Design and Implementation of a 3D National Digital Cadastral Database based on Land Administration Domain Model: Lessons Learned from a 3D Cadastre Project in Malaysia

Abbas Rajabifard, Behnam Atazadeh, Kit Meng Yip, Mohsen Kalantari, Mohsen Rahimipour Anaraki, Hamed Olfat, Farshad Badiee, Davood Shojaei, Chan Keat Lim and Mohd Azua Mohd Zain

csdila.unimelb.edu.au
linkedin.company.com/csdila
@UoMCSDILA

THE UNIVERSITY OF MELBOURNE

JUPEM

CSDILA
THE CENTRE FOR SPATIAL DATA INFRASTRUCTURES & LAND ADMINISTRATION
Est. 2001

ENVIRO
ENVIRO LAND SERVICES SDN BHD

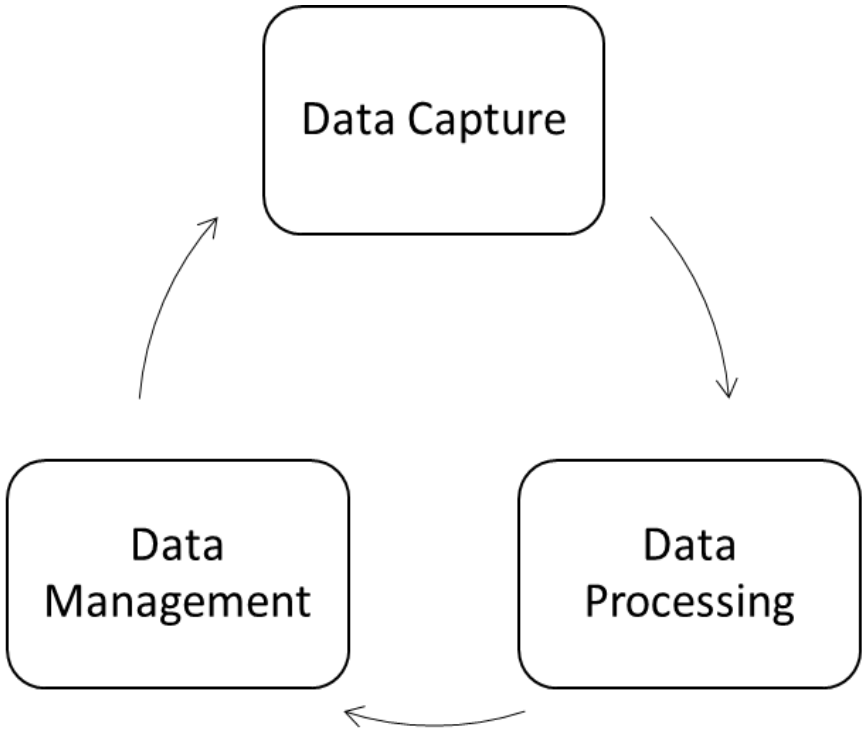
Background

With the growing dominance of urban infrastructures in Malaysia, 2D-based cadastral systems in this country are facing new challenges in recording, managing and visualizing the spatial extent of urban land parcels.

Problem

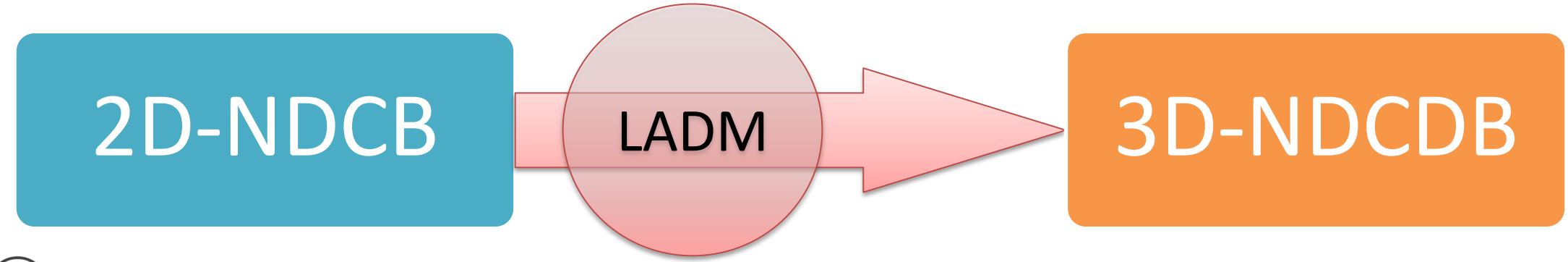
- The existing methods of data collection, calculation and adjustment of survey and processing data needs to be upgraded for the purposes of implementing 3D cadastral database and producing digitally certified 3D plans.

- In Malaysia, surveying and cadastral measurements are currently stored in the National Digital Cadastral Database (NDCDB), which is a 2D-based database in the form of planimetric coordinates (X, Y).



Aim

- A new LADM-based approach to develop and implement a 3D cadastral system for Malaysia. The main objective of this part is to determine the procedure of adding the height information to lot boundary marks in the 2D-NDCDB to create a 3D-NDCDB.
- The proposed approach comprises new changes in the current cadastral surveying practices and workflows, a new architecture to support 3D land parcels, and a new database for creating an LADM-based 3D cadastral system which is aligned with jurisdictional settings of Malaysia



Approach

Design and implementation of a 3D-NDCDB comprises four major steps:

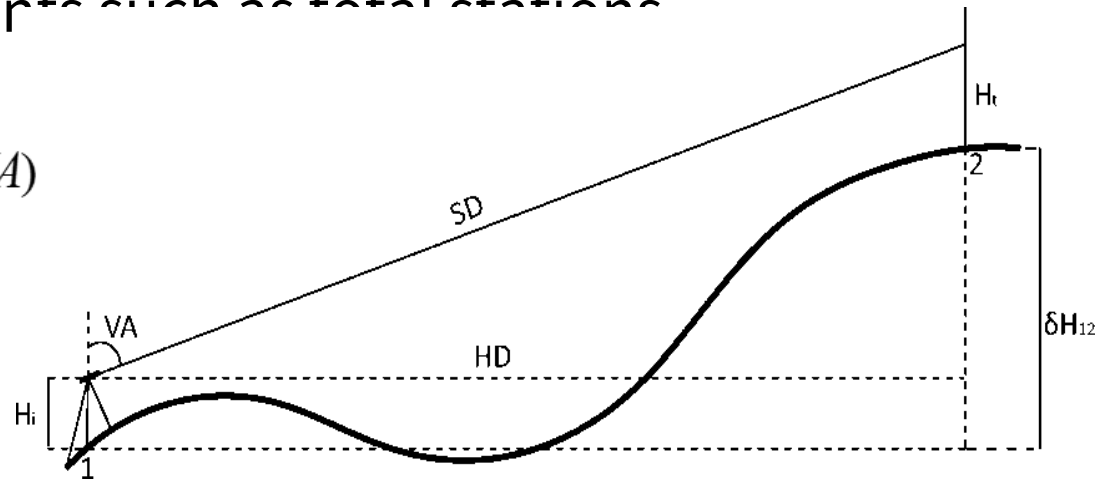
1. Developing a survey methodology
2. Adjustment computations to ensure height accuracy
3. Adoption of a new LADM-based data model
4. Implementation of 3D-NDCDB and 3D visualization of land parcels

Survey Approach and Height Adjustment

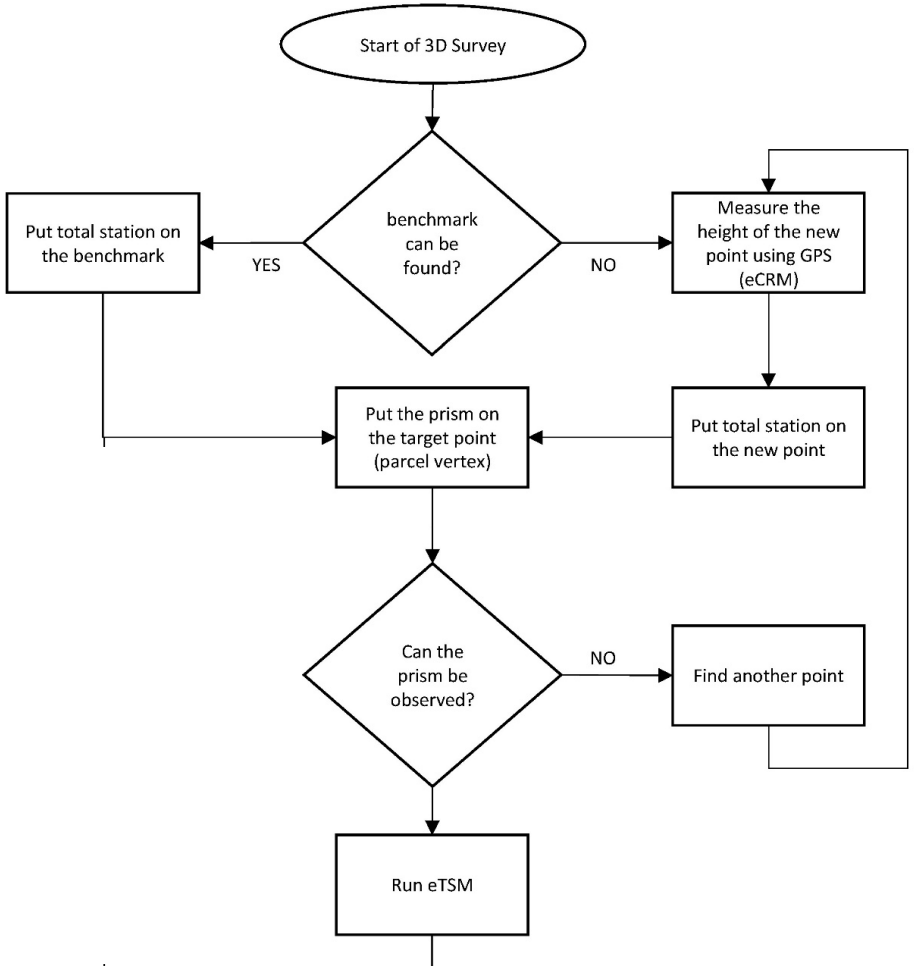
- The fundamental data for 3D cadastral system is the height of the land parcels.
- Based on the current practice , the trigonometric levelling was used for capturing the height information.
- This method is a particular type of surveying in which slope distances with angular measurements, i.e. zenith and horizontal angles, are precisely determined using surveying instruments such as total stations

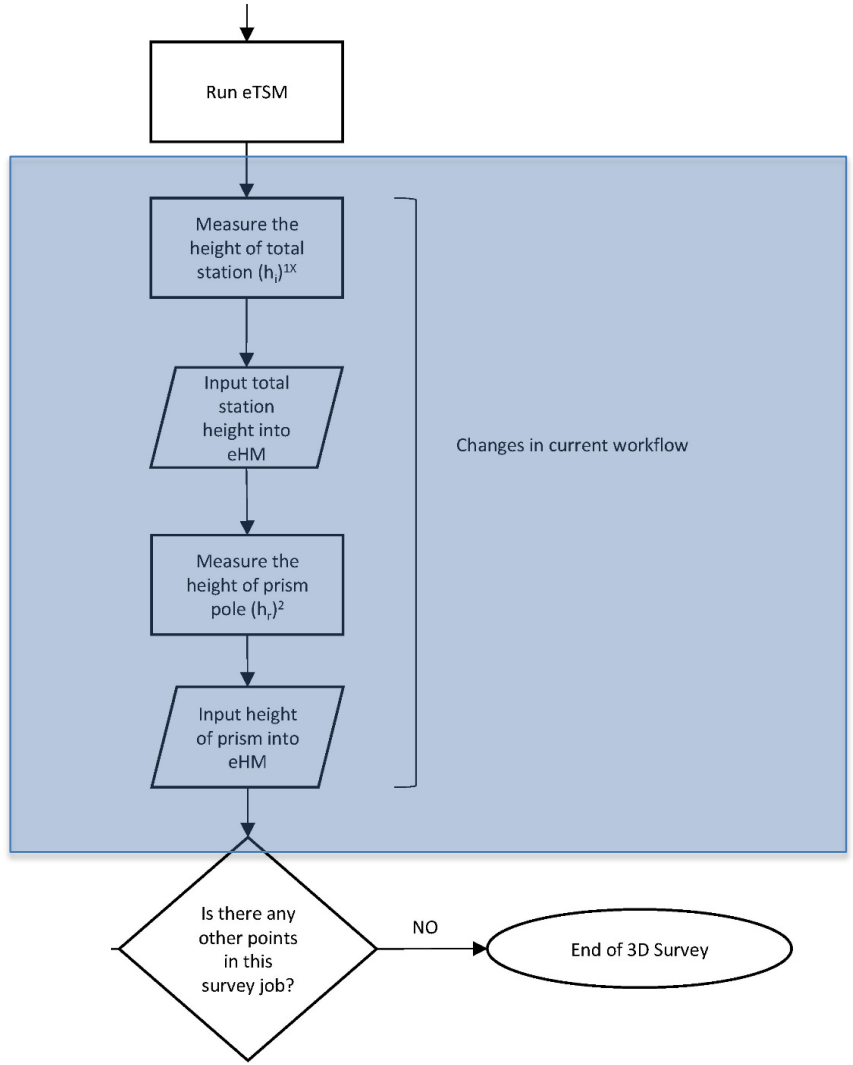
$$\delta H_{12} = H_i - H_t + SD \times Cos(VA)$$

$$VA = \frac{VACL + (360 - VACR)}{2}$$



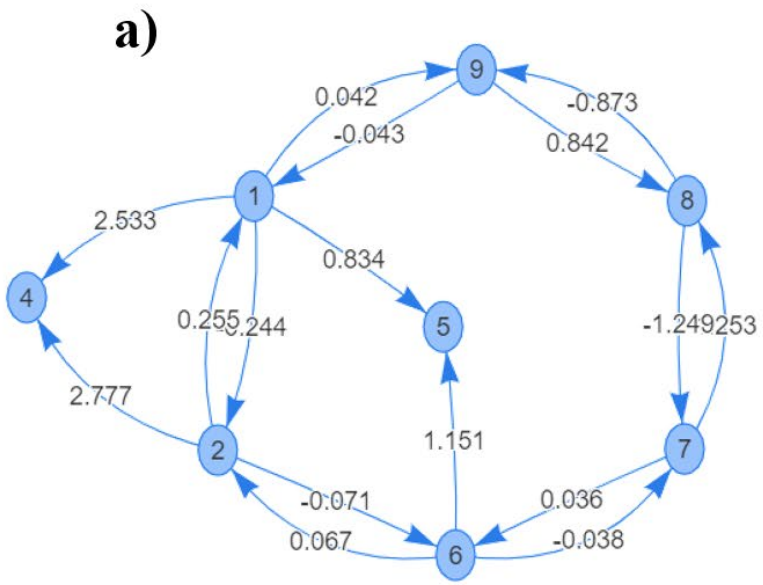
Height capturing flowchart

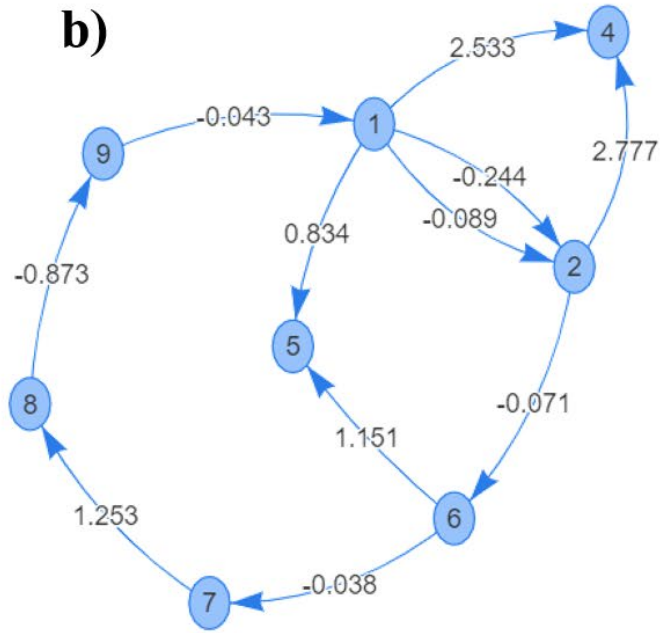




Accuracy for Survey Methodology

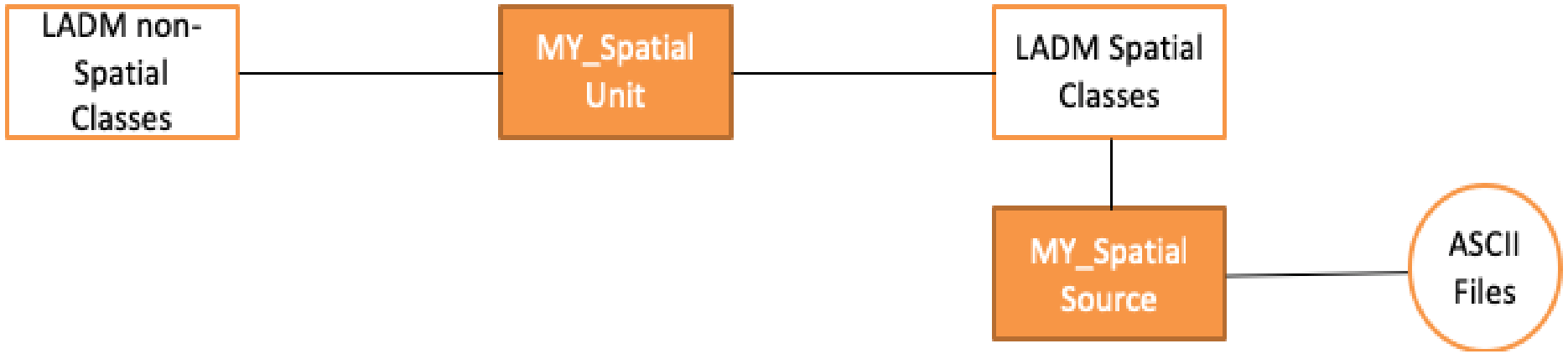
- Two independent sets of observations between every two successive points are required to improve the height accuracy measurement.
- The key advantage of these two independent measurements is recognizing any mistakes/blunders that may occur during the measurements for any reason.



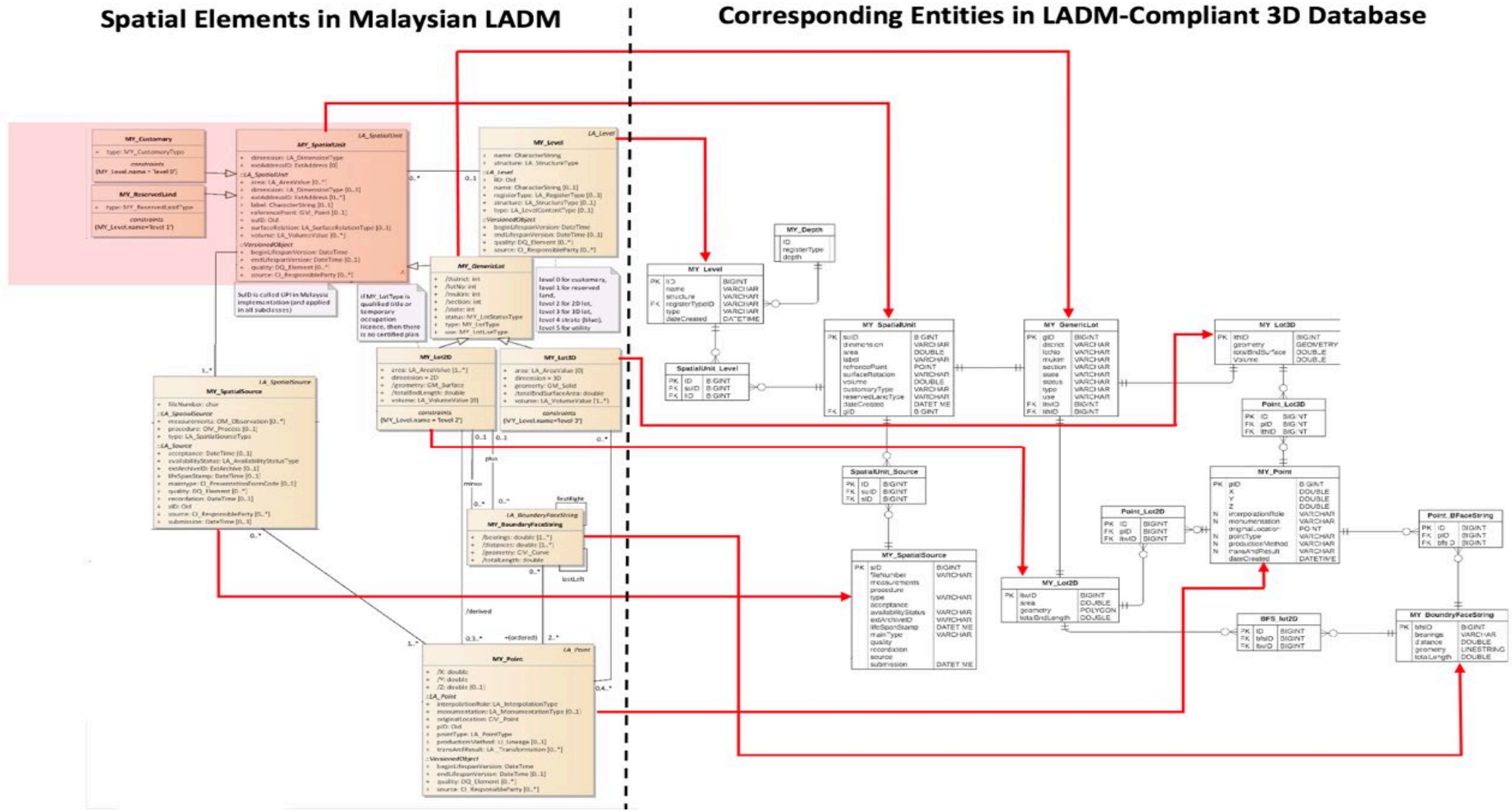


Data Model

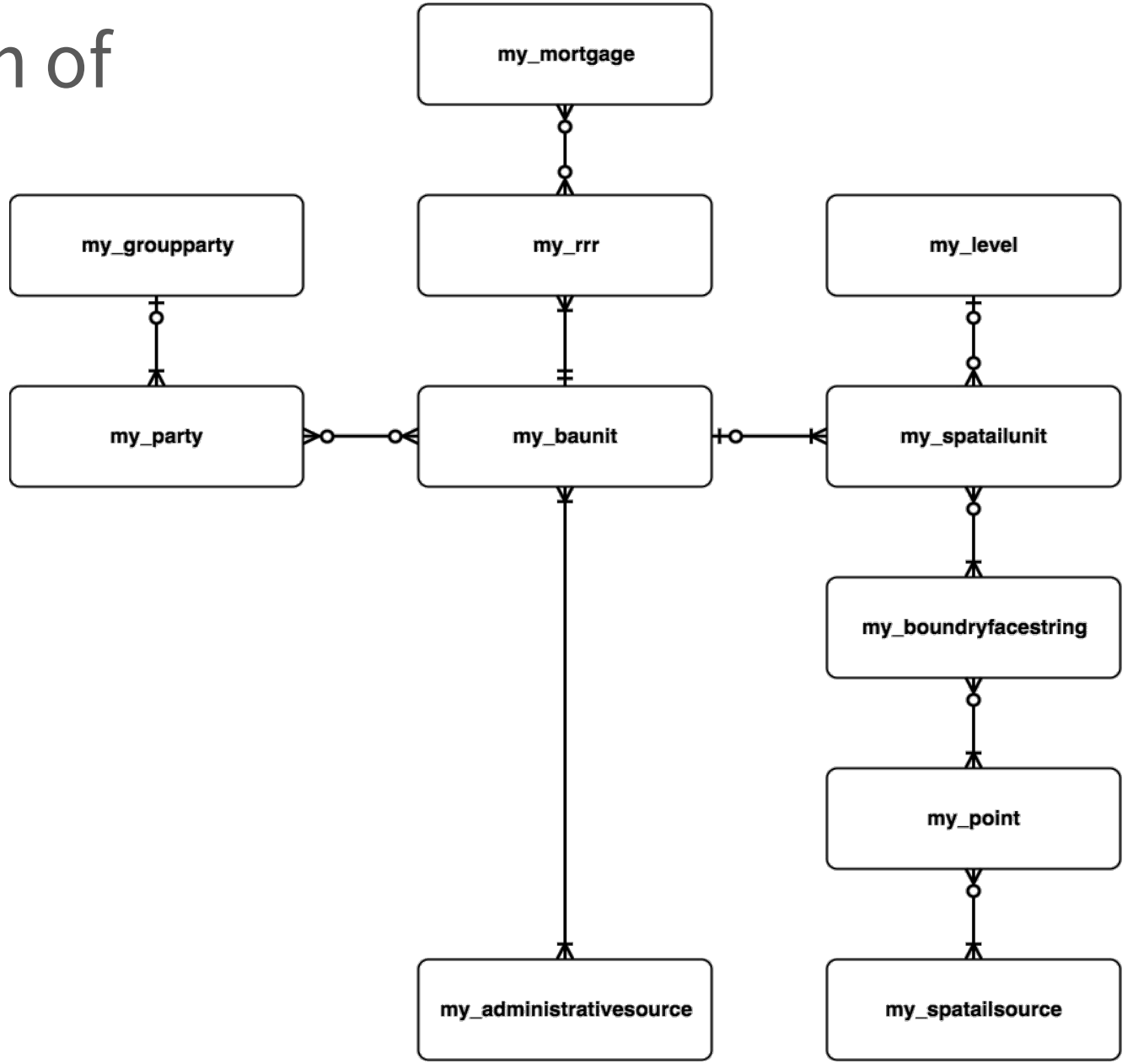
- The design of 3D-NDCDB is compliant with LADM and follows the standard practices of relational database design.
- 3D- NDCDB utilizes PostGIS which is an open source software program that adds support for spatial objects to the PostgreSQL object-relational database.



Mapping LADM Elements to a Relational DB



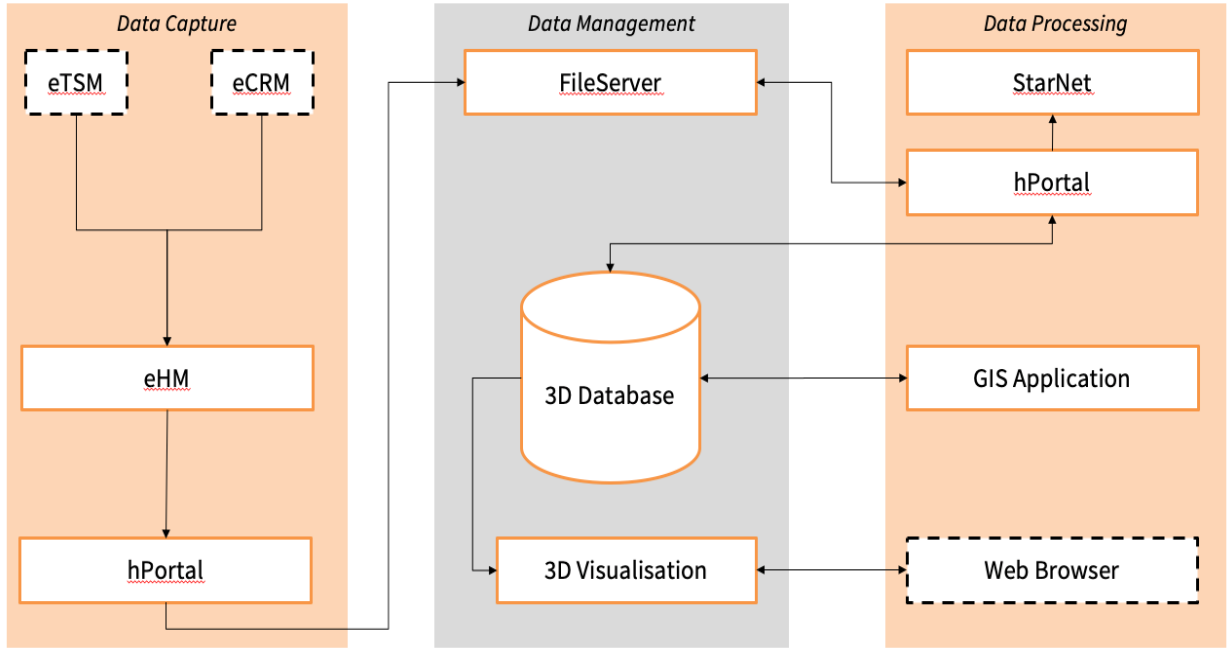
Simplified ER Diagram of 3D-NDCDB



Implementation

Based on the developed rational 3D-NDCDB, a system was implemented with these features

- Modular design
- Modern application framework
- Platform Independent
- Parallel process to 2D-NDCDB



3D Visualisation

- ❑ LADM viewer was developed based on 2 main open-source projects:
  - CesiumJS
  - GeoServer

- ❑ LADM viewer visualizes the 3D parcels, parcel boundaries and point boundaries on a customized Digital Elevation Model (provided by JUPEM) for Malaysia.
- ❑ It also enables some queries based on attributes in the 3D database. It is an open platform to provide information to other users since it is a web-based application which can be accessed using any modern web browser.

Main Lessons

- As the third dimension, height information is a critical piece of data in implementing 3D cadastral systems.

- Unless a country-wide systematic approach is adopted, the potential of 3D digital data will not be fully realized.

- Upgrade to a new system based on LADM-driven 3D digital data will lay the groundwork for Malaysia to become among the first nations in the world to have a 3D-enabled national spatial data infrastructure based on LADM.

Main Lessons

- The Malaysian cadastral infrastructure , which includes land, strata and stratum titles, is ready for an upgrade to include 3D digital data that follows the standard approach adopted by the LADM standard.

- Development of a good implementation guide for LADM

Next Steps

- Investigating legislative requirements for the introduction of 3D data collection into the current workflows

- Implementation of the current system into those areas, in which coordinate values stored in NDCDB are stable

- Integrating BIM into Malaysian land administration systems and querying 3D cadastral information in complex built environments


Thank you
Terima Kasih