23** and **Figure 6-24**.

Error 500--Internal Server Error

```
java.lang.OutOfMemoryError: Java heap space
	at java.util.Arrays.copyOf(Arrays.java:2271)
	at java.io.ByteArrayOutputStream.grow(ByteArrayOutputStream.java:113)
	at java.io.ByteArrayOutputStream.ensureCapacity(ByteArrayOutputStream.java:93)
	at java.io.ByteArrayOutputStream.write(ByteArrayOutputStream.java:122)
	at oracle.spatial.ws.svrproxy.SdoWsXmlServlet.doPost(SdoWsXmlServlet.java:90)
	at javax.servlet.http.HttpServlet.service(HttpServlet.java:751)
	at javax.servlet.http.HttpServlet.service(HttpServlet.java:844)
	at weblogic.servlet.internal.StubSecurityHelper$ServletServiceAction.run(StubSecurityHelper.java:242)
	at weblogic.servlet.internal.StubSecurityHelper$ServletServiceAction.run(StubSecurityHelper.java:216)
	at weblogic.servlet.internal.StubSecurityHelper.invokeServlet(StubSecurityHelper.java:132)
	at weblogic.servlet.internal.ServletStubImpl.execute(ServletStubImpl.java:338)
	at weblogic.servlet.internal.ServletStubImpl.execute(ServletStubImpl.java:221)
	at weblogic.servlet.internal.WebAppServletContext$ServletInvocationAction.wrapRun(WebAppServletContext.java:3284)
	at weblogic.servlet.internal.WebAppServletContext$ServletInvocationAction.run(WebAppServletContext.java:3254)
	at weblogic.security.acl.internal.AuthenticatedSubject.doAs(AuthenticatedSubject.java:321)
	at weblogic.security.service.SecurityManager.runAs(SecurityManager.java:120)
	at weblogic.servlet.provider.WlsSubjectHandle.run(WlsSubjectHandle.java:57)
	at weblogic.servlet.internal.WebAppServletContext.doSecuredExecute(WebAppServletContext.java:2163)
	at weblogic.servlet.internal.WebAppServletContext.securedExecute(WebAppServletContext.java:2089)
	at weblogic.servlet.internal.WebAppServletContext.execute(WebAppServletContext.java:2074)
	at weblogic.servlet.internal.ServletRequestImpl.run(ServletRequestImpl.java:1513)
	at weblogic.servlet.provider.ContainerSupportProviderImpl$WlsRequestExecutor.run(ContainerSupportProviderImpl.java:254)
	at weblogic.work.ExecuteThread.execute(ExecuteThread.java:256)
	at weblogic.work.ExecuteThread.run(ExecuteThread.java:221)
```

Figure 6-23 Error message
(The response of error message from server)

```
[oracle.spatial.ws.svrproxy.SdoWsXmlServlet, Mon May 21 11:16:14 BST 2012, INFO]
 Initialize SpatialWS XML Servlet ...
[oracle.spatial.ws.svrproxy.SdoWsXmlServlet, Mon May 21 11:16:14 BST 2012, INFO]
 Ws Configure file is C:\app\product\11.2.0\dbhome_1\md\jlib\sdows.ear\sdows.war
\WEB-INF/conf/WSConfig.xml
[oracle.spatial.ws.svrproxy.SdoWsXmlServlet, Mon May 21 11:16:14 BST 2012, INFO]
 Make Spatial Request (XML interface) ...
<May 21, 2012 11:16:24 AM BST> <Error> <HTTP> <BEA-101017> <[ServletContext@3869
08848[app:sdows module:SpatialWS-SpatialWS-context-root path:null spec-version:n
ull], request: weblogic.servlet.internal.ServletRequestImpl@59227bd3[
POST /SpatialWS-SpatialWS-context-root/SpatialWSXmlServlet HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:11.0) Gecko/20100101 Firefox/
11.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-us,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive
Content-Type: application/x-www-form-urlencoded
Content-Length: 230

]] Root cause of ServletException.
java.lang.OutOfMemoryError: Java heap space
        at java.util.Arrays.copyOf(Arrays.java:2271)
        at java.io.ByteArrayOutputStream.grow(ByteArrayOutputStream.java:113)
        at java.io.ByteArrayOutputStream.ensureCapacity(ByteArrayOutputStream.ja
va:93)
        at java.io.ByteArrayOutputStream.write(ByteArrayOutputStream.java:122)
        at oracle.spatial.ws.svrproxy.SdoWsXmlServlet.doPost(SdoWsXmlServlet.jav
a:90)
        Truncated. see log file for complete stacktrace
>
[oracle.spatial.ws.svrproxy.SdoWsXmlServlet, Mon May 21 11:39:44 BST 2012, INFO]
 Make Spatial Request (XML interface) ...
<May 21, 2012 11:42:40 AM BST> <Error> <HTTP> <BEA-101017> <[ServletContext@3869
08848[app:sdows module:SpatialWS-SpatialWS-context-root path:null spec-version:n
ull], request: weblogic.servlet.internal.ServletRequestImpl@6641512b[
POST /SpatialWS-SpatialWS-context-root/SpatialWSXmlServlet HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:11.0) Gecko/20100101 Firefox/
11.0
```

Figure 6-24 Server log report
(The response of error message from server in log report)

Referring to a sample from the document of Oracle® Spatial Developer's Guide11g Release 2 (Murray, 2011), the rest of transaction can be performed as follows:

a. DescribeFeatureType

Request

```
<?xml version="1.0" ?>
<wfs:DescribeFeatureType
   service="WFS"
   version="1.0.0"
   xmlns:wfs="http://www.opengis.net/wfs"
   xmlns:myns="http://www.example.com/myns"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xmlns:xsd="http://www.w3.org/2001/XMLSchema"
   xsi:schemaLocation="http://www.opengis.net/wfs ../wfs/1.0.0/WFS-basic.xsd">
   <wfs:TypeName>myns:COLA</wfs:TypeName>
</wfs:DescribeFeatureType>
```

Response

```
<xsd:schema targetNamespace="http://www.example.com/myns"
xmlns:wfs="http://www.opengis.net/wfs" xmlns:myns="http://www.example.com/myns"
xmlns:gml="http://www.opengis.net/gml" elementFormDefault="qualified"
version="1.0.0" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
   <xsd:import namespace="http://www.opengis.net/gml"
schemaLocation="http://localhost:8888/examples/servlets/xsds/feature.xsd"/>
   <xsd:element name="COLA" type="myns:COLAType" substitutionGroup="gml:_
Feature"/>
   <xsd:complexType name="COLAType">
      <xsd:complexContent>
         <xsd:extension base="gml:AbstractFeatureType">
            <xsd:sequence>
               <xsd:element name="MKT_ID" type="xsd:double"/>
               <xsd:element name="NAME" nillable="true">
                  <xsd:simpleType>
                     <xsd:restriction base="xsd:string">
                        <xsd:maxLength value="32"/>
                     </xsd:restriction>
                  </xsd:simpleType>
               </xsd:element>
               <xsd:element name="SHAPE" type="gml:PolygonMemberType"
nillable="true"/>
            </xsd:sequence>
            <xsd:attribute name="fid" type="xsd:double"/>
         </xsd:extension>
      </xsd:complexContent>
   </xsd:complexType>
</xsd:schema>
```

b.	GetFeatures

Request

```
<?xml version="1.0" ?>
<wfs:GetFeature
   service="WFS"
   version="1.0.0"
   xmlns:wfs="http://www.opengis.net/wfs"
   xmlns:ogc="http://www.opengis.net/ogc"
   xmlns:myns="http://www.example.com/myns"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://www.opengis.net/wfs ../wfs/1.0.0/WFS-basic.xsd">
   <wfs:Query typeName="myns:COLA">
      <ogc:PropertyName>myns:MKT_ID</ogc:PropertyName>
      <ogc:PropertyName>myns:NAME</ogc:PropertyName>
      <ogc:PropertyName>myns:SHAPE</ogc:PropertyName>
      <ogc:Filter>
          <ogc:And>
            <ogc:And>
                <ogc:PropertyIsGreaterThan>
                        <ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
                        <ogc:Literal> 2 </ogc:Literal>
                </ogc:PropertyIsGreaterThan>
                <ogc:PropertyIsEqualTo>
                        <ogc:PropertyName>myns:COLA/myns:NAME</ogc:PropertyName>
                <ogc:Literal>cola_c</ogc:Literal>
                </ogc:PropertyIsEqualTo>
            </ogc:And>
            <ogc:Or>
                <ogc:PropertyIsEqualTo>
                        <ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
                        <ogc:Literal>3</ogc:Literal>
                </ogc:PropertyIsEqualTo>
                <ogc:PropertyIsEqualTo>
                        <ogc:PropertyName>myns:COLA/myns:NAME</ogc:PropertyName>
                        <ogc:Literal>cola_d</ogc:Literal>
                </ogc:PropertyIsEqualTo>
            </ogc:Or>
          </ogc:And>
      </ogc:Filter>
   </wfs:Query>
</wfs:GetFeature>
```

GetFeature uses the OGC filter syntax which allows flexibility of expression to query spatial and non spatial. Standard query functions, such as within, greater than, equal to, etc. can be used.

Response

```
http://localhost:8888/wfsservlet?featureTypeId=1 http://www.opengis.net/wfs
../wfs/1.0.0/WFS-basic.xsd" xmlns:wfs="http://www.opengis.net/wfs"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
   <gml:boundedBy xmlns:gml="http://www.opengis.net/gml">
      <gml:Box srsName="SDO:8307">
         <gml:coordinates>3.0,3.0 6.0,5.0</gml:coordinates>
      </gml:Box>
   </gml:boundedBy>
   <gml:featureMember xmlns:gml="http://www.opengis.net/gml">
      <myns:COLA fid="3" xmlns:myns="http://www.example.com/myns">
         <myns:MKT_ID>3</myns:MKT_ID>
         <myns:NAME>cola_c</myns:NAME>
         <myns:SHAPE>
            <gml:Polygon srsName="SDO:8307"
xmlns:gml="http://www.opengis.net/gml">
               <gml:outerBoundaryIs>
                  <gml:LinearRing>
                     <gml:coordinates decimal="." cs="," ts=" ">3.0,3.0 6.0,3.0
6.0,5.0 4.0,5.0 3.0,3.0 </gml:coordinates>
                  </gml:LinearRing>
               </gml:outerBoundaryIs>
            </gml:Polygon>
         </myns:SHAPE>
      </myns:COLA>
   </gml:featureMember>
</wfs:FeatureCollection>
```

The query feature will respond in GML format, which gives the value of the coordinates, geometry type and other information.

c. GetFeatureWithLock

The GetFeatureWithLock function will get a set of features, and lock them for a certain period of time. Only one requester can hold a lock on a feature. Other users can still can read the feature by using the function GetFeature. GetFeatureWithLock will unlock after expire.

Request

```
<?xml version="1.0" ?>
<wfs:GetFeatureWithLock
   service="WFS"
   version="1.0.0"
   expiry="5"
   xmlns:wfs="http://www.opengis.net/wfs"
   xmlns:ogc="http://www.opengis.net/ogc"
   xmlns:gml="http://www.opengis.net/gml"
   xmlns:myns="http://www.example.com/myns"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" >
   <wfs:Query typeName="myns:COLA">
      <ogc:PropertyName>myns:MKT_ID</ogc:PropertyName>
      <ogc:PropertyName>myns:NAME</ogc:PropertyName>
      <ogc:PropertyName>myns:SHAPE</ogc:PropertyName>
      <ogc:Filter>
         <ogc:PropertyIsEqualTo>
            <ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
            <ogc:Literal> 3 </ogc:Literal>
         </ogc:PropertyIsEqualTo>
      </ogc:Filter>
   </wfs:Query>
</wfs:GetFeatureWithLock>
```

In this case, the lock time is 5 minutes.

Response

```
<wfs:FeatureCollection xmlns:wfs="http://www.opengis.net/wfs" lockId="1"
xsi:schemaLocation="http://www.example.com/myns
http://localhost:8888/SpatialWS-SpatialWS-context-root/wfsservlet?featureTypeId=1
" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
   <gml:boundedBy xmlns:gml="http://www.opengis.net/gml">
      <gml:Box srsName="SDO:8307">
         <gml:coordinates>3.0,3.0 6.0,5.0</gml:coordinates>
      </gml:Box>
   </gml:boundedBy>
   <gml:featureMember xmlns:gml="http://www.opengis.net/gml">
      <myns:COLA xmlns:myns="http://www.example.com/myns" fid="3">
         <myns:MKT_ID>3</myns:MKT_ID>
         <myns:NAME>cola_c</myns:NAME>
         <myns:SHAPE>
            <gml:Polygon srsName="SDO:8307">
               <gml:outerBoundaryIs>
                  <gml:LinearRing>
                     <gml:coordinates decimal="." cs="," ts=" ">3.0,3.0 6.0,3.0
6.0,5.0 4.0,5.0 3.0,3.0 </gml:coordinates>
                  </gml:LinearRing>
               </gml:outerBoundaryIs>
            </gml:Polygon>
         </myns:SHAPE>
      </myns:COLA>
   </gml:featureMember>
</wfs:FeatureCollection>
```

The response feature will give the lock ID. This ID was generated by the system. This lock ID is going to be used to update the data later. The update operation will fail without specifying LockID.

d. LockFeature

The function of LockFeature will lock a set of feature instances. No other user will be able to update this feature before the expiry time.

Request

```
<?xml version="1.0" ?>
<wfs:LockFeature
   service="WFS"
   version="1.0.0"
   expiry="5"
   xmlns:wfs="http://www.opengis.net/wfs"
   xmlns:ogc="http://www.opengis.net/ogc"
   xmlns:gml="http://www.opengis.net/gml"
   xmlns:myns="http://www.example.com/myns"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" >
   <wfs:Lock typeName="myns:COLA">
      <ogc:Filter>
           <ogc:PropertyIsEqualTo>
              <ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
              <ogc:Literal> 2 </ogc:Literal>
           </ogc:PropertyIsEqualTo>
      </ogc:Filter>
   </wfs:Lock>
</wfs:LockFeature>
```

Response

```
<wfs:WFS_LockFeatureResponse xmlns:wfs="http://www.opengis.net/wfs">
   <wfs:LockId>2</wfs:LockId>
</wfs:WFS_LockFeatureResponse>
```

e. Insert

Insert can be used to insert a new feature.

Request

```
<?xml version="1.0"?>
<wfs:Transaction version="1.0.0" handle="TX01" service="WFS" xmlns="http://www.e
xample.com/myns" xmlns:myns="http://www.example.com/myns" xmlns:gml="http://ww
w.opengis.net/gml" xmlns:ogc="http://www.opengis.net/ogc" xmlns:wfs="http://www.
opengis.net/wfs" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" >
<wfs:Insert handle="INSERT01" >
<myns:COLA fid="5" xmlns:myns="http://www.example.com/myns">
         <myns:MKT_ID>5</myns:MKT_ID>
         <myns:NAME>cola_e</myns:NAME>
         <myns:SHAPE>
            <gml:Polygon srsName="SDO:8307"
xmlns:gml="http://www.opengis.net/gml">
               <gml:outerBoundaryIs>
                  <gml:LinearRing>
                     <gml:coordinates decimal="." cs="," ts=" ">1.0,3.0 6.0,3.0
6.0,5.0 4.0,5.0 1.0,3.0 </gml:coordinates>
                  </gml:LinearRing>
               </gml:outerBoundaryIs>
            </gml:Polygon>
         </myns:SHAPE>
      </myns:COLA>
</wfs:Insert>
</wfs:Transaction>
```

Response

```
<?xml version = '1.0' encoding = 'UTF-8'?>
<wfs:WFS_TransactionResponse version="1.0.0"
xmlns:wfs="http://www.opengis.net/wfs">
   <wfs:InsertResult handle="INSERT01">
      <ogc:FeatureId fid="5" xmlns:ogc="http://www.opengis.net/ogc"/>
   </wfs:InsertResult>
   <wfs:TransactionResult handle="TX01">
      <wfs:Status>
         <wfs:SUCCESS/>
      </wfs:Status>
   </wfs:TransactionResult>
</wfs:WFS_TransactionResponse>
```

f. Update

Request

```
<?xml version="1.0"?>
<wfs:Transaction version="1.0.0" handle="TX01" service="WFS"
xmlns="http://www.example.com/myns"
xmlns:myns="http://www.example.com/myns" xmlns:gml="http://www.opengis.net/gml"
xmlns:ogc="http://www.opengis.net/ogc" xmlns:wfs="http://www.
opengis.net/wfs" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" >
<wfs:Update handle="UPDATE1" typeName="myns:COLA" >

<wfs:Property>
<wfs:Name>myns:COLA/myns:NAME</wfs:Name>
<wfs:Value>cola_c1</wfs:Value>
</wfs:Property>
<ogc:Filter>
<ogc:And>
<ogc:And>
<ogc:PropertyIsGreaterThan>
<ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
<ogc:Literal> 2 </ogc:Literal>
</ogc:PropertyIsGreaterThan>
<ogc:PropertyIsLessThan>
<ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
<ogc:Literal> 4 </ogc:Literal>
</ogc:PropertyIsLessThan>
</ogc:And>
<ogc:Not>
<ogc:PropertyIsNull>
<ogc:PropertyName>myns:COLA/myns:NAME</ogc:PropertyName>
</ogc:PropertyIsNull>
</ogc:Not>
</ogc:And>
</ogc:Filter>
</wfs:Update>
</wfs:Transaction>
```

Response

```
<?xml version = '1.0' encoding = 'UTF-8'?>
<wfs:WFS_TransactionResponse version="1.0.0"
xmlns:wfs="http://www.opengis.net/wfs">
<wfs:TransactionResult handle="TX01">
<wfs:Status>
<wfs:SUCCESS/>
</wfs:Status>
</wfs:TransactionResult>
</wfs:WFS_TransactionResponse>
```

g. Delete

Request

```
<?xml version="1.0"?>
<wfs:Transaction version="1.0.0" handle="TX01" service="WFS"
xmlns="http://www.example.com/myns"
xmlns:myns="http://www.example.com/myns" xmlns:gml="http://www.opengis.net/gml"
xmlns:ogc="http://www.opengis.net/ogc" xmlns:wfs="http://www.
opengis.net/wfs" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" >
<wfs:Delete handle="DELETE1" typeName="myns:COLA" >
<ogc:Filter>
<ogc:And>
<ogc:And>
<ogc:PropertyIsGreaterThan>
<ogc:PropertyName>myns:COLA/myns:MKT_ID</ogc:PropertyName>
<ogc:Literal> 3 </ogc:Literal>
</ogc:PropertyIsGreaterThan>
Java API for WFS Administration
Web Feature Service (WFS) Support 15-13
<ogc:PropertyIsEqualTo>
<ogc:PropertyName>myns:COLA/myns:NAME</ogc:PropertyName>
<ogc:Literal> cola_e </ogc:Literal>
</ogc:PropertyIsEqualTo>
</ogc:And>
<ogc:Not>
<ogc:PropertyIsNull>
<ogc:PropertyName>myns:COLA/myns:NAME</ogc:PropertyName>
</ogc:PropertyIsNull>
</ogc:Not>
</ogc:And>
</ogc:Filter>
</wfs:Delete>
</wfs:Transaction>
```

Response

```
<?xml version = '1.0' encoding = 'UTF-8'?>
<wfs:WFS_TransactionResponse version="1.0.0"
xmlns:wfs="http://www.opengis.net/wfs">
<wfs:TransactionResult handle="TX01">
<wfs:Status>
<wfs:SUCCESS/>
</wfs:Status>
</wfs:TransactionResult>
</wfs:WFS_TransactionResponse>
```

Besides using SQL, the client can use JAVA APIs which use JAVA to run all the functions above.

6.13 SOA - BPEL process

After WFS and WMS are enabled, the user can implement SOA concepts, such as BPEL, to design work flows according to real world practice. BPEL can call the Web Service for data when any information needed. The BPEL process may include a few agencies that are involved in a particular business or legal endeavour.

6.14 Deploy SOA-Infra in Weblogic

Before BPEL is designed and implemented, the SOA platform needs to be deployed in WebLogic Server as shown in **Figure 6-25**. This is set during the creation of the domain in the WebLogic Application Server. The successful deployment will show ‘Active’ status in the server.

	soa-infra	Active	OK	Enterprise Application	350
	Modules				
	/b2b			Web Application	
	/bpm/services			Web Application	
	/integration/services			Web Application	
	/integration/services/AGAdminService			Web Application	
	/integration/services/AGMetadataService			Web Application	
	/integration/services/AGQueryService			Web Application	

Figure 6-25 SOA application deployment in WebLogic

6.15 Creating BPEL application in Jdeveloper

A BPEL process application can be designed using Jdeveloper that provides a drag and drop interface as shown in **Figure 6-26**. The category of application is set when a new project is opened. In this case the SOA application is selected.

Figure 6-27 shows the user can select SOA technology to enable BPEL composite applications.

After the SOA technology is selected, the user can choose the BPEL process setting as shown in **Figure 6-28** to start to develop the work flow and the project folder.

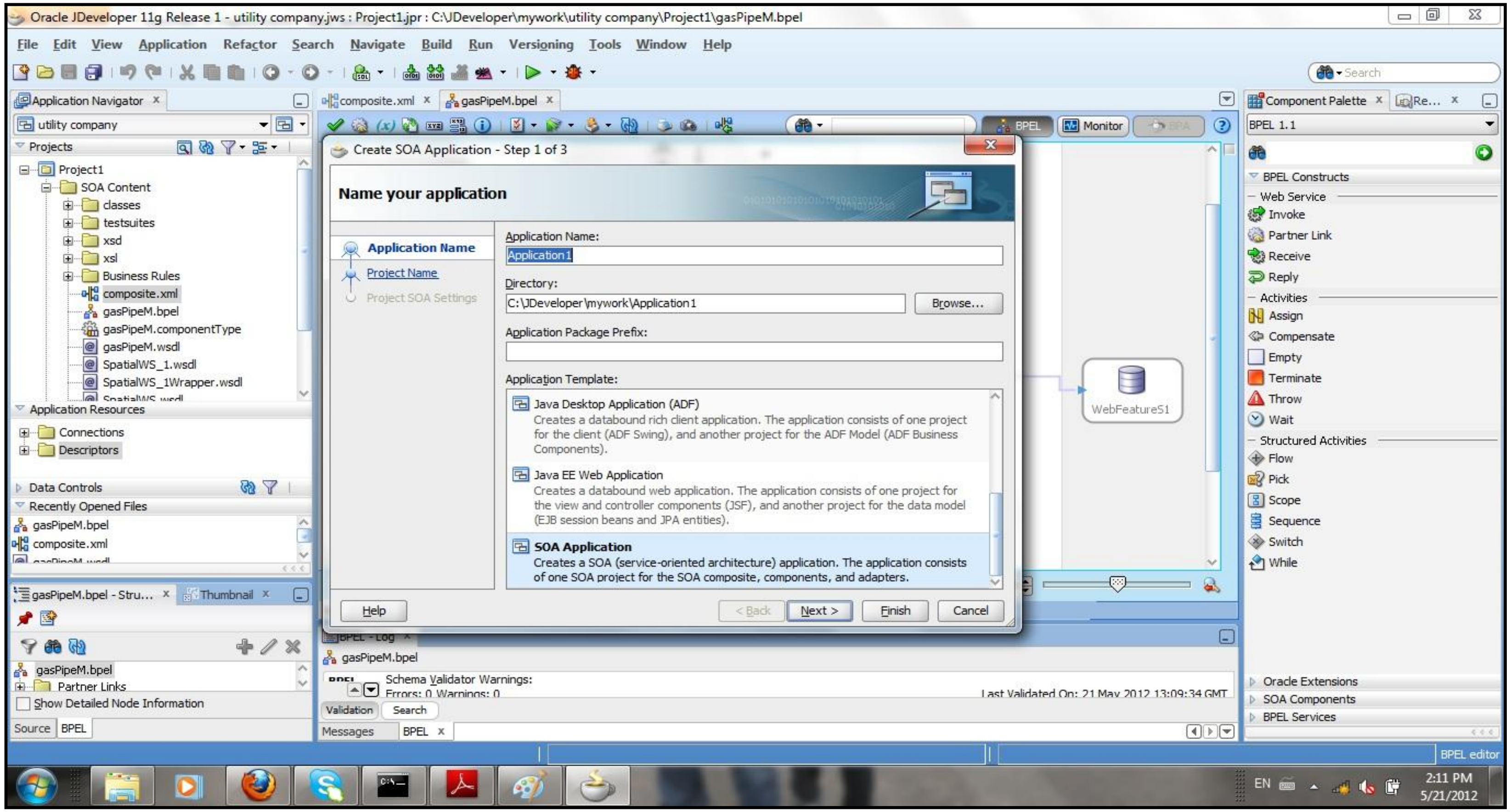


Figure 6-26 Create new application in Jdeveloper

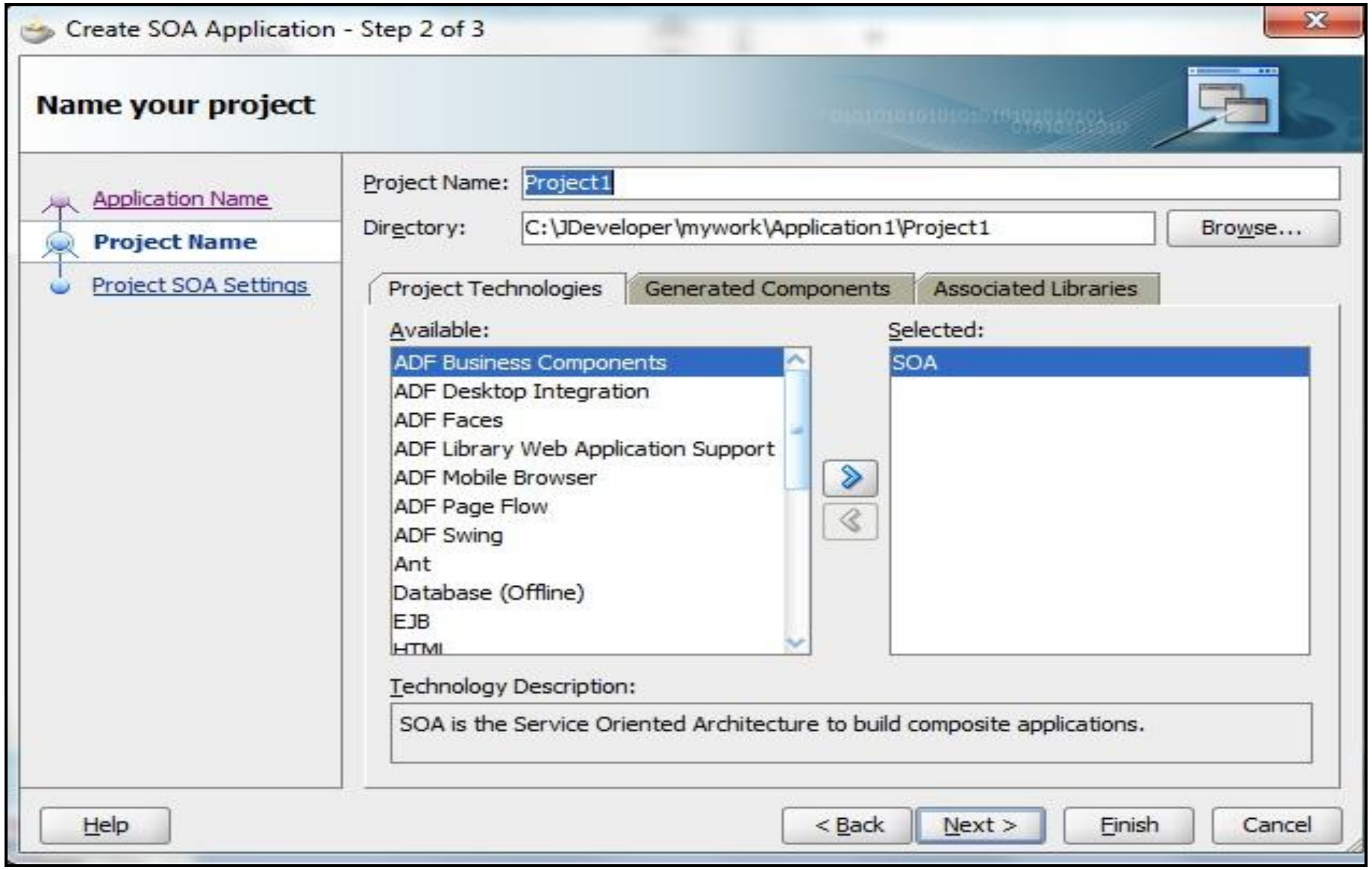


Figure 6-27 SOA technology is selected

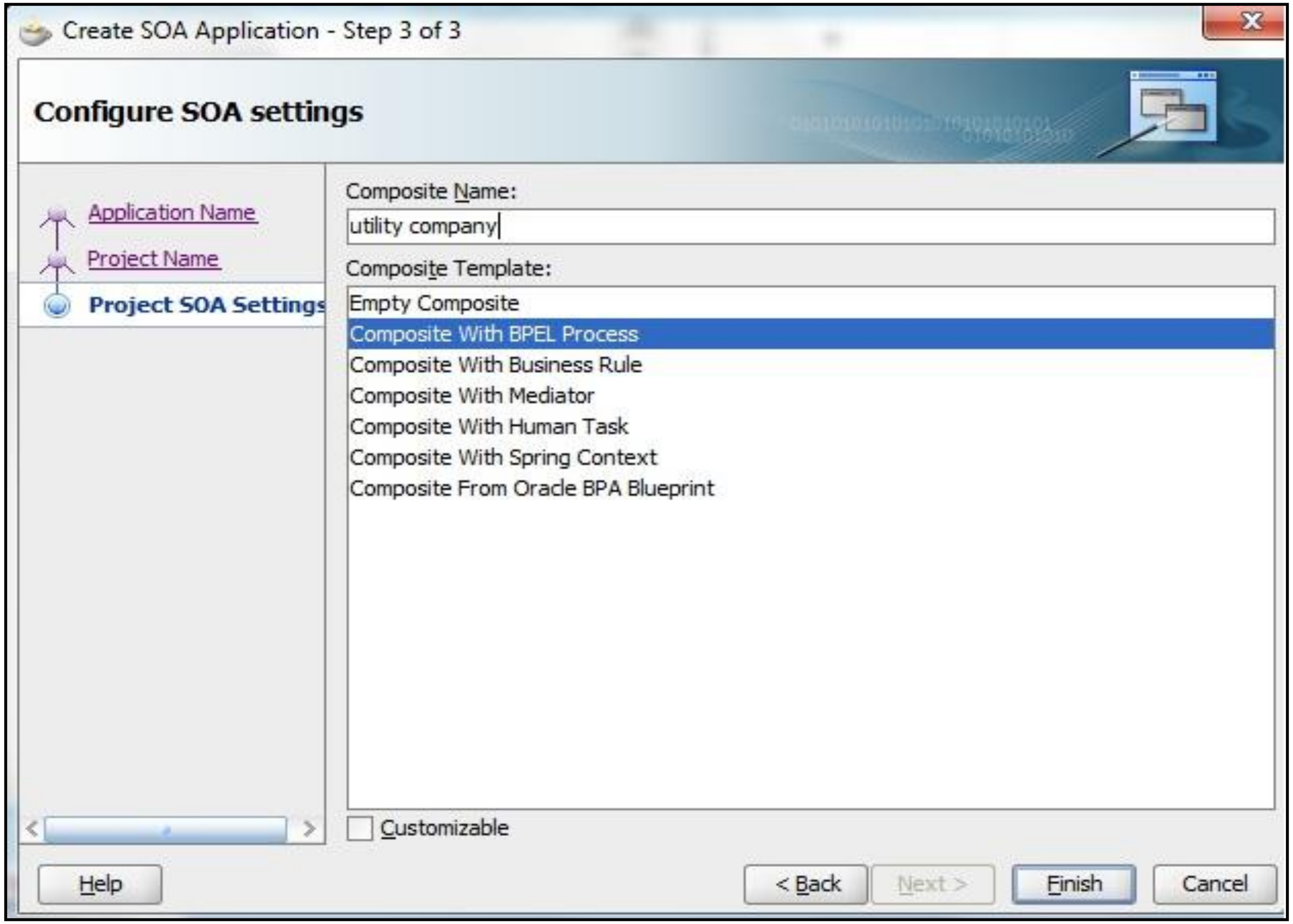


Figure 6-28 BPEL process is selected

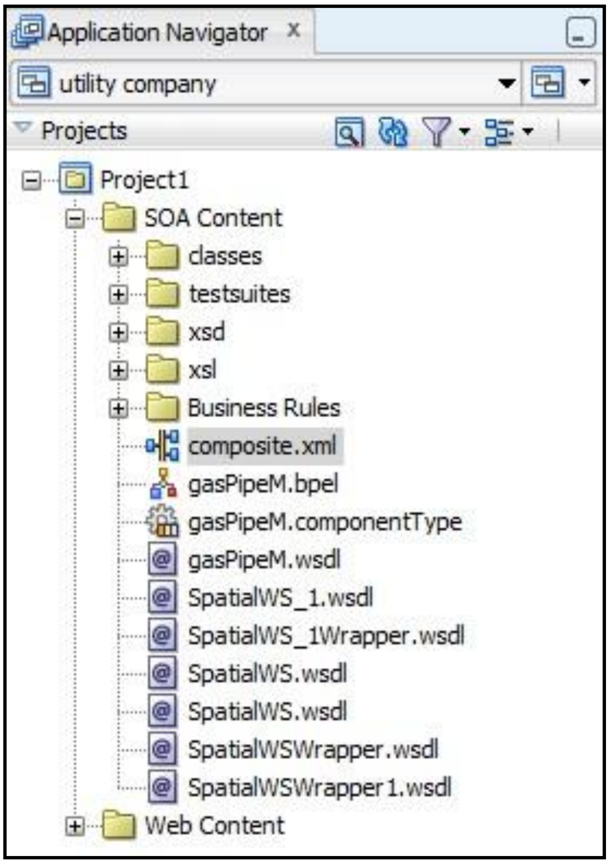


Figure 6-29 The application project folder

Figure 6-29 shows that the project folder is generated after the settings were made.

6.16 Calling the web service in BPEL

When a decision is needed to made in the business process, users can recall a particular Web Services for information. The process is called 'Invoke'. A user must know the address of the web services before the process of recall. Every web service published its Web Services Description Language (WSDL) file to tell user about the URL address. **Figure 6-30** shows the sample of a work flow of a business process which involves utility data.

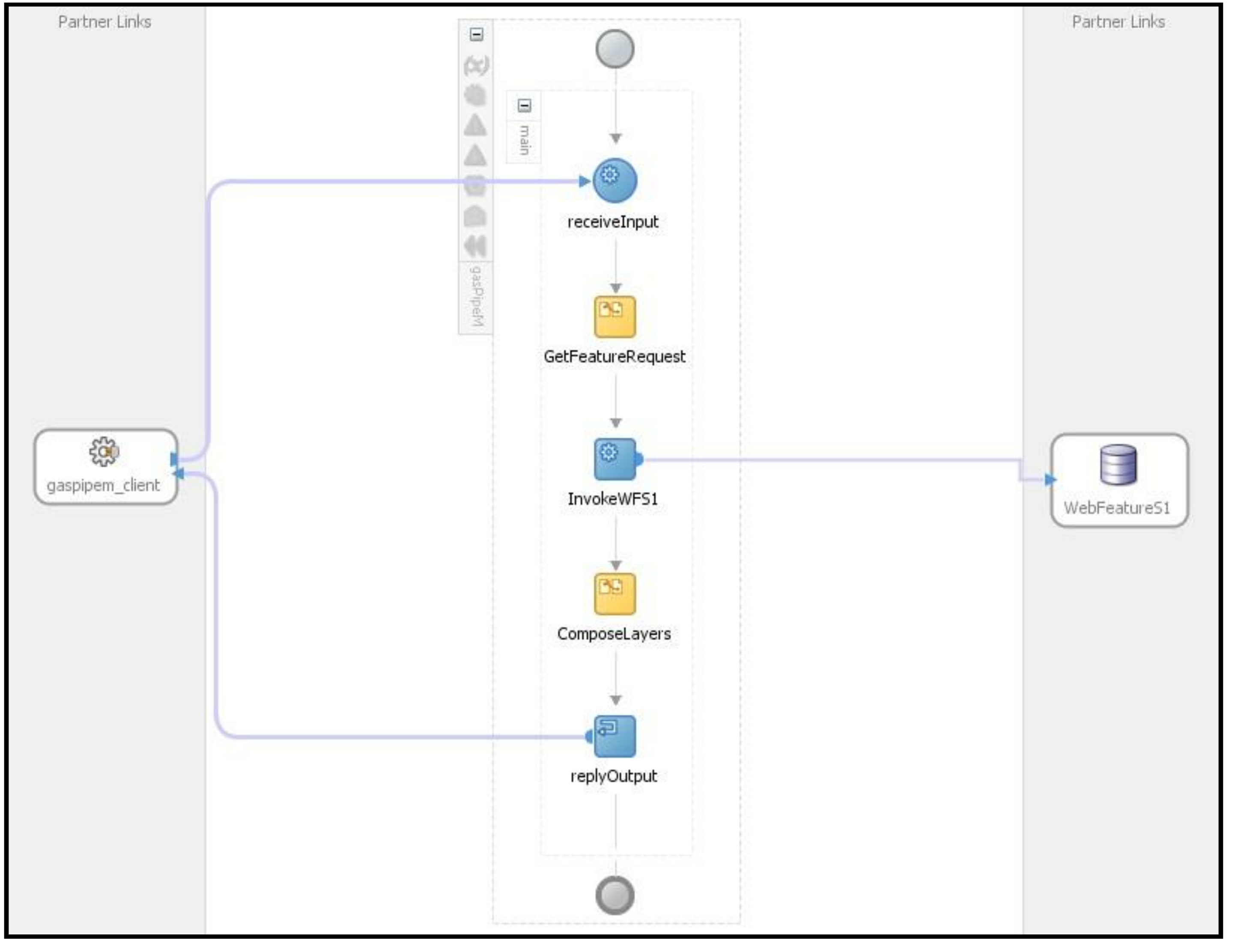


Figure 6-30 **The diagram show the flow of BPEL process**

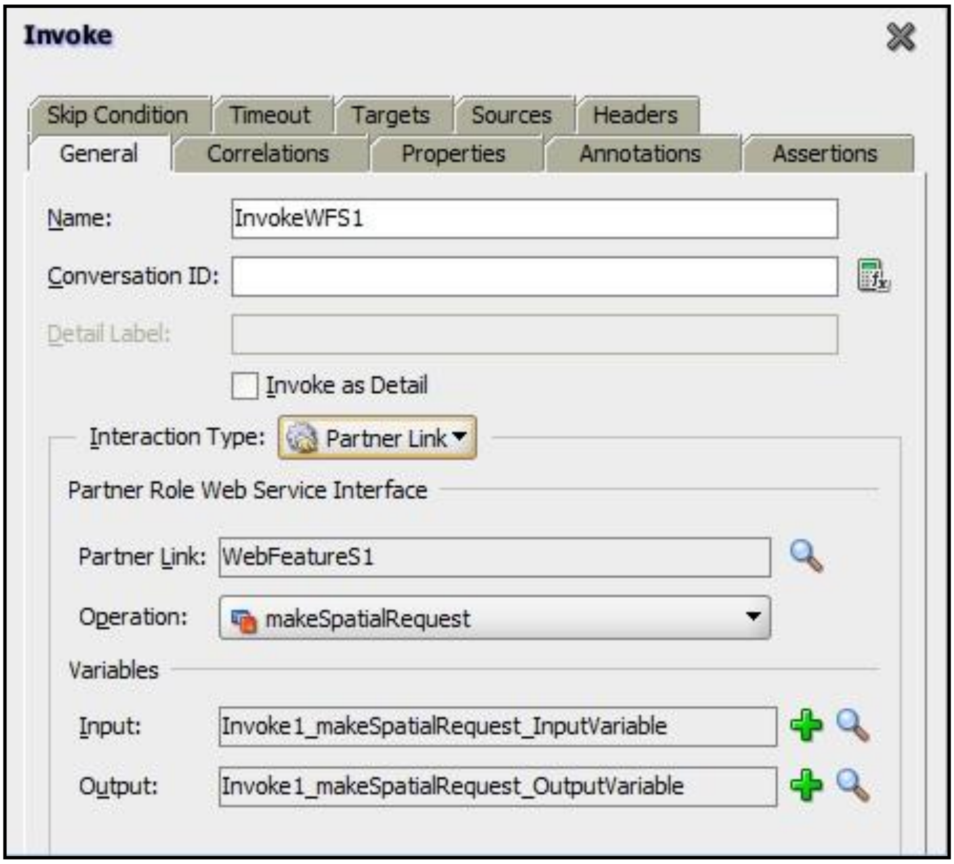


Figure 6-31 WFS is linked using the Invoke function

Figure 6-31 shows how the WFS is called using the Invoke function.

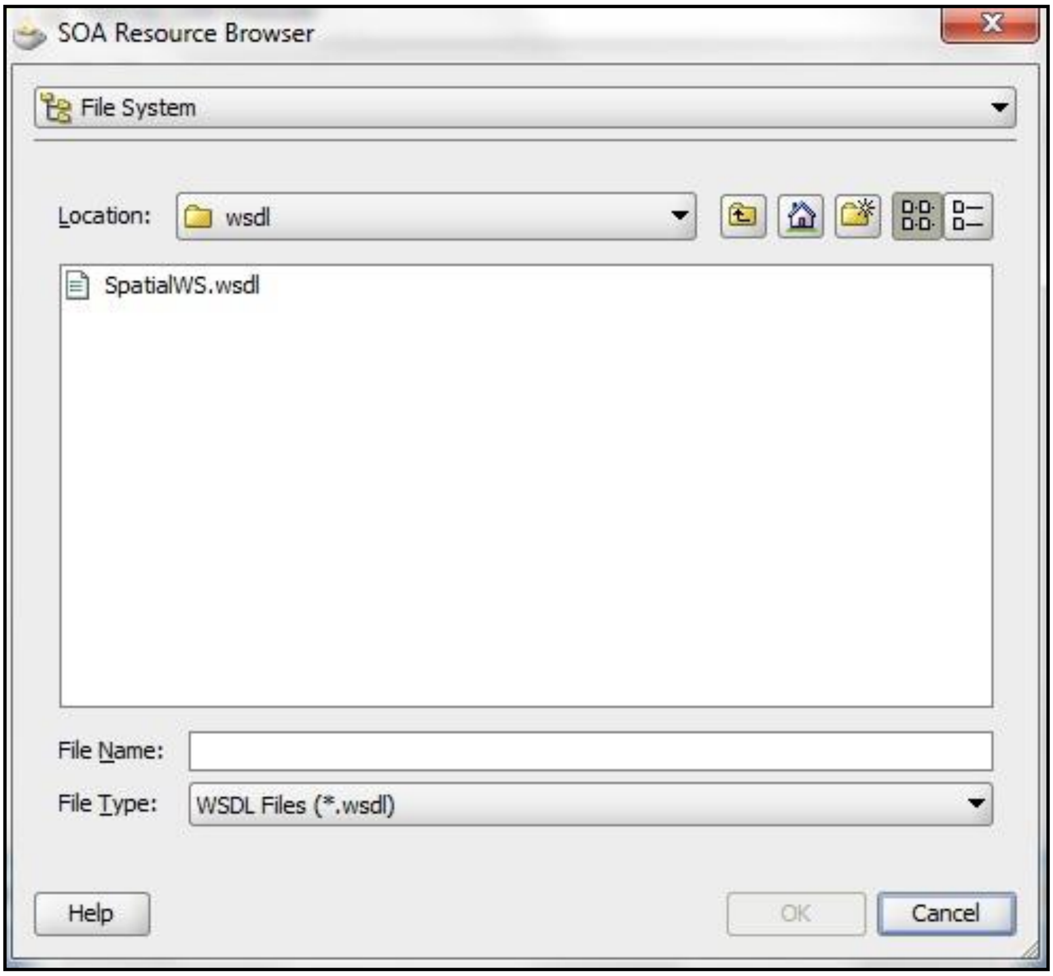


Figure 6-32 WSDL file that defines the location of WFS is selected

The Web Services Description Language (WSDL) is the XML format file that is generated by WFS to tell the client about the location of WFS and describes network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. **Figure 6-32** shows that before a web service is called, the user needs to provide a WSDL file in order to invoke the process.

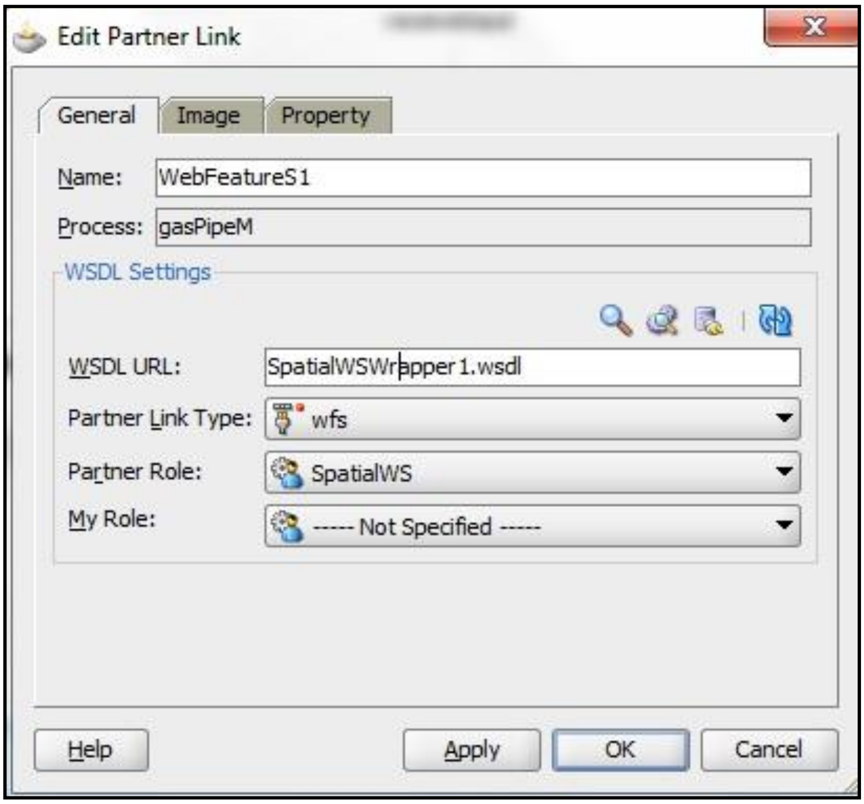


Figure 6-33 The link of WSDL URL with BPEL process

The invoke process in BPEL will wrap the WSDL file and generate a copy into the BPEL as shown **Figure 6-33.**

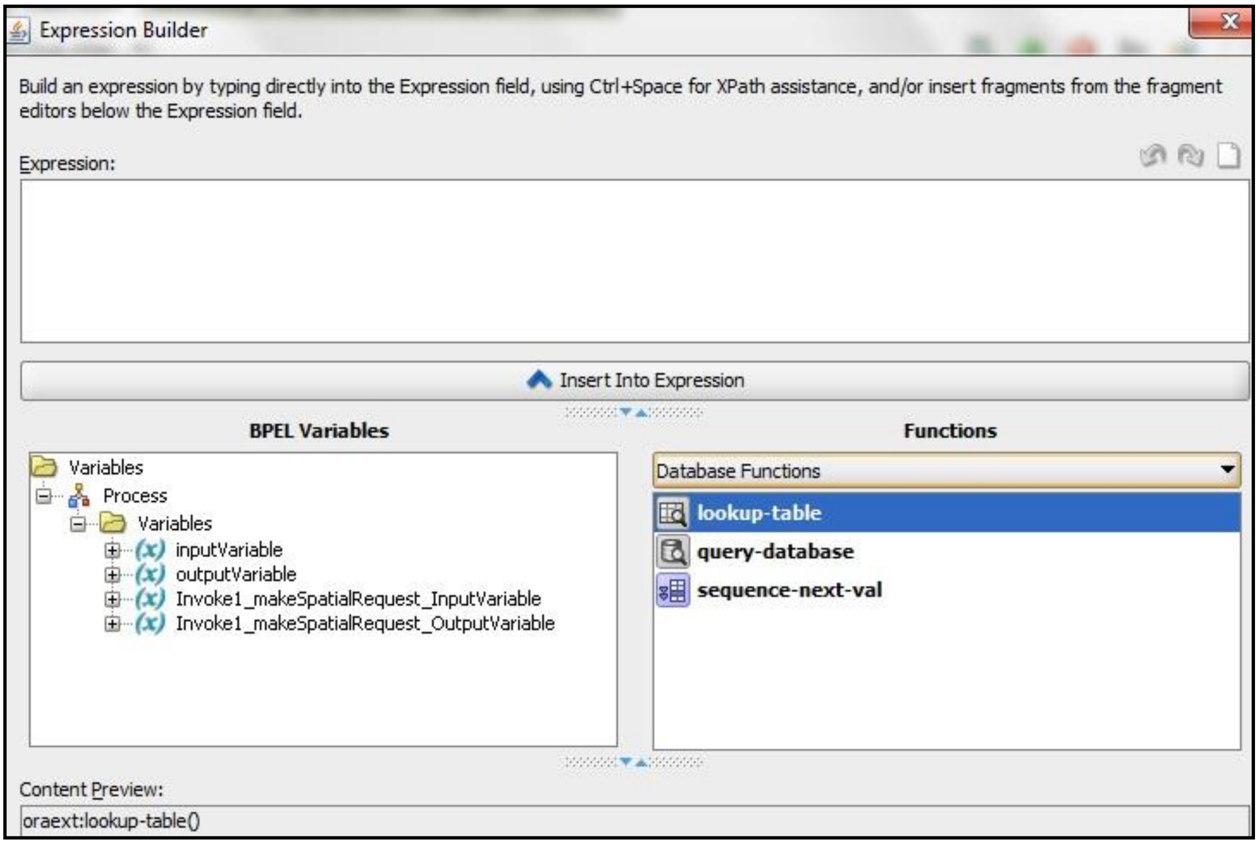


Figure 6-34 The Expression Builder
(is used to request data from WFS)

The user can design the input variable (to get the information) and output variable from the WFS as shown in **Figure 6-34**. This can be the xml request message. After the assign activity is completed, the user has to deploy the application into server as shown in **Figure 6.36**.

6.17 Deploy the BPEL application in the SOA server

After the process of application of BPEL is completed, the user can deploy the application into the server using Jdeveloper as shown in **Figure 6-35**. The user can select the Admin Server as a location of this application as shown in **Figure 6-36.**

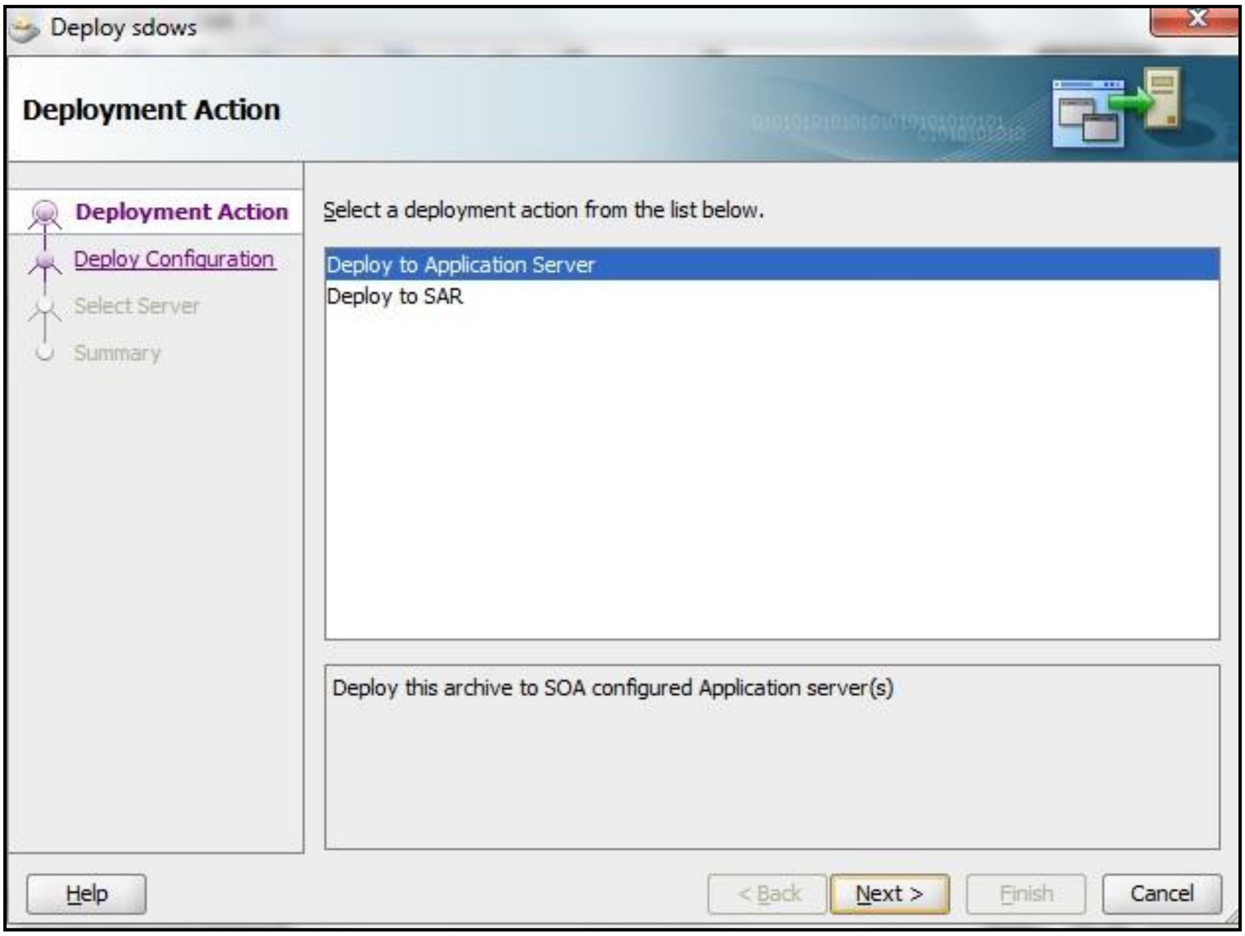


Figure 6-35 Application of BPEL is deploy in the server.

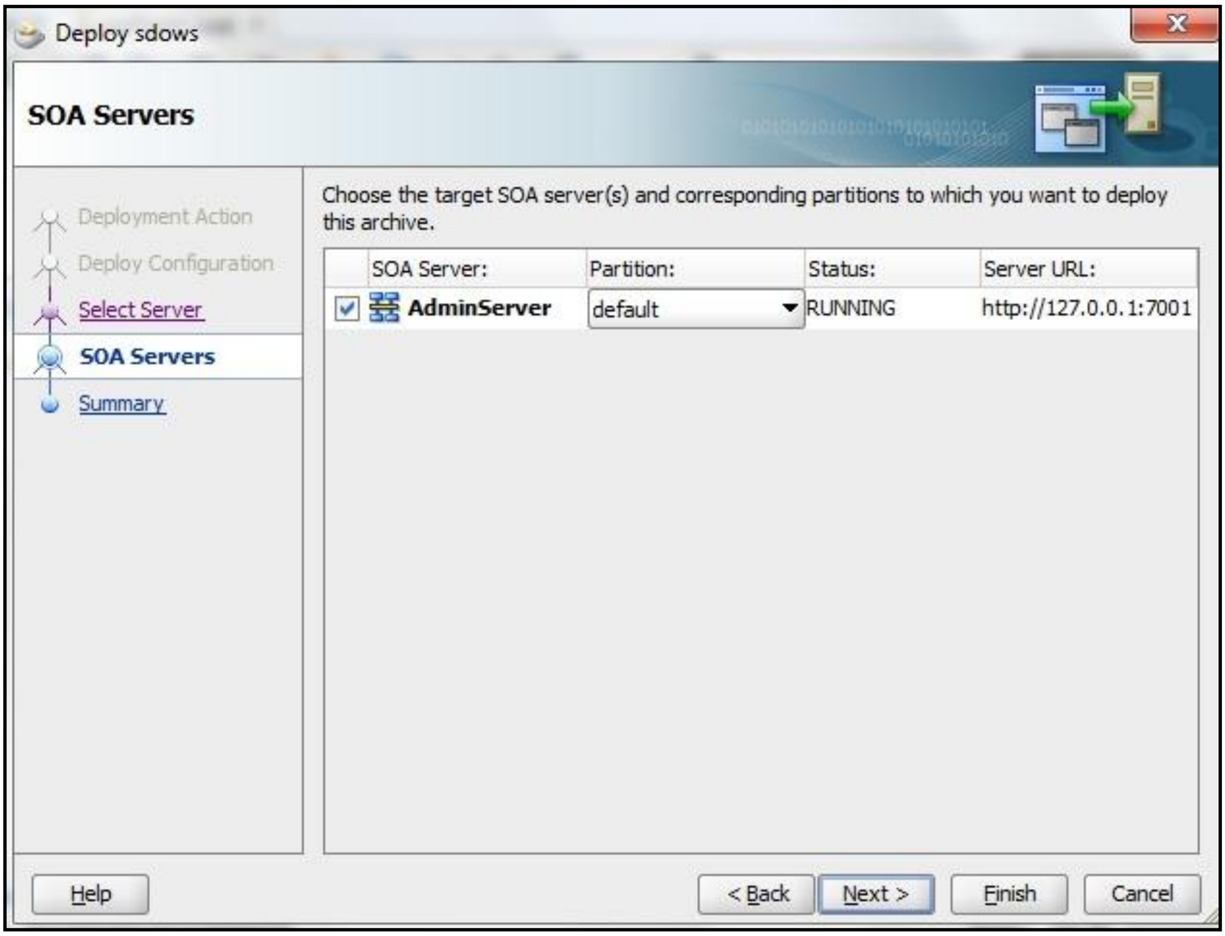


Figure 6-36 The admin server is selected

6.18 Deployment test in Oracle Enterprise Manager

The BPEL process application that is deployed in the server can be tested in Oracle Enterprise Manager at the address:

Http://localhost:7001/em

The user has to log on as the administrator user as set up created during the domain creation process as shown in **Figure 6.37**.

Figure 6-38 shows an interface screen which contains the deployment of all applications. The sdows that contain the BPEL application is up and no error is detected.

The user can test the BPEL application that is deployed in the enterprise manager as shown in **Figure 6-39**.

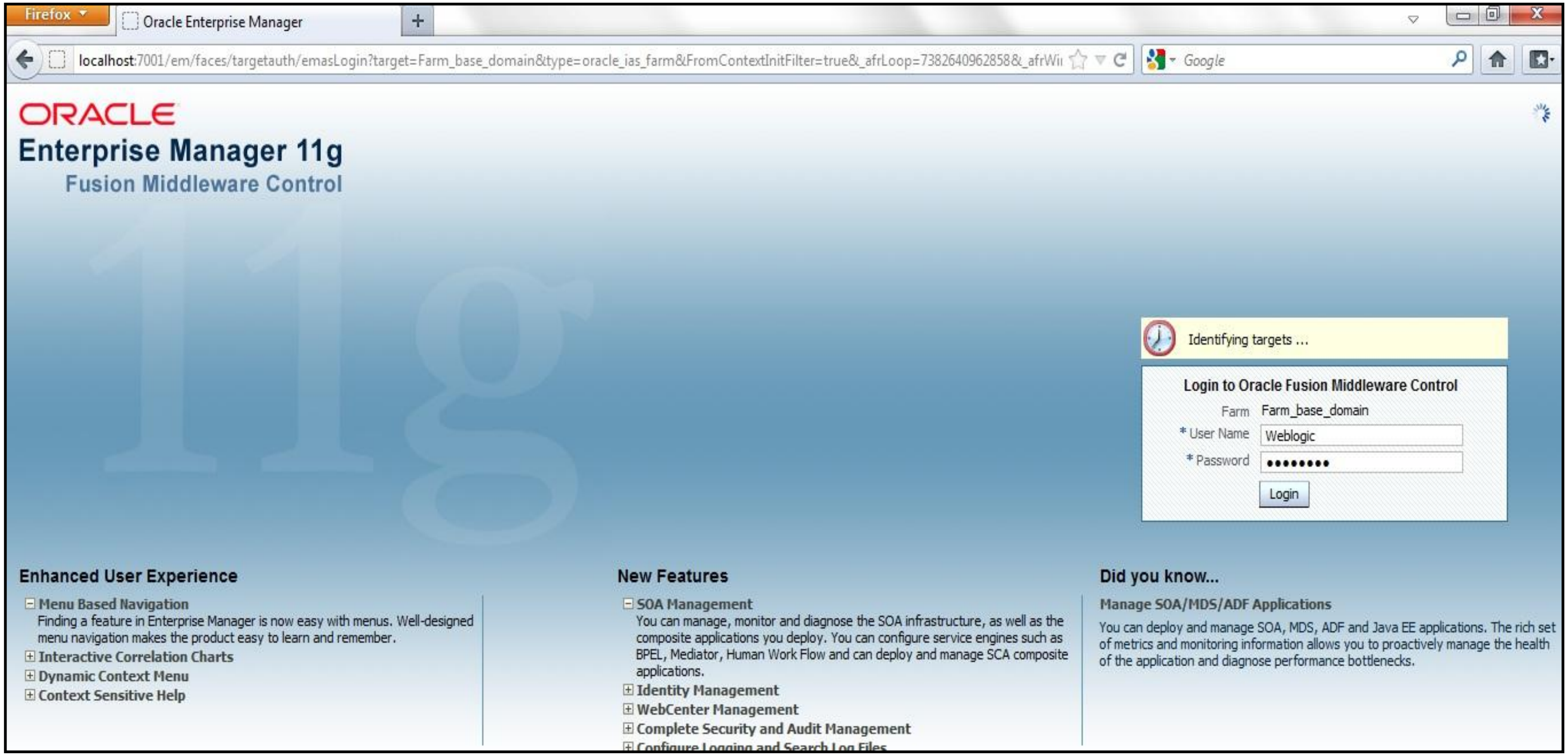


Figure 6-37 Oracle Enterprise Manager
(Access to BPEL application using Oracle Enterprise Manager)

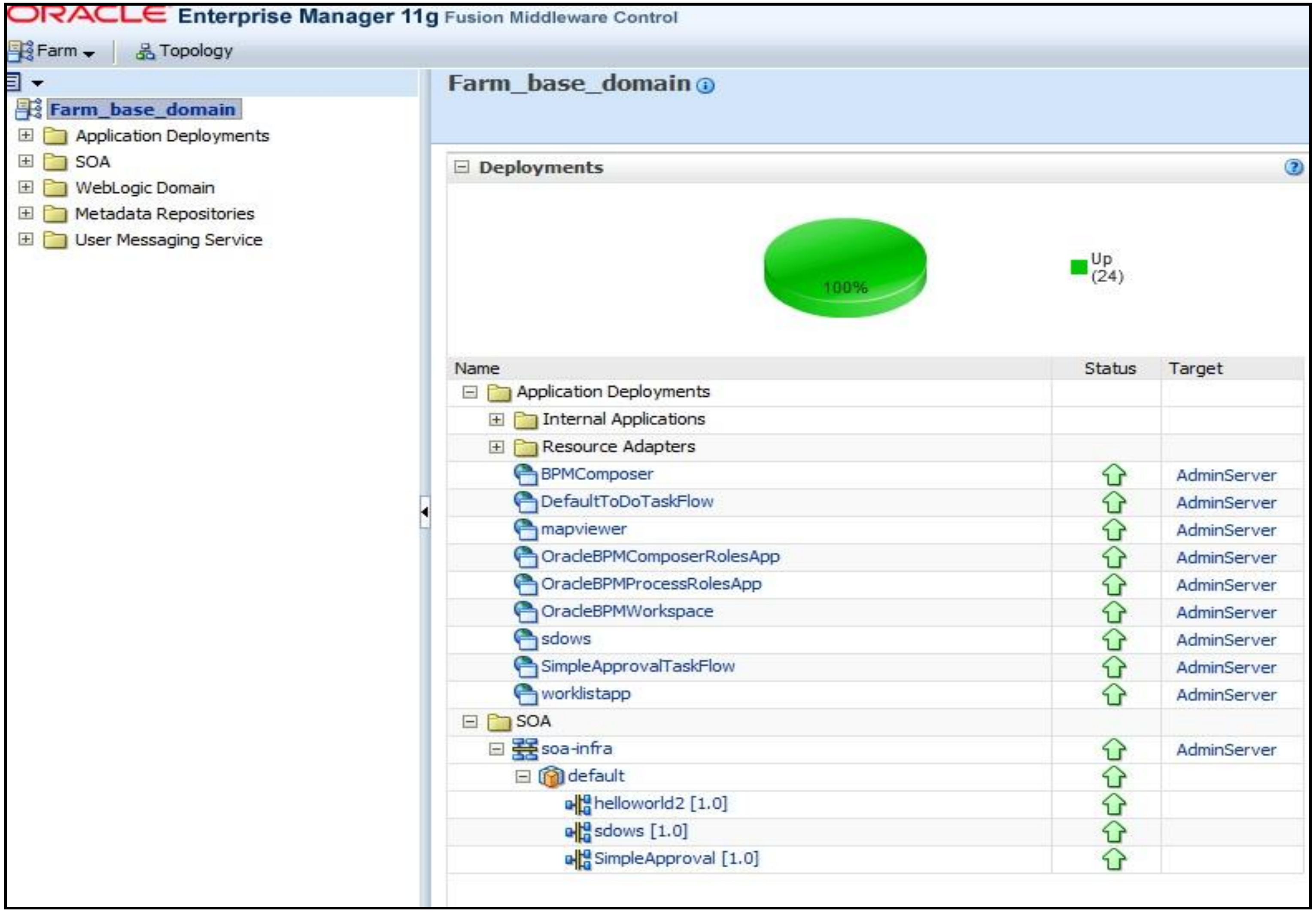


Figure 6-38 BPEL application deployment status
(The enterprise manager will show the deployment status)

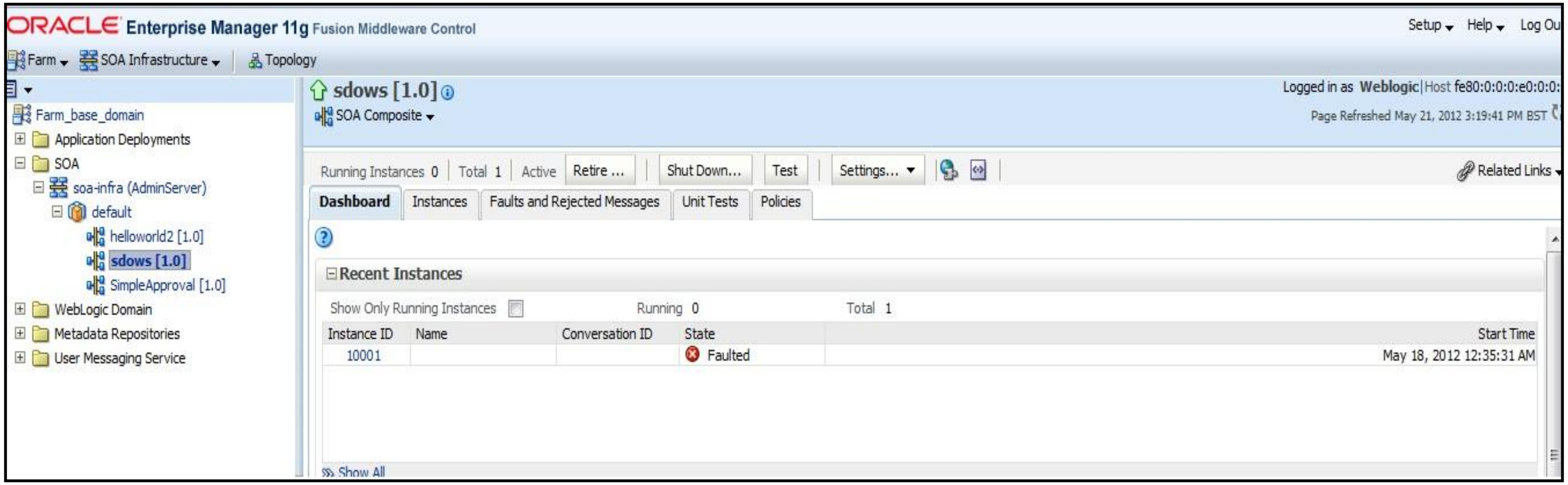


Figure 6-39 Testing can be done for the BPEL process.

6.19 Summary of Chapter 6

The SOA service can be called in any BPEL process when information is needed for decision making. According to real world business processes, each data layer should be kept independently reflecting the agencies that have authority for each data layer.

A simple case of a legal topic such as an easement for utility data can be implemented in the BPEL process since the data of utility, parcel data and title document are separately store in the real world situation.

The WFS or WMS using the BPEL process can be applied to develop the data model type 1 which is proposed in this investigation. The services provided depend on the data format requirements - whether in image or GML feature. The image data layers were simpler to implement, as the data are lighter and the server response faster than that for a GML feature. But, if users need to manipulate the data, the most suitable format to publish it is as a GML feature.

The SOA method used in the construction of a MPC database will require extensive IT use, especially a high specification server. The advantage of the SOA concept in MPC is to avoid redundant data collection and processing. Today, the cost of data collection, particularly in the field is probably the greatest cost to a spatial data agency. Investment in IT technologies is the best option contributing towards sustainable management within the spatial service sector. But before doing any heavy investment more highly skill personnel in the SOA field should be recruited or trained in order to run the system smoothly.

Chapter 7: Conclusion and future works

7.1 Conclusion

This thesis has attempted to provide concept and technology update for the development of a multipurpose cadastre system (MPC) in Malaysia. The development of a sample MPC database based on the Oracle environment is to emulate the systems that currently are used by the Department of Land Survey and Mapping of Malaysia (JUPEM) and other agencies which are expected to be data providers of the MPC system. This investigation also reviews the developments in modern cadastre internationally which are currently taking place around the world. The practical work of Service Oriented Architecture (SOA) in the last chapter has contributed knowledge and experience to this researcher for potential use of this IT concept in an MPC system.

Review of the progress of multipurpose cadastre in selected countries shows that evolution towards MPC is influenced by the demands of the users in those particular countries. Although new concepts, policies and standards are suggested by international organizations such as FIG, ISO and OGC, some countries still cautiously give priority to the cost recovery factor, thus this has slowed down progress. Difficulties in funding projects were hurdles in their development. The studied countries tend to focus on open source systems which can be developed with lower cost by their own employees.

The Torrens System which is the most rigid cadastre system and emphasizes the accuracy of boundaries and rights has shaped the different systems for countries such as Malaysia and Australia. To supply what users want, systems now need highly sophisticated GIS and survey technologies, for example using geodetic GPS systems to collect data in the field. Highly sophisticated GIS and survey technologies come at a great price, investment and knowledge, and as a result, the process of moving towards MPC can be more difficult for a country that practises the Torrens system. This investigation has created a relational multipurpose cadastre database data model that can help the understanding of high accuracy MPC model. The topology rule was applied and data validations executed in the SQL language for a particular data object such as a parcel. The integrity of existing structure of cadastre data such NDCDB should be improved as suggested in this thesis.

The spatial functionality, various other functions and syntax in SQL language that are used by the Oracle system help ease query and maintain the database. The now evident realization of the importance of spatial data by technology providers will help more flexible databases to be designed in the future.

The capability to render the map and data feature in the XML format, available in the internet, can benefit the clients who are able to request a map in raster format and overlay layer maps in their application. Data that is stored in different silos (data provider preferred) must be in a standard format such as XML or GML. The case study conducted considers how the database can generate an easement for utility data has proved the objective is achieved by showing the complete legal situation of a parcel, compared to the previous system where the user had to manually search for legal documents and deal with the ambiguous locations of legal objects.

The data model also can be expandable and flexible by adding the application of right, restriction and responsibility (RRR) of the MPC database.

The investigation of the legal requirements of a multipurpose cadastre system shows there is a need to gather the existing legislation concerning each data class in the multipurpose data model and store it as an attribute to the data. The evaluation of provisions in the National Land Code 1965 relating to MPC need to be executed such as into sample provided in this thesis. This may come into reality when the Geospatial Act comes into force by the year 2013.

The main objective of MPC in Malaysia is to provide information for management and planning towards sustainable development. Due to this, the investigation of the organizational requirements of a multipurpose cadastre system gave an overview of existing data providers according to the flow of land development. The concepts that exist such as data custodian in the Malaysia SDI, or MyGDI, provide experience to set up the MPC system.

Apart from putting all the datasets into one database (data model type 2) the review and practical works of SOA provided an alternative of interoperability to gather, validate, maintain and deliver of data (data model type 1). Each data layer can be kept independently according to the agencies that have authority for each data layer but they are all needing to have web service capability in order to be recalled. This thesis will provide future workers with a good background to the relevant web services (Web Map Service and Web Feature Service) and BPEL – Business process. Thus this is an introduction to design according to the real world business process and can tremendously reduce the running cost of a system. The MPC system shall be designed by taking into account the recycling of data or reuse of data, this is a more viable and feasible investment for Malaysia, based on the current world economy and for a future sustainable system.

7.2 Future work

Although all of the investigation objectives have been tackled, a range of further tasks have emerged during this investigation:

a. The works flow should be designed for exchange of data between the private sector, government agencies and the public who will become either data providers or consumers according to the SOA concept. This should be done in the BPEL process and applications should be developed according to legal topics such as easement, forest reserves, planning zones, etc. The users that are involved in this legal process should have access to this flow at certain stages when the decisions need to be made. It is expected many non spatial web services also will be recalled during the process. This will impact on real world business processes when everything is digitized, some of redundant processes will be eliminated and may result in the restructuring and disposal of certain organizations. This will totally change the conventional architecture of IT networks in all government agencies.

b. Investigations should be done on how to migrate JUPEM2u to web services. It should be able to respond to the need to reuse services. This will change the way of data provision in the portal.

c. Customers would always need the latest update of the data, the long process of providing this data may result in outdated data published to users. The study should determine how to utilize web feature service (WFS) as a tool to update databases. This is a fast way for the spatial data to become available to users.

d. Data security systems shall be designed to protect the interest and privacy of all the users involved.

e. The SOA BPEL examination should be continued on a larger machine which has server grade capability, online testing should be done between servers to analyse the interoperability of the process, data format, accuracy, speed. The BPEL process should be continued from the stage where the author has stopped in this investigation, the process needs to be able to recall the WFS to provide information in decision making in a real case scenario in the network environment, this will need high specification hardware and further IT knowledge for the testing.

f. The hybrid model which combines of data model type 1 and data model type 2 should be further investigated according to the real world business.

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Appendices

List of Appendices are as follow:

Appendix A

NDCDB database structure translation

NDCDB_BDY	
Field Description	Translation
UPI	Unique Parcel Identifier
ADJPARCEl	Adjacent Parcel
BEARING	The bearing value of boundary line
DISTANCE	The distance value of boundary line
FNODE	The start point of boundary line
TNODE	The end point of boundary line
TARIKH_KEMASKINI	Update date to database

NDCDB_PLAN	
Field Description	Translation
PA	Short form of *Pelan Akui* (certified plan)
APDATE	Approve date by Director of Survey
APPROVER	Name of approver
APPROVERIC	Identity number of the approver
SURVEYOR	Surveyor who survey the parcel
SURVEYORIC	Identity number of Surveyor
SURVEYCOMPLETED	Field survey completed data
NOSYITPIAWAI	Number of standard sheet
TARIKH_KEMASKINI	Update date to database

NDCDB_LOT	
Field Description	Translation
NEGERI	State
DAERAH	District
MUKIM	Sub District
SESKYEN	Section
LOT	Parcel number
UPI	Unique Parcel Identifier
NOPEJTANAH	State land office file number
NOFAILUKUR	Federal Survey and Mapping department file number
S_AREA	The area
KOD_KEGUNAANTANAH	Land use coding
PA	*Pelan Akui* (certified plan) number
APDATE	Approve date by Director of Survey
TARIKH_KEMASKINI	Update date to database

NDCDB_STN	
Field Description	Translation
STN_ID	The boundary point ID
SERIAL	Serial number of boundary point
MARK_DESC	The description of boundary point such as stone, spike, nail and etc.
NORTH_CAS	The northing coordinate in Cassini Solder coordinate system
EAST_CAS	The easting coordinate in Cassini Solder coordinate system
STD_ERR_NORTH_CAS	Standard error of northing coordinate in Cassini Solder coordinate system
STD_ERR_EAST_CAS	Standard error of easting coordinate in Cassini Solder coordinate system
NORTH_RSO	The northing coordinate in Rectified Skew Orthomorphic coordinate system
EAST_RSO	The easting coordinate in Rectified Skew Orthomorphic coordinate system
TARIKH_KEMASKINI	Update date to database

Appendix B

The SQL spatial coding for development of MPC database:

```
--METHOD 1 : Using the topology data model with a topology built from
Spatial geometry data

--Drop any spatial tables that exist in database
DROP TABLE MPC_BUILD_GEOM PURGE;
DROP TABLE MPC_UTILITY_GEOM PURGE;
DROP TABLE MPCNDCDB_BDY_GEOM PURGE;
DROP TABLE MPCNDCDB_PARCEL_GEOM PURGE;
DROP TABLE MPCNDCDB_MARKER_GEOM PURGE;


--Create Table for boundary point

CREATE TABLE MPCNDCDB_MARKER_GEOM(

    STN_ID DEC(13,0) NOT NULL CONSTRAINT MPCNDCDB_MARKER_GEOM_pkey
    PRIMARY KEY,
   SERIAL VARCHAR2(8),
   MARK_DESC VARCHAR2 (13),
   NORTH_CAS VARCHAR2(13),
   EAST_CAS VARCHAR2 (12),
   STD_ERR_NORTH_CAS DEC(18,6),
   STD_ERR_EAST_CAS DEC(18,6),
   NORTH_RSO VARCHAR2(12),
   EAST_RSO VARCHAR2(12),
   UPDATE_DATE DATE,
   GEOM SDO_GEOMETRY
      );

DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME =
'MPCNDCDB_MARKER_GEOM' AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME, DIMINFO,
SRID)

VALUES ('MPCNDCDB_MARKER_GEOM', 'GEOM',
SDO_DIM_ARRAY
(SDO_DIM_ELEMENT('X', -1000000, 1000000, 0.05),
SDO_DIM_ELEMENT('Y', -1000000, 1000000, 0.05)
), 18000000
);


insert into MPCNDCDB_MARKER_GEOM values (101,
'180377','stone','408157.394','325418.770',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408157.394,325418.770,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (102,
'180377','stone','408164.239','325415.365',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408164.239,325415.365,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (103,
'180377','stone','408294.716','325378.741',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408294.716,325378.741,NULL),
NULL, NULL));
```

```
insert into MPCNDCDB_MARKER_GEOM  values (104,
'180377','stone','408320.846','325376.204',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408320.846,325376.204,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (105,
'180377','stone','408322.132','325374.675',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408322.132,325374.675,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (106,
'180377','stone','408319.352','325341.734',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408319.352,325341.734,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (107,
'180377','stone','408325.016','325309.732',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408325.016,325309.732,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (108,
'180377','stone','408336.896','325280.169',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408336.896,325280.169,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (109,
'180377','stone','408350.965','325252.355',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408350.965,325252.355,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (110,
'180377','stone','408365.253','325234.628',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408365.253,325234.628,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (111,
'180377','stone','408365.385','325227.153',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408365.385,325227.153,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (112,
'180377','stone','408297.411','325138.980',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408297.411,325138.980,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (113,
'180377','stone','408288.095','325127.064',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408288.095,325127.064,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (114,
'180377','stone','408280.837','325117.640',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408280.837,325117.640,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (115,
'180377','stone','408280.621','325117.206',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408280.621,325117.206,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (116,
'180377','stone','408273.471','325143.638',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408273.471,325143.638,NULL),
NULL, NULL));
```

```
insert into MPCNDCDB_MARKER_GEOM  values (117,
'180377','stone','408249.423','325214.049',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408249.423,325214.049,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (118,
'180377','stone','408216.168','325291.392',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408216.168,325291.392,NULL),
NULL, NULL));
insert into MPCNDCDB_MARKER_GEOM  values (119,
'180377','stone','408156.525','325417.345',0.004, 0.003,'10002','10003',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY(2001, 18000000, SDO_POINT_TYPE (408156.525,325417.345,NULL),
NULL, NULL));

CREATE INDEX MPCNDCDB_MARKER_GI ON MPCNDCDB_MARKER_GEOM  (GEOM) INDEXTYPE
IS MDSYS.SPATIAL_INDEX;

--Create table for parcel

CREATE TABLE MPCNDCDB_PARCEL_GEOM  (
      UPII VARCHAR2 (16) NOT NULL CONSTRAINT MPCNDCDB_PARCEL_GEOM_pkey
      PRIMARY KEY,
   STATE VARCHAR2 (2),
   DISTRICT VARCHAR2 (2),
   SUBDISTRICT VARCHAR2(2),
   SECTION VARCHAR2 (3),
   PARCEL VARCHAR2 (7),
   NOLANDOFFICE VARCHAR2 (70),
   NOFSURVEY VARCHAR2 (30),
   S_AREA DEC (18,3),
   LANDUSECODE VARCHAR2(2),
   CP VARCHAR2(15),
   APDATE VARCHAR2(8),
       UPDATE_DATE DATE,
   GEOM SDO_GEOMETRY
   );

DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME =
'MPCNDCDB_PARCEL_GEOM' AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME, DIMINFO,
SRID)
VALUES ('MPCNDCDB_PARCEL_GEOM', 'GEOM',
SDO_DIM_ARRAY
(SDO_DIM_ELEMENT('X', -1000000, 1000000, 0.05),
SDO_DIM_ELEMENT('Y', -1000000, 1000000, 0.05)
), 18000000
);

INSERT INTO MPCNDCDB_PARCEL_GEOM  VALUES (
'16014009383', '1','2','3','4','5','6','7', 100.44, '9','10','11',
to_date('2003/05/03 21:02:44', 'yyyy/mm/dd hh24:mi:ss'),

SDO_GEOMETRY(2003, 18000000, Null, SDO_ELEM_INFO_ARRAY(1,1003,1),

SDO_ORDINATE_ARRAY   (408157.394, 325418.770,
408156.525, 325417.345,408216.168, 325291.392,408249.423,
325214.049,408273.471, 325143.638,
408280.621, 325117.206,408280.837, 325117.640,408288.095,
325127.064,408297.411, 325138.980,
408365.385, 325227.153,408365.253, 325234.628,408350.965,
325252.355,408336.896, 325280.169,
```

```
408325.016, 325309.732,408319.352 ,325341.734,408322.132,
325374.675,408320.846, 325376.204,
408294.716, 325378.741,408164.239, 325415.365,
                     408157.394, 325418.770)));

CREATE INDEX MPC_parcels_GI ON MPCNDCDB_PARCEL_GEOM(GEOM) INDEXTYPE IS
MDSYS.SPATIAL_INDEX;



-- CREATE UTILITY TABLE of SDO_GEOMETRY

CREATE TABLE MPC_UTILITY_GEOM (
UUI VARCHAR2 (16) NOT NULL CONSTRAINT MPC_UTILITY_GEOM_pkey PRIMARY KEY,
UTILITY_NAME CHAR (10),
-- CODE1, 1 = Main hole 2= Pipe, 3 = Valve/clip
UTILITY_CODE1 VARCHAR2 (5),
-- Code2  Pipe Material 1 = Carbon Fiber 2 = Metal 3= Plastic 4= Null
UTILITY_CODE2 VARCHAR2 (5),
-- Code 3 Diameter 1 = 5cm, 2 = 10cm, 3 = 50cm, 4 = null
UTILITY_CODE3 VARCHAR2 (5),
-- refer to building related
BUILDING_NAME CHAR (24),
-- related parcel
UParcelUI VARCHAR2 (16),
-- coordinate
GEOM SDO_GEOMETRY,
CONSTRAINT MPC_UTILITY_fkey FOREIGN KEY (UParcelUI) REFERENCES
MPCNDCDB_PARCEL_GEOM (UPII));

DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME = 'MPC_UTILITY_GEOM'
AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME, DIMINFO,
SRID)

VALUES ('MPC_UTILITY_GEOM', 'GEOM',
MDSYS.SDO_DIM_ARRAY
(MDSYS.SDO_DIM_ELEMENT('X', -1000000, 1000000, 0.05),
MDSYS.SDO_DIM_ELEMENT('Y', -1000000, 1000000, 0.05)
), 18000000
);

-- INSERT Utility data: GAS Pipeline
INSERT INTO MPC_UTILITY_GEOM VALUES('16014009383','PETRONAS',
'2','1','1','FLAT HIJAU','16014009383',
SDO_GEOMETRY (2002,18000000, Null, SDO_ELEM_INFO_ARRAY(1,2,1, 17,2,1),

SDO_ORDINATE_ARRAY(408297.262, 325402.895,408279.059,
325332.834,408236.736, 325319.922,
408238.842,325274.202,408309.116,325201.600,408344.676,325214.300,408364.
361,325232.292,
408378.311,325220.862,
408309.116,325201.600,
408298.956,325152.917,408329.608,325119.486)));

CREATE INDEX MPC_UTILITY_GI ON MPC_UTILITY_GEOM (GEOM) INDEXTYPE IS
MDSYS.SPATIAL_INDEX;

-- Create spatial table for building data

CREATE TABLE MPC_BUILD_GEOM (

--1 Unique Indetify number
   UBUI VARCHAR2 (16) NOT NULL CONSTRAINT MPC_BUILD_GEOM_pkey PRIMARY KEY,
```

```
-- according to Malaysia Standard 1759-2400 Feature and Attribute Code
--2 Feature code
   Fcode char (10),
--3 Area measuarement (sq m)
   ARM Number (10),
--4 Building name
   BA1 char(24),
--5 Bulding number
   BA2 char(24),
--6 Street name
   BA3 char(24),
--7 Post code
       BA4 char(24),
--8 State name
   BA5 char(24),
--9 Lift facility
   LIF char(10),
--10 Name
   NAM char (80),
--11 Number of storey
   NOS Number (10),
--12 Residential building type
   RET char(10),
--13 Residential usage
   REV char(10),
-- Foreign Key,
   UBLI VARCHAR2 (16),
   GEOM SDO_GEOMETRY,
   CONSTRAINT MPCBUILD_fkey FOREIGN KEY (UBLI) REFERENCES
MPCNDCDB_PARCEL_GEOM (UPII) );

DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME = 'MPC_BUILD_GEOM'
AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME, DIMINFO,
SRID)

VALUES ('MPC_BUILD_GEOM', 'GEOM',
MDSYS.SDO_DIM_ARRAY
(MDSYS.SDO_DIM_ELEMENT('X', -1000000, 1000000, 0.05),
MDSYS.SDO_DIM_ELEMENT('Y', -1000000, 1000000, 0.05)
), 18000000
);

INSERT INTO MPC_BUILD_GEOM  VALUES (
'10001', '1','2','3','4','5','6','7', 100, '9','10','11',
'1','16014009383',

SDO_GEOMETRY(2003, 18000000, Null, SDO_ELEM_INFO_ARRAY(1,1003,1),

SDO_ORDINATE_ARRAY ( 408245.752,325290.750,
408258.387,325293.424,408258.018,325294.900,
408265.212,325296.560,408263.183,325306.521,
408276.925,325309.472,408279.566,325297.546,
408292.788,325300.249,
408287.623,325324.228,408240.956,325314.544,
                     408245.752,325290.750)));

CREATE INDEX MPC_BUILD_GI ON MPC_BUILD_GEOM(GEOM) INDEXTYPE IS
MDSYS.SPATIAL_INDEX;

-- Create spatial table for boundary lines

CREATE TABLE MPCNDCDB_BDY_GEOM (
```

```
   UBI VARCHAR2(16) NOT NULL CONSTRAINT MPCNDCDB_BDY_GEOM_pkey PRIMARY
KEY,
       ADJPARCEL1 VARCHAR2 (16),
   ADJPARCEL2 VARCHAR2 (16),
       BEARING VARCHAR2(9),
   DISTANCE DEC (12),
   FNODE DEC (13,0),
   TNODE DEC (13,0),
   UPDATE_DATE DATE,
   GEOM SDO_GEOMETRY,
   CONSTRAINT MPCNDCDB_BDY1_fkey FOREIGN KEY (FNODE) REFERENCES
MPCNDCDB_MARKER_GEOM (STN_ID),
   CONSTRAINT MPCNDCDB_BDY2_fkey FOREIGN KEY (TNODE) REFERENCES
MPCNDCDB_MARKER_GEOM (STN_ID),
   CONSTRAINT MPCNDCDB_BDY4_fkey FOREIGN KEY (ADJPARCEL1) REFERENCES
MPCNDCDB_PARCEL_GEOM (UPII),
   CONSTRAINT MPCNDCDB_BDY5_fkey FOREIGN KEY (ADJPARCEL2) REFERENCES
MPCNDCDB_PARCEL_GEOM (UPII));



DELETE FROM USER_SDO_GEOM_METADATA WHERE TABLE_NAME = 'MPCNDCDB_BDY_GEOM'
AND COLUMN_NAME = 'GEOM' ;

INSERT INTO USER_SDO_GEOM_METADATA (TABLE_NAME, COLUMN_NAME, DIMINFO,
SRID)

VALUES ('MPCNDCDB_BDY_GEOM', 'GEOM',
MDSYS.SDO_DIM_ARRAY
(MDSYS.SDO_DIM_ELEMENT('X', -1000000, 1000000, 0.05),
MDSYS.SDO_DIM_ELEMENT('Y', -1000000, 1000000, 0.05)
), 18000000
);

INSERT INTO MPCNDCDB_BDY_GEOM VALUES('100001',
'16014009383','16014009383','180',30,101,102, to_date('2003/05/03
21:02:44', 'yyyy/mm/dd hh24:mi:ss'),
SDO_GEOMETRY (2002,18000000, Null, SDO_ELEM_INFO_ARRAY(1,2,1),

SDO_ORDINATE_ARRAY(408157.394, 325418.770,
408156.525, 325417.345,408216.168, 325291.392,408249.423,
325214.049,408273.471, 325143.638,
408280.621, 325117.206,408280.837, 325117.640,408288.095,
325127.064,408297.411, 325138.980,
408365.385, 325227.153,408365.253, 325234.628,408350.965,
325252.355,408336.896, 325280.169,
408325.016, 325309.732,408319.352 ,325341.734,408322.132,
325374.675,408320.846, 325376.204,
408294.716, 325378.741,408164.239, 325415.365)));

CREATE INDEX MPCNDCDB_BDY_GI ON MPCNDCDB_BDY_GEOM(GEOM) INDEXTYPE IS
MDSYS.SPATIAL_INDEX;

COMMIT;

-- Start the main steps for using the topology data model with a
-- topology built from Spatial geometry data.

--DELETE LAYER IF EXIST
EXECUTE SDO_TOPO.DELETE_TOPO_GEOMETRY_LAYER
('MPC_PRO','MPCNDCDB_MARKER','FEATURE');
EXECUTE SDO_TOPO.DELETE_TOPO_GEOMETRY_LAYER
('MPC_PRO','MPCNDCDB_PARCEL','FEATURE');
```

```
EXECUTE SDO_TOPO.DELETE_TOPO_GEOMETRY_LAYER
('MPC_PRO','MPCNDCDB_BDY','FEATURE');
EXECUTE SDO_TOPO.DELETE_TOPO_GEOMETRY_LAYER
('MPC_PRO','MPC_UTILITY','FEATURE');
EXECUTE SDO_TOPO.DELETE_TOPO_GEOMETRY_LAYER
('MPC_PRO','MPC_BUILD','FEATURE');

-- 1. Create the topology. (Null SRID in this example.)
EXECUTE SDO_TOPO.DROP_TOPOLOGY ('MPC_PRO');
EXECUTE SDO_TOPO.CREATE_TOPOLOGY('MPC_PRO', 0.005,18000000);

-- 2. Insert the universe face (F0). (id = -1, not 0)
INSERT INTO MPC_PRO_FACE$ values (
  -1, NULL, SDO_LIST_TYPE(), SDO_LIST_TYPE(), NULL);

COMMIT;

--Drop any Feature tables that exist in database AND
--CREATE FEATURE TABLE for bounday markers, parcel, utility

DROP TABLE MPC_UTILITY PURGE;
DROP TABLE MPC_BUILD PURGE;
DROP TABLE MPCNDCDB_BDY PURGE;
DROP TABLE MPCNDCDB_PARCEL PURGE;
DROP TABLE MPCNDCDB_MARKER PURGE;

CREATE TABLE MPCNDCDB_MARKER (

   STN_ID_FEATURE DEC(13,0) NOT NULL CONSTRAINT MPCNDCDB_MARKER_pkey
PRIMARY KEY,
   SERIAL_FEATURE VARCHAR2(8),
   MARK_DESC_FEATURE VARCHAR2 (13),
   NORTH_CAS_FEATURE VARCHAR2(13),
   EAST_CAS_FEATURE VARCHAR2 (12),
   STD_ERR_NORTH_CAS_FEATURE DEC(18,6),
   STD_ERR_EAST_CAS_FEATURE DEC(18,6),
   NORTH_RSO_FEATURE VARCHAR2(12),
   EAST_RSO_FEATURE VARCHAR2(12),
   UPDATE_DATE_FEATURE DATE,
feature     SDO_TOPO_GEOMETRY);



CREATE TABLE MPCNDCDB_PARCEL  (

   UPII_FEATURE VARCHAR2 (16) NOT NULL CONSTRAINT MPCNDCDB_PARCEL_pkey
PRIMARY KEY,
   STATE_FEATURE VARCHAR2 (2),
   DISTRICT_FEATURE VARCHAR2 (2),
   SUBDISTRICT_FEATURE VARCHAR2(2),
   SECTION_FEATURE VARCHAR2 (3),
   PARCEL_FEATURE VARCHAR2 (7),
   NOLANDOFFICE_FEATURE VARCHAR2 (70),
   NOFSURVEY_FEATURE VARCHAR2 (30),
   S_AREA_FEATURE DEC (18,3),
   LANDUSECODE_FEATURE VARCHAR2(2),
   CP_FEATURE VARCHAR2(15),
   APDATE_FEATURE VARCHAR2(8),
       UPDATE_DATE_FEATURE DATE,
feature     SDO_TOPO_GEOMETRY);



CREATE TABLE MPC_UTILITY (
```

```
UUI_FEATURE VARCHAR2 (16) NOT NULL CONSTRAINT MPC_UTILITY_pkey PRIMARY
KEY,
UTILITT_NAME_FEATURE CHAR (10),
-- CODE1, 1 = Main hole 2= Pipe, 3 = Valve/clip
UTILITI_CODE1_FEATURE VARCHAR2 (5),
-- Code2  Pipe Material 1 = Carbon Fiber 2 = Metal 3= Plastic 4= Null
UTILITI_CODE2_FEATURE VARCHAR2 (5),
-- Code 3 Diameter 1 = 5cm, 2 = 10cm, 3 = 50cm, 4 = null
UTILITI_CODE3_FEATURE VARCHAR2 (5),
-- refer to building related
BUILDING_NAME_FEATURE CHAR (24),
-- related parcel
UParcelUI_FEATURE VARCHAR2 (16),
-- coordinate
feature  SDO_TOPO_GEOMETRY,
CONSTRAINT MPC_UTILITYF_fkey FOREIGN KEY (UParcelUI_FEATURE) REFERENCES
MPCNDCDB_PARCEL (UPII_FEATURE));


CREATE TABLE MPC_BUILD (

--1 Unique Indetify number
   UBUI_FEATURE VARCHAR2 (16) NOT NULL CONSTRAINT MPC_BUILD_pkey PRIMARY
KEY,
-- according to Malaysia Standard 1759-2400 Feature and Attribute Code
--2 Feature code
   Fcode_FEATURE char (10),
--3 Area measuarement (sq m)
   ARM_FEATURE Number (8),
--4 Building name
   BA1_FEATURE char(24),
--5 Bulding number
   BA2_FEATURE char(24),
--6 Street name
   BA3_FEATURE char(24),
--7 Post code
       BA4_FEATURE char(24),
--8 State name
   BA5_FEATURE char(24),
--9 Lift facility
   LIF_FEATURE char(10),
--10 Name
   NAM_FEATURE char (80),
--11 Number of storey
   NOS_FEATURE Number (30),
--12 Residential building type
   RET_FEATURE char(10),
--13 Residential usage
   REV_FEATURE char(10),
-- Foreign Key,
   UBLI_FEATURE VARCHAR2 (16),
   feature SDO_TOPO_GEOMETRY,
CONSTRAINT MPCBUILDF_fkey FOREIGN KEY (UBLI_FEATURE) REFERENCES
MPCNDCDB_PARCEL (UPII_FEATURE));


CREATE TABLE MPCNDCDB_BDY (

   UBI_FEATURE VARCHAR2(16) NOT NULL CONSTRAINT MPCNDCDB_BDY_pkey PRIMARY
KEY,
       ADJPARCEL1_FEATURE VARCHAR2 (16),
   ADJPARCEL2_FEATURE VARCHAR2 (16),
       BEARING_FEATURE VARCHAR2(9),
   DISTANCE_FEATURE DEC (12,4),
   FNODE_FEATURE DEC (13,0),
```

```
   TNODE_FEATURE DEC (13,0),
   UPDATE_DATE_FEATURE DATE,
   feature SDO_TOPO_GEOMETRY,
   CONSTRAINT MPCNDCDB_BDY1F_fkey FOREIGN KEY (FNODE_FEATURE) REFERENCES
MPCNDCDB_MARKER (STN_ID_FEATURE),
   CONSTRAINT MPCNDCDB_BDY2F_fkey FOREIGN KEY (TNODE_FEATURE) REFERENCES
MPCNDCDB_MARKER (STN_ID_FEATURE),
   CONSTRAINT MPCNDCDB_BDY4F_fkey FOREIGN KEY (ADJPARCEL1_FEATURE)
REFERENCES MPCNDCDB_PARCEL (UPII_FEATURE),
   CONSTRAINT MPCNDCDB_BDY5F_fkey FOREIGN KEY (ADJPARCEL2_FEATURE)
REFERENCES MPCNDCDB_PARCEL (UPII_FEATURE));

COMMIT;
--    Associate feature tables with the topology.
--    Add the three topology geometry layers to the CITY_DATA topology.
--    Any order is OK.

EXECUTE SDO_TOPO.ADD_TOPO_GEOMETRY_LAYER('MPC_PRO',
'MPCNDCDB_MARKER','FEATURE','POINT');
EXECUTE SDO_TOPO.ADD_TOPO_GEOMETRY_LAYER('MPC_PRO',
'MPCNDCDB_BDY','FEATURE','LINE');
EXECUTE SDO_TOPO.ADD_TOPO_GEOMETRY_LAYER('MPC_PRO',
'MPCNDCDB_PARCEL','FEATURE','POLYGON');
EXECUTE SDO_TOPO.ADD_TOPO_GEOMETRY_LAYER('MPC_PRO',
'MPC_UTILITY','FEATURE','LINE');
EXECUTE SDO_TOPO.ADD_TOPO_GEOMETRY_LAYER('MPC_PRO',
'MPC_BUILD','FEATURE','POLYGON');

--  As a result, Spatial generates a unique TG_LAYER_ID for each layer in
--  the topology metadata (USER/ALL_SDO_TOPO_METADATA).

-- 5. Create a TopoMap object and load the whole topology into cache for
updating.
EXECUTE SDO_TOPO_MAP.DROP_TOPO_MAP('MPC_PRO_TOPOMAP');
EXECUTE SDO_TOPO_MAP.CREATE_TOPO_MAP('MPC_PRO', 'MPC_PRO_TOPOMAP');
EXECUTE SDO_TOPO_MAP.LOAD_TOPO_MAP('MPC_PRO_TOPOMAP', 'true');


-- 6. Load feature tables, inserting data from the spatial tables and
--     using SDO_TOPO_MAP.CREATE_FEATURE.

BEGIN

  FOR MARKER_rec IN (SELECT
STN_ID,SERIAL,MARK_DESC,NORTH_CAS,EAST_CAS,STD_ERR_NORTH_CAS,
   STD_ERR_EAST_CAS,NORTH_RSO,EAST_RSO,UPDATE_DATE,
   GEOM FROM MPCNDCDB_MARKER_GEOM) LOOP

   INSERT INTO MPCNDCDB_MARKER
VALUES(MARKER_rec.STN_ID,MARKER_rec.SERIAL,MARKER_rec.MARK_DESC,
   MARKER_rec.NORTH_CAS,MARKER_rec.EAST_CAS,MARKER_rec.STD_ERR_NORTH_CAS,

MARKER_rec.STD_ERR_EAST_CAS,MARKER_rec.NORTH_RSO,MARKER_rec.EAST_RSO,MARK
ER_rec.UPDATE_DATE,

     SDO_TOPO_MAP.CREATE_FEATURE('MPC_PRO', 'MPCNDCDB_MARKER', 'FEATURE',
MARKER_rec.GEOM));

  END LOOP;
 END;
 /


 BEGIN
```

```
 FOR PARCEL_rec IN (SELECT
UPII,STATE,DISTRICT,SUBDISTRICT,SECTION,PARCEL,NOLANDOFFICE,NOFSURVEY,S_A
REA,LANDUSECODE,CP,
   APDATE,UPDATE_DATE,GEOM FROM MPCNDCDB_PARCEL_GEOM) LOOP

   INSERT INTO MPCNDCDB_PARCEL VALUES(PARCEL_rec.UPII, PARCEL_rec.STATE,
PARCEL_rec.DISTRICT,PARCEL_rec.SUBDISTRICT,

PARCEL_rec.SECTION,PARCEL_rec.PARCEL,PARCEL_rec.NOLANDOFFICE,PARCEL_rec.N
OFSURVEY,PARCEL_rec.S_AREA,
   PARCEL_rec.LANDUSECODE,PARCEL_rec.CP,PARCEL_rec.APDATE,
PARCEL_rec.UPDATE_DATE,

     SDO_TOPO_MAP.CREATE_FEATURE('MPC_PRO', 'MPCNDCDB_PARCEL',
'FEATURE',PARCEL_rec.GEOM));

  END LOOP;
   END;
   /

 BEGIN
 FOR BUILD_rec IN (SELECT UBUI, Fcode, ARM, BA1, BA2, BA3, BA4, BA5, LIF,
NAM, NOS, RET, REV, UBLI,
 GEOM FROM MPC_BUILD_GEOM) LOOP

   INSERT INTO MPC_BUILD VALUES(BUILD_rec.UBUI, BUILD_rec.Fcode,
BUILD_rec.ARM, BUILD_rec.BA1, BUILD_rec.BA2,
   BUILD_rec.BA3, BUILD_rec.BA4, BUILD_rec.BA5, BUILD_rec.LIF,
BUILD_rec.NAM,
   BUILD_rec.NOS, BUILD_rec.RET, BUILD_rec.REV, BUILD_rec.UBLI,

     SDO_TOPO_MAP.CREATE_FEATURE('MPC_PRO', 'MPC_BUILD', 'FEATURE',
BUILD_rec.GEOM ));

  END LOOP;
   END;
   /

BEGIN

  FOR BDY_rec IN (SELECT UBI, ADJPARCEL1, ADJPARCEL2, BEARING,
   DISTANCE, FNODE, TNODE, UPDATE_DATE,
   GEOM FROM MPCNDCDB_BDY_GEOM) LOOP

   INSERT INTO MPCNDCDB_BDY VALUES(BDY_rec.UBI, BDY_rec.ADJPARCEL1,
   BDY_rec.ADJPARCEL2, BDY_rec.BEARING, BDY_rec.DISTANCE, BDY_rec.FNODE,
   BDY_rec.TNODE, BDY_rec.UPDATE_DATE,

     SDO_TOPO_MAP.CREATE_FEATURE('MPC_PRO', 'MPCNDCDB_BDY', 'FEATURE',
BDY_rec.GEOM));

  END LOOP;
 END;
 /

CALL SDO_TOPO_MAP.COMMIT_TOPO_MAP();
--CALL SDO_TOPO_MAP.DROP_TOPO_MAP('MPC_PRO_TOPOMAP');

-- 7. Initialize topology metadata.
EXECUTE SDO_TOPO.INITIALIZE_METADATA('MPC_PRO');
```

Appendix C

Report of database generated from data modeller

All Entities Details

Design Name	Untitled_1
Version Date	06.03.2012 04:52:43
Version Comment	
Model Name	Logical

Entity Name	MPCNDCDB_BDY
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPCNDCDB_BDY	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	9
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UBI_FEATURE				VARCHAR (16 BYTE)	LT				
2	ADJPARCEL1_FEATURE		F		VARCHAR (16 BYTE)	LT				
3	ADJPARCEL2_FEATURE		F		VARCHAR (16 BYTE)	LT				
4	BEARING_FEATURE				VARCHAR (9 BYTE)	LT				
5	DISTANCE_FEATURE				NUMERIC (22)	LT				
6	FNODE_FEATURE		F		NUMERIC (22)	LT				
7	TNODE_FEATURE		F		NUMERIC (22)	LT				
8	UPDATE_DATE_FEATURE				Date (7)	LT				
9	FEATURE					LT				

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_MARKER				0..*:0..1			Y
MPCNDCDB_MARKER				0..*:0..1			Y
MPCNDCDB_PARCEL				0..*:0..1			Y
MPCNDCDB_PARCEL				0..*:0..1			Y

Entity Name	MPCNDCDB_BDY_GEOM
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPCNDCDB_BDY_GEOM	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	9
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UBI				VARCHAR (16 BYTE)	LT				
2	ADJPARCEL1		F		VARCHAR (16 BYTE)	LT				
3	ADJPARCEL2		F		VARCHAR (16 BYTE)	LT				
4	BEARING				VARCHAR (9 BYTE)	LT				
5	DISTANCE				NUMERIC (22)	LT				
6	FNODE		F		NUMERIC (22)	LT				
7	TNODE		F		NUMERIC (22)	LT				
8	UPDATE_DATE				Date (7)	LT				
9	GEOM					ST				

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_MARKER_GEOM				0..*:0..1			Y
MPCNDCDB_MARKER_GEOM				0..*:0..1			Y
MPCNDCDB_PARCEL_GEOM				0..*:0..1			Y
MPCNDCDB_PARCEL_GEOM				0..*:0..1			Y

Entity Name	MPCNDCDB_MARKER
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPCNDCDB_MARKER	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	11
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0

Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	STN_ID_FEATURE	P		Y	NUMERIC (22)	LT				
2	SERIAL_FEATURE				VARCHAR (8 BYTE)	LT				
3	MARK_DESC_FEATURE				VARCHAR (13 BYTE)	LT				
4	NORTH_CAS_FEATURE				VARCHAR (13 BYTE)	LT				
5	EAST_CAS_FEATURE				VARCHAR (12 BYTE)	LT				
6	STD_ERR_NORTH_CAS_FEATURE				NUMERIC (22)	LT				
7	STD_ERR_EAST_CAS_FEATURE				NUMERIC (22)	LT				
8	NORTH_RSO_FEATURE				VARCHAR (12 BYTE)	LT				
9	EAST_RSO_FEATURE				VARCHAR (12 BYTE)	LT				
10	UPDATE_DATE_FEATURE				Date (7)	LT				
11	FEATURE					LT				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPCNDCDB_STN2_PKEY	Y	STN_ID_FEATURE	A		

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_BDY				0..*:0..1			Y
MPCNDCDB_BDY				0..*:0..1			Y

Entity Name	MPCNDCDB_MARKER_GEOM
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPCNDCDB_MARKER_GEOM	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	11
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	STN_ID	P		Y	NUMERIC (22)	LT				
2	SERIAL				VARCHAR (8 BYTE)	LT				
3	MARK_DESC				VARCHAR (13 BYTE)	LT				
4	NORTH_CAS				VARCHAR (13 BYTE)	LT				
5	EAST_CAS				VARCHAR (12 BYTE)	LT				
6	STD_ERR_NORTH_CAS				NUMERIC (22)	LT				
7	STD_ERR_EAST_CAS				NUMERIC (22)	LT				
8	NORTH_RSO				VARCHAR (12 BYTE)	LT				
9	EAST_RSO				VARCHAR (12 BYTE)	LT				
10	UPDATE_DATE				Date (7)	LT				
11	GEOM					ST				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPCNDCDB_STN_PKEY	Y	STN_ID	A		

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_BDY_GEOM				0..*:0..1			Y
MPCNDCDB_BDY_GEOM				0..*:0..1			Y

Entity Name	MPCNDCDB_PARCEL
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPCNDCDB_PARCEL	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	14
Number Of Rows Min.	0

Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UPII_FEATURE	P		Y	VARCHAR (16 BYTE)	LT				
2	STATE_FEATURE				VARCHAR (2 BYTE)	LT				
3	DISTRICT_FEATURE				VARCHAR (2 BYTE)	LT				
4	SUBDISTRICT_FEATURE				VARCHAR (2 BYTE)	LT				
5	SECTION_FEATURE				VARCHAR (3 BYTE)	LT				
6	PARCEL_FEATURE				VARCHAR (7 BYTE)	LT				
7	NOLANDOFFICE_FEATURE				VARCHAR (70 BYTE)	LT				
8	NOFSURVEY_FEATURE				VARCHAR (30 BYTE)	LT				
9	S_AREA_FEATURE				NUMERIC (22)	LT				
10	LANDUSECODE_FEATURE				VARCHAR (2 BYTE)	LT				
11	CP_FEATURE				VARCHAR (15 BYTE)	LT				
12	APDATE_FEATURE				VARCHAR (8 BYTE)	LT				
13	UPDATE_DATE_FEATURE				Date (7)	LT				
14	FEATURE					LT				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPCLOT2_PKEY	Y	UPII_FEATURE	A		

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPC_BUILD				0..*:0..1			Y

MPCNDCDB_BDY				0..*:0..1			Y
MPCNDCDB_BDY				0..*:0..1			Y
MPC_UTILITY				0..*:0..1			Y

Entity Name	MPCNDCDB_PARCEL_GEOM
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPCNDCDB_PARCEL_GEOM	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	14
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UPII	P		Y	VARCHAR (16 BYTE)	LT				
2	STATE				VARCHAR (2 BYTE)	LT				
3	DISTRICT				VARCHAR (2 BYTE)	LT				
4	SUBDISTRICT				VARCHAR (2 BYTE)	LT				
5	SECTION				VARCHAR (3 BYTE)	LT				
6	PARCEL				VARCHAR (7 BYTE)	LT				
7	NOLANDOFFICE				VARCHAR (70 BYTE)	LT				
8	NOFSURVEY				VARCHAR (30 BYTE)	LT				
9	S_AREA				NUMERIC (22)	LT				
10	LANDUSECODE				VARCHAR (2 BYTE)	LT				
11	CP				VARCHAR (15 BYTE)	LT				
12	APDATE				VARCHAR (8 BYTE)	LT				
13	UPDATE_DATE				Date (7)	LT				
14	GEOM					ST				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPCLOT_PKEY	Y	UPII	A		

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPC_BUILD_GEOM				0..*:0..1			Y
MPCNDCDB_BDY_GEOM				0..*:0..1			Y
MPCNDCDB_BDY_GEOM				0..*:0..1			Y
MPC_UTILITY_GEOM				0..*:0..1			Y

Entity Name	MPC_BUILD
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_BUILD	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	15
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UBUI_FEATURE				VARCHAR (16 BYTE)	LT				
2	FCODE_FEATURE				CHAR (10 BYTE)	LT				
3	ARM_FEATURE				NUMERIC (22)	LT				
4	BA1_FEATURE				CHAR (24 BYTE)	LT				
5	BA2_FEATURE				CHAR (24 BYTE)	LT				
6	BA3_FEATURE				CHAR (24 BYTE)	LT				
7	BA4_FEATURE				CHAR (24 BYTE)	LT				
8	BA5_FEATURE				CHAR (24 BYTE)	LT				

9	LIF_FEATURE				CHAR (10 BYTE)	LT				
10	NAM_FEATURE				CHAR (80 BYTE)	LT				
11	NOS_FEATURE				NUMERIC (22)	LT				
12	RET_FEATURE				CHAR (10 BYTE)	LT				
13	REV_FEATURE				CHAR (10 BYTE)	LT				
14	UBLI_FEATURE		F		VARCHAR (16 BYTE)	LT				
15	FEATURE					LT				

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_PARCEL				0..*:0..1			Y

Entity Name	MPC_BUILD_GEOM
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_BUILD_GEOM	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	15

Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UBUI				VARCHAR (16 BYTE)	LT				
2	FCODE				CHAR (10 BYTE)	LT				
3	ARM				NUMERIC (22)	LT				
4	BA1				CHAR (24 BYTE)	LT				
5	BA2				CHAR (24 BYTE)	LT				
6	BA3				CHAR (24 BYTE)	LT				
7	BA4				CHAR (24 BYTE)	LT				
8	BA5				CHAR (24 BYTE)	LT				
9	LIF				CHAR (10 BYTE)	LT				
10	NAM				CHAR (80 BYTE)	LT				
11	NOS				NUMERIC (22)	LT				
12	RET				CHAR (10 BYTE)	LT				
13	REV				CHAR (10 BYTE)	LT				
14	UBLI		F		VARCHAR (16 BYTE)	LT				
15	GEOM					ST				

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_PARCEL_GEOM				0..*:0..1			Y

Entity Name	MPC_PRO_EDGE$
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_PRO_EDGE$	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	10
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	EDGE_ID	P		Y	NUMERIC (22)	LT				
2	START_NODE_ID				NUMERIC (22)	LT				
3	END_NODE_ID				NUMERIC (22)	LT				
4	NEXT_LEFT_EDGE_ID				NUMERIC (22)	LT				
5	PREV_LEFT_EDGE_ID				NUMERIC (22)	LT				
6	NEXT_RIGHT_EDGE_ID				NUMERIC (22)	LT				
7	PREV_RIGHT_EDGE_ID				NUMERIC (22)	LT				
8	LEFT_FACE_ID				NUMERIC (22)	LT				
9	RIGHT_FACE_ID				NUMERIC (22)	LT				
10	GEOMETRY					ST				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPC_PRO_PKEID$	Y	EDGE_ID	A		

Entity Name	MPC_PRO_FACE$
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_PRO_FACE$	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	5
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	FACE_ID	P		Y	NUMERIC (22)	LT				
2	BOUNDARY_EDGE_ID				NUMERIC (22)	LT				
3	ISLAND_EDGE_ID_LIST					LT				
4	ISLAND_NODE_ID_LIST					LT				
5	MBR_GEOMETRY					ST				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
SYS_C0013220	Y	FACE_ID	A		

Entity Name	MPC_PRO_HISTORY$
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_PRO_HISTORY$	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	7
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0

Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	TOPO_TX_ID	P		Y	NUMERIC (22)	LT				
2	TOPO_SEQUENCE	P		Y	NUMERIC (22)	LT				
3	TOPOLOGY				VARCHAR (20 BYTE)	LT				
4	TOPO_ID				NUMERIC (22)	LT				
5	TOPO_TYPE				NUMERIC (22)	LT				
6	TOPO_OP				VARCHAR (3 BYTE)	LT				
7	PARENT_ID				NUMERIC (22)	LT				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPC_PROHIS_PK	Y	TOPO_TX_ID	A		
		TOPO_SEQUENCE	A		

Entity Name	MPC_PRO_NODE$
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_PRO_NODE$	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	4
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	NODE_ID	P		Y	NUMERIC (22)	LT				
2	EDGE_ID				NUMERIC (22)	LT				
3	FACE_ID				NUMERIC (22)	LT				
4	GEOMETRY					ST				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
SYS_C0013218	Y	NODE_ID	A		

Entity Name	MPC_PRO_RELATION$
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_PRO_RELATION$	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	5
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	TG_LAYER_ID	P		Y	NUMERIC (22)	LT				
2	TG_ID	P		Y	NUMERIC (22)	LT				
3	TOPO_ID	P		Y	NUMERIC (22)	LT				
4	TOPO_TYPE	P		Y	NUMERIC (22)	LT				
5	TOPO_ATTRIBUTE				VARCHAR (100 BYTE)	LT				

Identifiers

Name	Primary Identifier	Element Name	Element Type	Source Label	Target Label
MPC_PROREL_PK	Y	TG_LAYER_ID	A		
		TG_ID	A		
		TOPO_ID	A		
		TOPO_TYPE	A		

Entity Name	MPC_UTILITY
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_UTILITY	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	8
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UUI_FEATURE				VARCHAR (16 BYTE)	LT				
2	UTILITT_NAME_FEATURE				CHAR (10 BYTE)	LT				
3	UTILITI_CODE1_FEATURE				VARCHAR (5 BYTE)	LT				
4	UTILITI_CODE2_FEATURE				VARCHAR (5 BYTE)	LT				
5	UTILITI_CODE3_FEATURE				VARCHAR (5 BYTE)	LT				
6	BUILDING_NAME_FEATURE				CHAR (24 BYTE)	LT				
7	UPARCELUI_FEATURE		F		VARCHAR (16 BYTE)	LT				
8	FEATURE					LT				

Has Relationships With

Entity Name	Role	Other Role	In	Cardinality	Dominant	Identifying	Transferable

			Arc		Role		
MPCNDCDB_PARCEL				0..*:0..1			Y

Entity Name	MPC_UTILITY_GEOM
Preferred Abbreviation	
Classification Type Name	
Object Type Name	
Super Type	
Synonyms	

Mapped Tables

Table Name	
Relational_1.YEN.MPC_UTILITY_GEOM	

Comments

Description	
Notes	

Quantitative Information

Number Of Attributes	8
Number Of Rows Min.	0
Number Of Rows Max.	9999999
Expected number Of Rows	0
Expected Growth	0
Growth Interval	Year

Attributes

No	Attribute Name	PK	FK	M	Data Type	DT Kind	Domain Name	Formula (Default Value)	Preferred Abbreviation	Synonyms
1	UUI				VARCHAR (16 BYTE)	LT				
2	UTILITY_NAME				CHAR (10 BYTE)	LT				
3	UTILITY_CODE1				VARCHAR (5 BYTE)	LT				

4	UTILITY_CODE2				VARCHAR (5 BYTE)	LT				
5	UTILITY_CODE3				VARCHAR (5 BYTE)	LT				
6	BUILDING_NAME				CHAR (24 BYTE)	LT				
7	UPARCELUI		F		VARCHAR (16 BYTE)	LT				
8	GEOM					ST				

Has Relationships With

Entity Name	Role	Other Role	In Arc	Cardinality	Dominant Role	Identifying	Transferable
MPCNDCDB_PARCEL_GEOM				0..*:0..1			Y

Appendix D

The SQL spatial coding for development of coordinate system:

```
-- Create an EPSG equivalent for the following CRS:
-- CS_NAME:    GDM2000_Peninsula_RSO
-- SRID:       18000000
-- AUTH_SRID:  18000000
-- AUTH_NAME:  GDM2000_Peninsula_RSO
-- WKTEXT:
--
-- PROJCS[
--   "GDM2000_Peninsula_RSO",
--   GEOGCS[
--     "ITRF2000",
--     DATUM[
--       "IERS_TERRESTRIAL_REFERENCE_FRAME_2000",
--       SPHEROID["GRS_1980", 6378137.0, 298.257222101]],
--     PRIMEM["Greenwich", 0.0],
--     UNIT["Decimal Degree",0.0174532925199433]],
--   PROJECTION["Hotine_Oblique_Mercator"],
--   PARAMETER["False_Easting", ],
--   PARAMETER["False_Northing", ],
--   PARAMETER["Latitude_of_projection_centre", ],
--   PARAMETER["Longitude_of_projection_centre", ],
--   PARAMETER["Azimuth_of_initial_line", ],
--   PARAMETER["Angle_from_Rectified_to_Skew_Grid", ],
--   PARAMETER["Scale_factor_on_initial_line", ],
--   UNIT["Meter", 1.0]]

-- First, the base geographic CRS ITRF2000 already exists in EPSG.
-- It is 4385:
-- Next, find the EPSG equivalent for
PROJECTION["Hotine_Oblique_Mercator"]:
-- It is EPSG method 9812. Create a projection operation 180000001, based
on it:

delete from cs_srs where srid = 18000000;
delete from MDSYS.SDO_COORD_OP_PARAM_VALS where COORD_OP_ID = 180000001;
delete from MDSYS.SDO_COORD_OPS where COORD_OP_ID = 180000001;

insert into MDSYS.SDO_COORD_OPS (
        COORD_OP_ID,
        COORD_OP_NAME,
        COORD_OP_TYPE,
        SOURCE_SRID,
        TARGET_SRID,
        COORD_TFM_VERSION,
        COORD_OP_VARIANT,
        COORD_OP_METHOD_ID,
        UOM_ID_SOURCE_OFFSETS,
        UOM_ID_TARGET_OFFSETS,
        INFORMATION_SOURCE,
        DATA_SOURCE,
        SHOW_OPERATION,
        IS_LEGACY,
        LEGACY_CODE,
        REVERSE_OP,
        IS_IMPLEMENTED_FORWARD,
        IS_IMPLEMENTED_REVERSE)
```

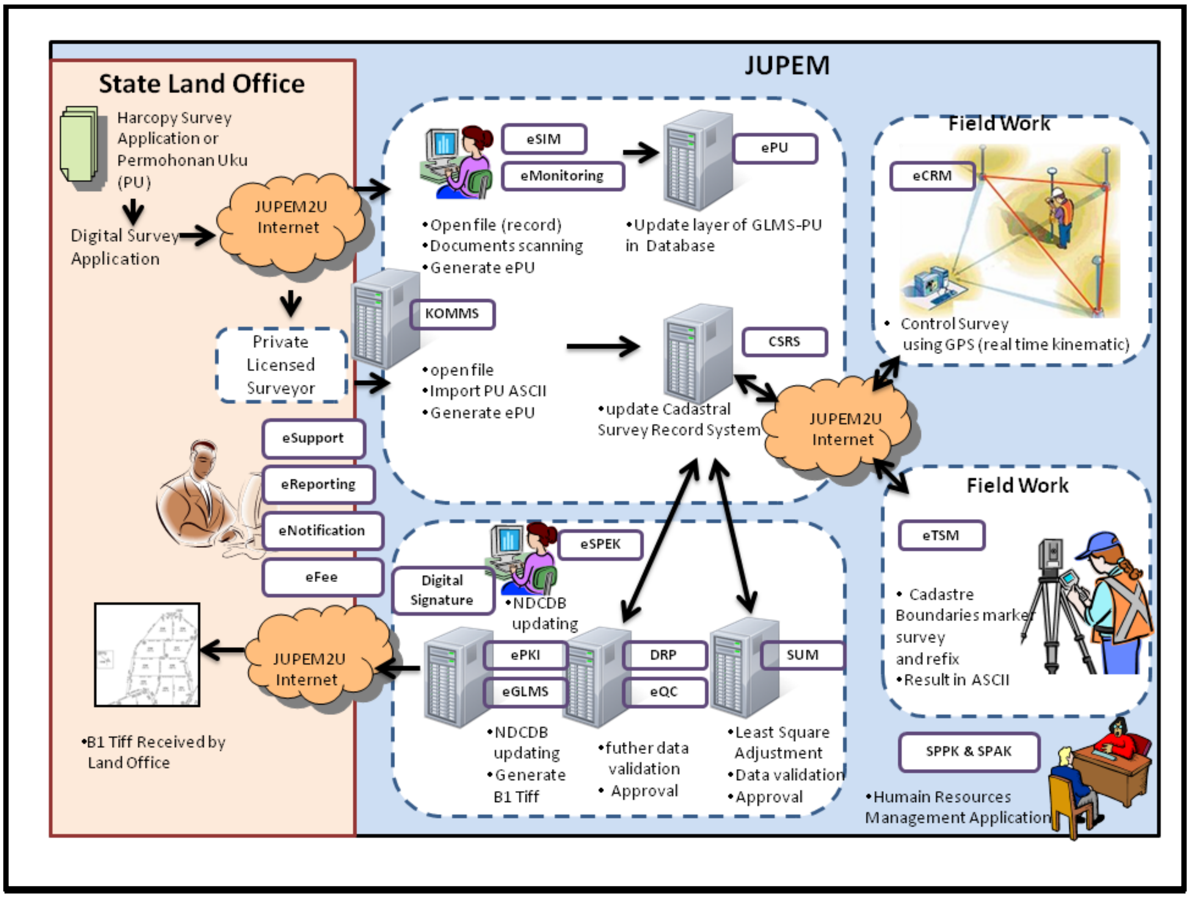
```
VALUES (
        180000001,
        'GDM2000_Peninsula_RSO',
        'CONVERSION',
        NULL,
        NULL,
        NULL,
        NULL,
        9812,
        NULL,
        NULL,
        NULL,
        NULL,
        1,
        'FALSE',
        NULL,
        1,
        1,
        1);

-- Now, configure the projection parameters:

-- 8806: False_Easting

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
      VALUES (
        180000001,
        9812,
        8806,
        804671.000,
        NULL,
        9001);

-- 8807: False_Northing

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
      VALUES (
        180000001,
        9812,
        8807,
        0.0,
        NULL,
        9001);

-- 8811: Latitude_of_projection_centre

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
```

```
      VALUES (
        180000001,
        9812,
        8811,
        4,
        NULL,
        9102);

-- 8812: Longitude_of_projection_centre

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
      VALUES (
        180000001,
        9812,
        8812,
        102.25,
        NULL,
        9102);

-- 8813: Azimuth_of_initial_line

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
      VALUES (
        180000001,
        9812,
        8813,
        323.0257964666666,
        NULL,
        9102);

-- 8814: Angle_from_Rectified_to_Skew_Grid

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
      VALUES (
        180000001,
        9812,
        8814,
        323.13010235415623,
        NULL,
        9102);

-- 8815: Scale_factor_on_initial_line

    insert into MDSYS.SDO_COORD_OP_PARAM_VALS (
        COORD_OP_ID,
        COORD_OP_METHOD_ID,
        PARAMETER_ID,
```

```
        PARAMETER_VALUE,
        PARAM_VALUE_FILE_REF,
        UOM_ID)
      VALUES (
        180000001,
        9812,
        8815,
        0.99984,
        NULL,
        9001);

-- Now, create the actual projected CRS.Look at the GEOG_CRS_DATUM_ID
-- and COORD_SYS_ID first. The GEOG_CRS_DATUM_ID is the datum of
-- the base geog_crs

-- And the COORD_SYS_ID is the Cartesian CS used for the projected CRS.
-- We can use 4400, if meters will be the unit:

select COORD_SYS_NAME from sdo_coord_sys where COORD_SYS_ID = 4400;

-- Cartesian 2D CS. Axes: easting, northing (E,N). Orientations: east,
north.
-- UoM: m.

-- Now create the projected CRS:

insert into MDSYS.SDO_COORD_REF_SYSTEM (
        SRID,
        COORD_REF_SYS_NAME,
        COORD_REF_SYS_KIND,
        COORD_SYS_ID,
        DATUM_ID,
        SOURCE_GEOG_SRID,
        PROJECTION_CONV_ID,
        CMPD_HORIZ_SRID,
        CMPD_VERT_SRID,
        INFORMATION_SOURCE,
        DATA_SOURCE,
        IS_LEGACY,
        LEGACY_CODE,
        LEGACY_WKTEXT,
        LEGACY_CS_BOUNDS,
        GEOG_CRS_DATUM_ID)
VALUES (
        18000000,
        'GDM2000_Peninsula_RSO',
        'PROJECTED',
        4400,
        null,
        4385,
        180000001,
        NULL,
        NULL,
        NULL,
        NULL,
        'FALSE',
        NULL,
        NULL,
        NULL,
        6269);

Drop table Test_transform PURGE;
CREATE TABLE Test_transform(
ID DEC(13,0),
GEOM SDO_GEOMETRY   );
```

Appendix E

Summary of eKadaster System



Referring to the above figure, the eKadaster system was developed through the Malaysia Development Plan Project in 2009 to reduce the period for production of a land title document, a process that involves the land office (under state government), JUPEM (under federal government) and a licensed surveyor (private sector). The electronic processes are based on the internet and an intranet which replaced the manual work processes. Private licensed surveyors and JUPEM surveyors are using the online module called JUPEM2u to conduct the 'data lodgement' in their business process.

The field work uses the module CRM (Cadastral Reference Mark) and a rigorous least squares adjustment. The software eTSM (electronic Title Survey Module) is stored in a ruggedized Notebook and the digital parcel database is brought to the field for title survey.

The survey technique used is real time kinematic GPS with correction from the MyRTKnet active permanent GNSS (Global Navigation Satellite System) stations that have been established around the country.

Other applications involved in this process are as following:

a. JUPEM2U

   An online application for organizations (state government - Land Office and federal government (JUPEM)) involved in the cadastre business to perform activities such as data lodgement, job process monitoring, data download;

b. *Sistem Pengurusan Aset Kadaster* (SPAK)

   Application that serves the purpose of managing JUPEM's properties such as registration, lending of the equipment, complaints about the equipment, equipments calibration and status report of all equipment;

c. Survey Record System (CSRS)

   Integrates spatial element functionalities into the modified and upgraded eSRS module of SPDK;

d. eReporting

   CSRS is capable of generating reports and graphics to fulfil JUPEM's requirements;

e. eSupport

   eSupport is a centralized online helpdesk support system which allows JUPEM State System Administrators (SAs) to report Fault Logs of their ICT equipment;

f. eMedmas

   The eMedmas implementation enables Medmas file management for tool calibration such as total station calibration;

g. Sistem Ukur Maya (SUM)

   A web-based Least Square Adjustment carried out by a server which is fully automated and assists office operators in checking field data; and,

h. eQC module

   Checking and verification of 16 ASCII (the field works files submitted by private licensed surveyors) via JUPEM2U.

The end product of the eKadaster system is a digital certified plan or PA for the parcel (TIFF format). The Land Office in a particular state will attach this plan together with land title document to produce a final title for the land proprietor.

Appendix F

Web Feature Service Capabilities XML file

```
<WFS_Capabilities version="1.0.0" xmlns="http://www.opengis.net/wfs"
xmlns:ogc="http://www.opengis.net/ogc" >
   <Service>
  <Name> Oracle WFS </Name>
  <Title> Oracle Web Feature Service </Title>
  <Abstract> Web Feature Service maintained by Oracle </Abstract>
  <OnlineResource> http://www.someserver.com/wfs/cwwfs.cgi?
</OnlineResource>
</Service>
   <Capability>
      <Request>
         <GetCapabilities>
            <DCPType>
               <HTTP>
                  <Get onlineResource="http://www.myserver.com/get?"/>
               </HTTP>
            </DCPType>
            <DCPType>
               <HTTP>
                  <Post onlineResource="http://www.myserver.com/post?"/>
               </HTTP>
            </DCPType>
         </GetCapabilities>
         <DescribeFeatureType>
            <SchemaDescriptionLanguage>
               <XMLSCHEMA/>
            </SchemaDescriptionLanguage>
            <DCPType>
               <HTTP>
                  <Post onlineResource="http://www.myserver.com/post?"/>
               </HTTP>
            </DCPType>
         </DescribeFeatureType>
         <GetFeature>
            <ResultFormat>
               <GML2/>
            </ResultFormat>
            <DCPType>
               <HTTP>
                  <Post onlineResource="http://www.myserver.com/post?"/>
               </HTTP>
            </DCPType>
         </GetFeature>
         <GetFeatureWithLock>
            <ResultFormat>
               <GML2/>
            </ResultFormat>
            <DCPType>
               <HTTP>
                  <Post onlineResource="http://www.myserver.com/post?"/>
               </HTTP>
            </DCPType>
         </GetFeatureWithLock>
         <Transaction>
            <DCPType>
               <HTTP>
                  <Post onlineResource="http://www.myserver.com/post?"/>
               </HTTP>
            </DCPType>
```

```xml
        &lt;/Transaction&gt;
        &lt;LockFeature&gt;
          &lt;DCPType&gt;
            &lt;HTTP&gt;
              &lt;Post onlineResource="http://www.myserver.com/post?"/&gt;
            &lt;/HTTP&gt;
          &lt;/DCPType&gt;
        &lt;/LockFeature&gt;
      &lt;/Request&gt;
    &lt;/Capability&gt;
    &lt;FeatureTypeList&gt;
      &lt;Operations&gt;
        &lt;Insert/&gt;
        &lt;Update/&gt;
        &lt;Delete/&gt;
        &lt;Query/&gt;
        &lt;Lock/&gt;
      &lt;/Operations&gt;
    &lt;/FeatureTypeList&gt;
    &lt;ogc:Filter_Capabilities&gt;
      &lt;ogc:Spatial_Capabilities&gt;
        &lt;ogc:Spatial_Operators&gt;
          &lt;ogc:BBOX/&gt;
          &lt;ogc:Equals/&gt;
          &lt;ogc:Disjoint/&gt;
          &lt;ogc:Intersect/&gt;
          &lt;ogc:Touches/&gt;
          &lt;ogc:Crosses/&gt;
          &lt;ogc:Within/&gt;
          &lt;ogc:Contains/&gt;
          &lt;ogc:Overlaps/&gt;
          &lt;ogc:Beyond/&gt;
          &lt;ogc:DWithin/&gt;
        &lt;/ogc:Spatial_Operators&gt;
      &lt;/ogc:Spatial_Capabilities&gt;
      &lt;ogc:Scalar_Capabilities&gt;
        &lt;ogc:Logical_Operators/&gt;
        &lt;ogc:Comparison_Operators&gt;
          &lt;ogc:Simple_Comparisons/&gt;
          &lt;ogc:Like/&gt;
          &lt;ogc:Between/&gt;
          &lt;ogc:NullCheck/&gt;
        &lt;/ogc:Comparison_Operators&gt;
        &lt;ogc:Arithmetic_Operators&gt;
          &lt;ogc:Simple_Arithmetic/&gt;
        &lt;/ogc:Arithmetic_Operators&gt;
      &lt;/ogc:Scalar_Capabilities&gt;
    &lt;/ogc:Filter_Capabilities&gt;
&lt;/WFS_Capabilities&gt;
```