



# The Integration of 3D GIS and Virtual Technology in the Design and Development of Residential Property Marketing Information System (GRPMIS)

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## Abstract

This paper discusses about a research with the aim of investigating the potential integration of 3D GIS and virtual technology in designing and developing residential property marketing information system. The method adopted in this research is a standard system development lifecycle; commencing with the user requirements study, followed by the system design, the system development, the system implementation and finally the system evaluation. This research uses an informal method i.e. semi-structured interview, survey questionnaire and review of the existing information system to establish the user requirements. Ten user requirements were outlined alongside with the examination of four 3D integration and three virtual reality methods. Three out four methods of 3D features integration are selected for the system development. The developed system is tested using the black box and white box testing methods. The prototype system can be used by the real estate agents and property developer as the concept, framework and references for future development of a better conducive property marketing information system as well as simplifying the traditional flow of housing selection which gives positive impacts in the marketing transaction.

## 1. Introduction

Property Management is a term that has many disciplines related in it. According to Narains Corporation (1971) a famous property consultant and realtor in India, property management can be defined as the function of looking after buildings. These functions comprise of rental collection, payment, building maintenance, services condition, insurance policy and many more. Selling and marketing are also one of property management functions which have become the main focus in this research. Marketing involves several parties such as estate agents, home owners, developers, lawyers and legal companies. Housing estates and property industries have become significantly active industry in Malaysia.

This has led to a large number of investments from the property developers, contractors, professionals and local authorities. The rapidity of property development results in more choices of houses available. Consumers have certainly become more indecisive towards making a choice.

Traditionally, house buying activity involves site visiting and verbal communication between the property sellers and buyers. Even though the practice has been successfully implemented for many years back, this method is rationally inefficient as it requires more time, energy and money. Having known that, some of the property developers and estate agents have taken one step ahead by putting and advertising properties on the road billboard, newspapers, television, posters and even on the web for selling and renting purposes. These methods only succeed in getting the information reach the consumer. Consumers still need to go to the site to obtain details such as the ground state and architectural design. Considering these issues, an investigation on the potential technology to be embedded in designing a marketing system to facilitate the needs of such activities has to be established to improve the traditional activity of choosing, buying and selling a property.

Currently there are a number of property marketing systems available in Malaysia. Examples of such systems are *Fullhouse.com.my* and *Propertycity.com.my* websites. *Fullhouse.com.my* was developed by *Fullhouse Sdn.Bhd* and Real Estate and Housing Developers' Association Malaysia (REHDA). The system only provides the database information of the house and images for some of the listed property. *Propertycity.com.my* was created by *LCT Info Enterprise*. This system is a one stop property search engine for users to search for potential house/properties for sale or rent and it also provides a Real-Time Property Alert through email to their subscribers.

The computerised property systems have moved from database-oriented to the location-based system using GIS technology. GIS technology is particularly beneficial in integrating data from a wide range of sources using location as a common point of reference. The applications of GIS are generally set out to fulfil the *five Ms* i.e. mapping, measurement, monitoring, modelling and management (Longley *et al.*, 2001). These capabilities can be seen in the *GIS-based Property Database*. It was developed to permit the geographical representation of property information at the individual property level (Wyatt, 1997). Despite the realisation of the importance of using location-based system using GIS technology, the development of such a system has not been the focus of many property marketing systems. Thus the objectives of this research are:

- i) To analyse the user requirements for the design and development of Property Marketing Information System (PMIS) and its current practices,
- ii) To design and develop the GIS-based Residential Property Marketing Information System (GRPMIS).

In view of this, the next section provides a brief review of the 3D GIS and virtual technology in the property and marketing disciplines.

## 2. Literature Review

The introduction of GIS technology in computerised property systems has enable users to handle large spatial data and improve the system efficiency. Evidences and justifications of insufficiencies in the existing information systems to handle spatial information were identified by several authors (Bodum *et al.*, 1998; Crowell *et al.*, 1994; Doyle *et al.*, 1998; Gruber *et al.*, 1997 and Tempfli, 1998). GIS technology is typically implemented in the property field when the property systems are designed to support geographical information (Wyatt and Ralphs, 2003). Recent technological advances in the delivery of spatial data across the web have facilitated the development of open and scaleable land management solutions, with interfaces to centralized data sets from the internet, intranet, and local and wide area networks.

According to Zlatanova (2000), commonly established systems dealing with spatial data are 2 Dimensional (2D) GIS and 3 Dimensional (3D) Computer Aided Design (CAD) system. The CAD system was found to have deficiencies in modelling large models of 3D visualization. These deficiencies can be overcome with the technology such as Virtual Reality (VR) and the improvements of hardware and libraries. VR is a form of human-computer interface (HCI) that involves the creation based on a reality (Brodlić *et al.*, 2002). VR is a computer generated simulation that allows user to interact with data that gives the appearance of a three-dimensional environment, while 3D is a view that provides depth perceptions. Fisher and Unwin (2002), have demonstrated numerous applications of virtual reality in geography (see also Brodlić *et al.*, 2002; Kluitmans and Collin, 1991; Gillings, 2002; Haklay, 2002; Kraak, 2002; Batty and Smith, 2002; Ogleby, 2002 and Cheeseman and Perkins, 2002). The VR technology such as animation can provide a walk through model of building and construction sites. Animation enables the 3D view to become alive. This can be done by recording actions and replay as desired.

Earlier studies (Md Sadek *et al.*, 2005, Ljungvist, 2003, Dogan *et al.*, 2004; Kolbe and Groger, 2003; Smith and Friedman, 2004, Zhou *et al.*, 2004 and Zlatanova, 2000) have identified the uses of 3D and VR for city modelling and planning. The result has shown a significant difference in the degree of efficiency throughout the study (Marcus, 2005 and Dogan *et al.*, 2004). The application of 3D and VR technologies in property systems could improve the

management efficiency. According to Kolbe and Groger (2003), to reach interoperability on the system level, multiplatform compatibility has to be achieved. Hack and Sides (1994) stated that VR or simulated worlds will be used for GIS modelling in three-dimensions in the future. The animated GIS objects will enable us to visualize spatio-temporal objects in the environment (Davis and Williams, 1989). The key element in utilizing 3D GIS is the conceptual model. Zlatanova (2000) stated that the conceptual 3D model integrates information about semantics, 3D geometry and 3D spatial relationships (3D topology). The methods for describing real world are provided through the conceptual model (Zlatanova, 2000).

Having known that technologies such as GIS, 3D and virtual reality have the capabilities to improve system efficiency, the establishment of the integration of such technologies in the property marketing system could improve and simplify the process of selecting, buying and selling a property. The time requirements may be shortened and information retrieval could be done effectively. These technologies have not yet been utilised in any of the existing property marketing system. In due respect to the above concerns, this thesis particularly investigates and explores the potential integration of these technologies in the design and development of property marketing system and how GIS technology helps to manage many projects and to produce more effective, more equitable and more predictable results. Property management decisions need to be made on the basis of accurate information and therefore GIS applications often entail a relatively low level of analysis but high degree of accuracy (Wyatt and Ralphs, 2003). Therefore, investment in GIS technology and data collection can be justified.

### 3. Methodology

Based on standard System Development Life-Cycle (SDLC) five stages i.e. the study of user requirement, system design, system development, system implementation and system testing and evaluation were applied in the development of the system. With some alteration, these stages are further divided into three phases (refer Figure 1). The study of user requirements is conducted by using semi structured interview, survey questionnaires and review of existing system. Triangulated research model for this study is adapted from Sauer (1993). This model described the need for the system engineer and the potential user to work together in order to establish the user requirement.

Two groups were chosen in the study of user requirements are the global perspectives and individual perspectives groups. The global perspectives group provides experiences of using the existing property marketing system. This is usually done by going through the technical ability of the system, system report, reviewing current practices and functions available within the existing system. The information is gathered using interviews and conducting a survey. The individual perspectives group on the other hand supply information regarding the users' perception and expectation through interviews, observations and questionnaire. This group provide useful information for the design of the proposed system user interface.

The core of the system design phase is the establishment of conceptual, logical and physical design for the proposed system. Two approaches used to create the conceptual, logical and physical design are the database approach and object-based approach.

The proposed system needs to undergo testing and evaluation. The testing methods that are used in this study are the Black Box and White Box testing.

### 4. The Result of the User Requirements Analysis

There are three methods used for the user requirements analysis in this study. First, literature review and observation of the existing property marketing systems were conducted. Second, semi-structured interview to the property developers, real estate agents and potential consumers and third is the questionnaires to the potential users of the proposed system integration. The observation of current practices and existing system is carried out by looking at the current activity of buying/selling property, observation on the existing property marketing systems in Malaysia and analyzing existing study performed to identify user requirements for building information system. Several existing property marketing system have been looked at provide insight into the overall system architecture of the existing property marketing information system. The semi-structured interviews were undertaken to selected individuals from different organizations.

The inferential method was applied for the identification of user requirement in the survey questionnaire option. The inferential statistics is used to infer and conclude the population judgement and opinion of the development of the proposed information system based on the responded questionnaire. As the name implies, the inferential statistics are used to draw conclusions, to make inferences, or to make predictions about a given population from sample data from the population. Based on the population of the Seksyen 7, Shah Alam, Selangor, Malaysia observed in year 2000, the number of population is 5440 and number of sample is calculated based on margin of error of 10 percent which is the amount of error that can be tolerated, 90 percent ( $90\% = \pm 1.645$ ) tolerated amount of uncertainty (confidence level). Five hundred questionnaires were distributed; only 260 samples are used for the study. The result from the study undertaken reveals 10 user requirements to be used in the development of the proposed system as listed below:

1. The system should enable users to perform database query and view tabulated result.
2. The system should allow users to perform location query and view projected map on the screen.
3. The system should allow users to perform visual query and visualize query result on-screen and report.
4. The system should provide users with the facilities information for the housing area.
5. The system should allow users to obtain information regarding the housing property e.g. price, built in area, address, owner/developer, etc.
6. The system should provide users with the topographic information of the housing area.
7. The system should allow users to view inside and outside the house in 3D and perform virtual analysis (walk through/fly through and shadow).
8. The system should allow advertisement (permitted to certain users).
9. The system should enable users to print out the report.
10. The system should be user friendly, conducive and easily access.

## 5. The Development of GRPMIS

The system development of the GRPMIS involves several stages. First is data preparation which will be described in Section 5.1. Second is the animation development. The animation development comprises of the exploration of three methods. These methods are described in detail in Section 5.2. Third is the system integration. Four methods are examined for the proposed system integration is described in Section 5.3. Figure 2 shows the proposed system development workflow.

### 5.1 Data Preparation

Figure 3 shows the workflow of the constructions of basemap for the GRPMIS. The data preparation workflow illustrates that two main data types are generated. First is vector data generation. The vector data for the proposed system is generated from digital map and topographic map. Second is 3D data generation. The 3D data is constructed by using digital photograph and house floor plan. Three major steps involved are data acquisition, extract layer and post-processing. The output of the data preparation is the basemap of the test area for the proposed system development.

#### 5.1.1 Vector Data Preparation

The process of vector data preparation involves 4 sub-stages i.e. data acquisition, extract layer, post processing and output. Data pre-processing consist of vector data registration and calibration. Vector data registration is constructed by assigning the coordinate system to the unsigned data. The uniformity of the coordinate system and projection is crucial. Vector data calibration is done by performing some topological testing. At this stage all the layers are converted into geodatabase and the topological rules are applied. This step is important in order to ensure that the topological property of the data is valid. Topological rules can be applied within the ArcCATALOG environment.

The existing digital data is then reproduced, edited, updated and corrected. Four layers that were extracted from the topographic map are *street*, *land lot*, *contour* and *building* layers. The data produced from the topographic map and existing digital map are then merged. The database of the topographic map and the digital map need to be connected by unique identifier so the attributes table can be related. With that, the GIS spatial data and attributes data are now integrated. Using the 3D analyst extension, a Digital Elevation Model (DEM) is constructed to give perspective view of the test area. All the designated test layers were draped onto the DEM giving a new evolution of visualization. The test area is then represented in model view where the topographic features can now be identified. The completions of vector data preparation provide the basemap of the test area.

#### 5.1.2 3D Data Generation

The 3D data of the test area do not need to be constructed after the vector data are prepared. 3D data can be generated at anytime or alongside the vector data preparation. This is because some of the 3D such as trees, play-ground, lamp or street furniture data do not need the base-map as the point of reference. The need for the reference point is dependent on the method chosen to integrate 3D features into GIS data. The method tested for integration is elaborated in Section 5.3. As in vector data preparation, four stages are involved in 3D data generation i.e. data acquisition, extract layer, post processing and output.

The textures for the 3D features generated for the test area are acquired based on the digital photograph captured at the test area. The photographs are edited using the selected graphic software and implanted into the 3D features of the test area. The floorplan is used to generate 3D house of the test area. The floorplan is scaled and projected based on the spatial data imported into the selected 3D software. The coordinate system is maintained according to the spatial properties of the GIS data. The construction of the 3D data is performed by using Sketch-Up 5 and 3D ModelBuilder

software. The 3D features are then imported into the geodatabase or directly imported to ArcScene through the 3D marker symbol option.

### 5.2 Animation Development

Animations consist of tracks that are bound to objects. These objects may consist of layers, the map view (ArcMap), the camera (ArcScene and ArcGlobe), or the scene (ArcScene) whose properties can be animated. The animation scheme is developed from two softwares; ArcGIS and Sketch-Up 5. Figure 4 shows the animation development workflow. It involves five format of 3D features and these data are examined using three methods of generating animation. The animation files are then imported into VRML and .AVI format. VRML format require virtual files player such as Cosmo Player.

Scene animation for the whole study area is created using ArcScene while the residential property animation and facilities are created within the Sketch-Up program. The animation toolbox is activated via the standard pulldown menu in ArcScene. There are three methods of creating animation in ArcGIS 3D Analyst; animation capture by camera, by scene and by layer.

#### 5.2.1 Method 1: Motion capture by Layer

Layers in ArcScene can be animated in various ways. The proposed system is chosen to animate moving layer such as a car track at the study scene. One way of creating the layer track is to move a layer along the path and create flyby from path. Using the existing layer such as road or street layer, a path is selected and the options to move layer along the path and create flyby from path will be activated. Subsequently, the move layer along path options and the scene importer will be prompted.

The motion animation can be displayed in various formats (vrml, .avi and .asa). Viewing animation files in format .avi require exporting animation to video step. When the file types format to be saved is selected as .avi, the menu for video compression option will be prompted. There are several choices of video codec compression options available. However the cinepak compressor is recommended by ESRI. The 'Compression Quality' setting indicates how high a resolution will be used when rendering the video. The higher the setting, the sharper is the video resolution. However, it results in a larger file size and will require more sophisticated and faster computer for the processing.

#### 5.2.2 Method 2: Scene Animation capture by Camera

Motion capture by scene is done by manipulating the scene view and uses camera tools to save the scene. The animation will move from sequential captured keyframes. These keyframes are captured by using the navigation tools in ArcScene to select the preferred perspective view of the study area and camera from the Animation Tools for scene capturing.

Each scene, layer or frame captured using ArcScene Animation Tools is managed by using the Animation Manager. Animation Manager control the timeframe of the animation. When the animation files are saved, these files are saved into two format (.AVI and VRML). File format .avi is used for the scene playback. Using windows media player this animation files can be viewed without users control. The VRML format will offers 3D Scene user navigation power.

#### 5.2.3 Method 3: Sketch-Up 5 Animation Developer

Creating animation in Sketch-Up 5 is fairly straightforward. Theoretically, animation in Sketch-Up is the same as Scene animation in ArcScene. The difference is that the scene is save in separated window and played according to the window arrangement. Every scene of the house is stored in different windows tab, and the sequential scene is saved in another window tab simply by adding new tab. The preview of the animation can be displayed within the Sketch-Up windows itself by selecting the slideshow option. When the desired sequential is saved and completed, these house scenes can be exported using export to animation option.

### 5.3 3D System Integration

The data preparation stages have to be completed in order for the 3D system integration to take place. The output from data preparation stages is used at this stage. Figure 5 shows the integration of 3D features into spatial data. Four methods are examined. Each method is described in detail in the following sections.

The 3D model library output is represented in two different formats; the OpenFlight (.flt) and Sketch-Up format (.skp). Both formats are compatible with ArcScene, this is important in order to be able to visualize and retrieve the symbols in ArcScene. The basemap created within data preparation is used as the reference subject for placement of the 3D models and features created.

The process of bringing the 3D models into the base map fulfills the integration of 3D GIS. To retrieve these 3D features from Sketch-up, ESRI GIS Plug-Ins is needed. This extension will enable the 3D model to be imported into ArcMAP Personal Geodatabase. Customization is started when all the 3D models are fully retrieved into the base map. From this point, the development of the system begins by using Microsoft Visual Basic and MapObjects as the GIS enabling tools. Four Methods are examined to investigate the capabilities of the 3D model integration into GIS data.

### 5.3.1 Method 1: Importing TIN into Sketch-Up and Drape Lotpoly layer onto TIN

The perspective view map displayed in ArcScene can be imported into Sketch-Up. The first method is by selecting the features and clicking the import to Sketch-Up button provided the GIS plug-Ins is installed. The import window is prompted and it will ask whether TIN should be included as the import features or not. TIN is crucial to maintain the height value of each land lot. These features need to be included. In some cases where the height value is stored within the land lot attributes table, TIN can be excluded. This step will not affect the projection and coordinate system that has been assigned to the spatial data in the earlier process. The Lotpoly layer is brought up onto the TIN surface. Soften edges tool is used to smooth the TIN surface. This is done to simplify the TIN and to minimize the processing time. A complex triangulated network contained in TIN layer may delay or even fail the draping process. Although this method can be used for the integration, it requires more time to complete due to the TIN complexity that also affects the visual memory and capacity. The performance of the machine tends to get affected and it is impossible to complete the 3D features placement of only one house on an average of ten minutes. Only if this problem could be solved, a perfect 3D GIS integration method is found.

### 5.3.2 Method 2: Convert layer into 3D and import using Shapefile Importer

The second method uses the shapefiles importer. This options is easier but it might take awhile if the shapefile size is big. Digital Elevation Model (DEM) is created from the layer contour. Within ArcToolBox, using 3D Analyst extension in ArcGIS, this DEM is interpolated into polygon multipatch with the *lotpoly* layer. This is done in order to preserve the high value within DEM into the specified layer. The result of this method is that the layer output in shapefiles (.shp) data format instead of multipatch. The value of height is stored within the type of polygon as '*Polygon ZM*'. Although the layer displays well in ArcScene, the features from interpolation appeared to be in multipatch format and cannot be imported into Sketch-Up and as for the shapefiles (.shp) output, it failed to import a complete layer of lotpoly layer. Some contains in lotpoly layer appeared to be missing. Although, the layer appears to be elevated in Sketch-Up but the missing pieces interrupt the process of 3D features placement and retrieval.

### 5.3.3 Method 3: Using Plane-view layer and import using Import to Sketch-Up tools

Method 3 is examined by using the land lot GIS layer. This method only requires the Import to Sketch-Up plug-Ins. The import process of GIS layer into 3D software is easy. The step is straightforward by selecting the layers and using Import to Sketch-Up button in ArcMAP or ArcSCENE, the layer is available in Sketch-Up. The method of import GIS layer into 3D software used in method 3 is the same with the one used in method 1. This time, the option of bringing TIN (elevation model) into 3D software is not selected (unchecked). This is to examine how is the complexity of the elevation model may affects the performance of the memory of the machine capacity and the time require to model the 3D features created. As a result, the placement of 3D features using this method is easy. The only drawback of this method is that all the 3D features is placed onto a plane land lot instead of the lot with an elevation. That is why the process did not require longer time.

### 5.3.4 Method 4: Importing 3D features by creating point layers

This method is examined to determine the performance of 3D software and GIS software by eliminating the large and complex value of layers such as the large files to export 3D site from Sketch-Up to ArcScene. This method is performed by creating point layers for each lot, where the original polygon layer for lot is converted into point features. For other features such as trees and road facilities, the point features are digitized and the type of trees and facilities are stored.

## 6. The GRPMIS

This section described the GRPMIS functions and flow according to the three levels of user. The elaboration starts with the guest user environment, followed by the registered user environment and finally the admin user environment. The detail about how GRPMIS runs within each environment is illustrated. The GRPMIS will start with the window shows in Figure 6.

This window introduces the research and GRPMIS in brief. Three links presented in this window are entering the system (GRPMIS), looking up for system info (SYSTEM INFO) and exit starting window (EXIT). Clicking at the GRPMIS link will lead to the Log In window of the system (refer Figure 7).

### 6.1 The Guest User

The user will have three different ways to Log In depending to the type of user browsing the system. Guest user is a system browser. Guest user can enter to the system without typing any username and password. However, the functions available to the user will be restricted. The guest user can click the Login button and that action will get them to the GRPMIS State Selection Menu (refer to Figure 8). Clicking at the Selangor link will take user to the GRPMIS Main Menu as shown in Figure 9.

As can be seen in Figure 9, the function Manage Property and Edit Propety are not active. These functions are meant for the registered and admin users. The guest user will only be allowed to perform the following functions:

- i. Layer Activation functions (1)
- ii. General function (2)
- iii. Standard Navigation Tool (3)
- iv. Viewing Window (4).

Layer activation function enables the user to select specific layer to be viewed in the viewing window. The standard navigation tool offer functions such as zoom in/out, interactive zoom in/out, pan and pointer. The general function allow guest user to perform buffer search, radius search, 3D GIS view, Search Advertisement and View Advertisement. Snapshot of the Search Advertisement window is shown in Figure 10.

From here, a guest user can access to the detail property information. User can highlight the search result by clicking on the *View House Details* button. A new House Details Window will appear on the screen (refer to Figure 11). This window has four connecting tabs (House Information, Picture, Floor Plan and 3D Floor Plan). All four tabs are available for the guest user to view. The House Information, Picture, Floor Plan and 3D Floor Plan tab is shown in figures 11 and 12 respectively.

The Floor Plan 1, Floor Plan 2 and Floor Plan 3 buttons will lead the user to 3D animation Plan as shown in the following Figure 13. Finally, guest user is able to print out the report of the search result information.

A Guest user can also access to the property information through the viewing window. This can be done by clicking at the pointer function at the navigation tool. Then click at the lot or land parcel at the map presented in the viewing window. A small window will appeared on top of the viewing window as presented in Figure 14.

Using the Pointer, a Guest user can choose any land parcel and from the pop up window user can click at the view button to display the House Details Window (same as Figure 11). However, the Edit button will not be activated in the pop up window, as the Guest user is restricted to use this function. This function will only be activated within the Registered User environment.

In additional, a Guest user can also perform radius and buffer search. Using *Pointer*, the chosen land parcel is selected (yellow dot become apparent indicating the selected land parcel). Clicking the Buffer or Radius button will lead user to the function menu. Figures 15a), b), c) and d) illustrate the results and the menus of these functions.

The 3D View function enables user to visualize the area in perspectives view. A user can access to the Perspective View window and the CosmoPlayer (VRML) window subsequently. In the Perspective View window, the navigation function is available with some limitations. The navigation function is operated using the mouse pointer. This window also allows user to visualize the area without the 3D model features. Only land parcel, road and other selected layers will be draped onto the elevation model. The Cosmo Player (VRML) window is able to view the elevation model of the test site. Further investigation is still needed as there still some problem in the rendering process of the 3D features. Figures 16 show the generated perspective view and CosmoPlayer(VRML) window.

## 6.2 The Registered User

The Registered user is the user with personal account or registered as the formal user of the system. Registered user will be provided with the username and password upon their registration to use the system (refer Figure 17). This type of user usually has specific purposes for joining as the system member such as to advertise and sell their property.

This username and password will allow them to access extra function called Edit Property function. A screen-chop of the Main Menu for the Registered user is shown in Figure 18.

As shown in Figure 18, the Registered user can access to all the functions available within the Guest User environment with an extra function known as Edit Property function. Furthermore, Registered user can access to the editing environment by clicking at the pop up pointer menu where the function Edit will be activated or from the Edit Property function. From these functions, the user will have access to the House Details window where another Edit button is activated (refer to Figure 19).

Access to the Edit function is undertaken by clicking at the highlighted Edit button (refer to Figure 20). Once the Registered user clicked at the Edit button, the new window called Advertisement (Edit) window will be prompted on the screen (refer to Figure 20).

A Registered user is able to perform editing task for the property database information only. Information to be entered are location, price, residential type, status, number of rooms, facilities, pictures and the contact number. To change the price, the user can select price range from the drop-down menu as shown in Figure 21. The property status can also be changed from the selections provided in the drop-down menu as shown in Figure 22.

Changing and updating the facilities information can be performed by clicking on the box given in the Advertisement (Edit) Menu (refer to Figure 20) while updating the house pictures can be done by selecting the pictures at the

Registered User local computer, where the system will download the pictures information into GRPMIS. Uploading pictures from the user local computer can be performed according to the steps given in Figure 23.

The Registered user can click at the triple dot button (as shown in (1)) and window explorer will open file menu as shown in (2) in figure above. Specific file is chosen to be uploaded into GRPMIS.

Finally, a registered user can also update the contact information by selecting the contact references available in the GRPMIS. This contact information is entered during the GRPMIS registration. This function is illustrated in Figure 24.

Once the Registered user has completed the editing task, Save button should be clicked to store the updated information and a window will be prompted stating the information have been updated (refer to Figure 25).

Besides these functions, a Registered user can also perform other tasks and functions available for the Guest User.

### 6.3 Admin User

The Admin User is the system author. The Admin user has the ability to reconstruct the GRPMIS. Within the Admin User Environment, all the functions are available including the Manage Property function. The Admin user will also have the Admin username and password. Figure 26 shows the Login window for the Admin User.

The Admin user functions enable the registered user to acquire the 3D model and virtual room (model) for their property. The Admin User will be the one who construct the 3D model and upload it in the specific property database. The Admin User is able to access Manage Property function (refer to Figure 27).

Once the 3D model construction is completed, Admin user will update the property information by clicking at the Manage Property button (1) within the Search/View Advertisement window as highlighted in Figure 27. Then, a new window titled Manage Property window (2) will become apparent. This window will lead the Admin User to the local machine storage where the completed 3D model is stored. Then the chosen 3D model and Virtual Room (model) are uploaded into GRPMIS for the Registered User and Guest User viewing. Figure 28 shows the open file explorer result when the triple dot button is clicked at the Manage Property window.

After the related files are chosen, the Admin user will update the uploaded information. When the information is successfully updated, a window will appear informing the Admin user that the information have been updated (refer to Figure 29).

Other functions that are available for the Guest and Registered User are also available for the Admin User. The Admin User has the freedom on how to manage the GRPMIS.

## 7. Testing

The objectives of system testing and evaluation is to enable the system in its entirety to be analyzed and to ensure that the business function for which it was originally intended is being met. These proposed functions will be examined in order to verify the reliability and effectiveness based on the users' perception and technical perception. One could view System testing as the final destructive testing phase before Acceptance testing. It was conducted using the Black Box. The term *black box* indicates that the internal implementation of the program being executed is not examined by the tester. The term *white box* (or *glass box*) indicates that testing is done with knowledge of the code used to execute certain functionality (Tonella and Ricca, 2004). For this reason, a programmer is usually required to perform white box tests. The following sections will elaborate on how these methods are adopted in this research.

### 7.1 The Black Box Testing

The Black Box Testing is also known as *functional testing*. This is a system testing technique whereby the internal workings of the item being tested are not known to the tester. The system testers for this method have no idea with the internal environment of the system. These people only look at the output of certain functions without knowing the rules and logic used in order to get that kind of output. The tester does not examine the coding and does not require having the background knowledge about the programming languages and so on. The focus of the Black Box testing is to ensure the functions are available and able to give outcomes. The advantages of this type of testing include:

- i) The test is unbiased because the designer and the tester are independent of each other.
- ii) The tester does not need knowledge of any specific programming languages.
- iii) The test is done from the point of view of the user, not the designer.
- iv) Test cases can be designed as soon as the specifications are complete.

The disadvantages of this type of testing include:

- i) The test results can be redundant due to the various tester backgrounds and if the testing has already been conducted.
- ii) The test cases are difficult to design.

Under the black box testing, there are a number of sub-testing aspects. Three components were tested for GRPMIS are integration testing, system testing and user interface testing.

#### 7.1.1 Component 1: Integration Testing

Integration testing is required to ensure the related sub-system and software is working correctly. The following list is the step taken to perform integration testing:

- i) Determine the sub-system to be tested.
- ii) Install system into testing machine.
- iii) Perform functional testing against the system.
- iv) Record test results.
- v) Verify the test results.

#### 7.1.2 Component 2: System Testing

System testing is required in order to verify all the system functionality and making sure that these functions is working correctly and conforms to specifications. It is done when all the system functions had been implemented. Steps below are taken during the system testing:

- i) Determine all functions to be tested.
- ii) Deploy the system into testing machine.
- iii) A checklist of all functions and requirements is used.
- iv) Record test results
- v) Verify the test results

#### 7.1.3 Component 3: User Interface Testing

This testing is conducted to rate the usability of GRPMIS. This testing is performed by selected system users or clients in order to find the true ends users experience and perceptions. Below are the steps taken to perform user interface testing:

- i) Install system to the test machine.
- ii) Guide the end user to use the product.
- iii) Give the tester User Interface Test Result.
- iv) Records user comments, suggestion, difficulties encountered and experience during the session.
- v) Report test result.
- vi) Verify the test result.

### 7.2 The White Box Testing

The White Box Testing is also known as *glass box testing*. This is a system testing technique whereby explicit knowledge of the internal workings of the item being tested is used to select the test data. Unlike black box testing, white box testing uses specific knowledge of programming language to examine the outputs. The focus of this test is to examine the robustness of the system construction and looking into the logic, rules and parameters used in order to get certain output. The test is accurate only if the tester knows what the program is supposed to do. White box testing does not account for errors caused by omission, and all visible code must also be readable. The advantages of White box testing are:

- i) As the knowledge of internal coding structure is prerequisite, it becomes very easy to find out which type of input/data can help in testing the application effectively.
- ii) The other advantage of white box testing is that it helps in optimizing the code.
- iii) It helps in removing the extra lines of code, which can bring in hidden defects.  
The disadvantages of white box testing are:
  - i) As knowledge of code and internal structure is a prerequisite, a skilled tester is needed to carry out this type of testing, which increases the cost.

- ii) It is nearly impossible to look into every bit of code to find out hidden errors, which may create problems, resulting in failure of the application.

White box testing is conducted by using security testing and database testing.

#### 7.2.1 Components 1: Security Testing

Security testing is performed to determine the safety measures of user login activity. Information that is uploaded within this activity is unique and redundancy should not exist as it will affect the system performance. The security testing is performed as follows:

- i) System developer choose an anonymous user ID and password
- ii) Perform standard procedure of user registration
- iii) Check the data uploaded
- iv) Repeat the task using unique name and same name to imitate data redundancy
- v) Check the result and determine whether the error is detected
- vi) Verify the error detected
- vii) Test results are reported and verified.

#### 7.2.2 Component 2: Database Testing

Database testing is required to determine the accuracy and reliability of the database design. The steps below are taken for the testing purpose:

- i) The data for testing is determined
- ii) The data server is connected.
- iii) The functional test is performed to ensure that update and edit function is correct.
- iv) Check the test result output is correct.
- v) Verify result with the information stored in database.
- vi) Test result is reported and verified.

Overall, the black box and white box tests have solved three problems i.e. idle codes elimination, display and loading layer problem and finally the login/logout/exit session from GRPMIS. The designed system can be successfully launched with several arrangements, corrections and improvements. The user requirements were then validated and the results are shown in Table 1.

### 8. The Integration Issues and Problems

There are several issues and problems identified during the integration process. These issues and problems relate to the technical and hardware capacity, software availability and timeframe. For the creation of complex three-dimensional models and scenes, time is always a major concern. Time is required for preparing data, modeling buildings, and importing models into a scene. For larger datasets, computer processing and refreshing time may become unacceptably long. These considerations make the use of high-end machines critical. For example, the scenes used in one of the previous study were generated using an Intel Xeon (dual) 3.2 GHz processor with 2 GB RAM.

The hardware requirements are considered when the investigations of the software component were performed. The machine that is used during the investigation consists of a capacity of 80 GBytes hard disk storage, 1GBytes memory (RAM) and Intel Centrino Duo Core Processor 1.66 GHz. The storage, memory and processor capacity does implicate the effectiveness of the system developments. The main challenge occurs during the graphical processing, 3D design and also performing virtual interactive. As a result the higher memory and processor capacity of desktop are needed.

Large TINs demand a high amount of computer resource. Without a sophisticated computer the 3D integration will be sluggish or jerky during the rendering process in ArcScene. ArcScene does not support files greater than 300mb, so large areas of high resolution or very high resolution imagery are not always possible to view as drapes. Again, a maximum of 300,000 nodes are supported which have caused limitation for handling large extents of complex data such as road networks, hydrology networks or property parcels. Any large dataset will cause a significant performance issues and subsequently restricted some of the functions proposed for the system constructions mainly the application of 3D GIS. Table 2 summarized the advantages and disadvantages of the four methods of 3D integration discussed above.

Other issues that arose during the integration and development process was the availability of the ArcGIS Designer License and ArcGIS Developer Kit. License tools such as the TOC Control, Scene Control and Globe Control require the designer license and developer kit in order for them to be available for the execution in Microsoft Visual Basic and MapObject. This control carries a complete 3D data manipulation functions. The unavailability of these controls result

in the limitations of the 3D GIS functions in the GRPMIS. Only SceneViewer Control is available to be used as the 3D GIS function in the developed system. Then again, there are also barriers identified as the programming language used in the developer kit is Visual Basic Application (VBA) and ArcObject is needed instead of MapObject as the companion module. ArcObject on the other hands still require the final user to have ArcGIS, designer license and developer in order to implement the system in their local machine/computer.

## 9. Conclusion

Generally, the work presented in this research shows that the integration of GIS technology into a property marketing information system can be performed. The integration of GIS technology also enables the house sellers and potential buyers to be independent in obtaining information about the house. Embedding 3D and virtual technology can be undertaken with the availability of the software needed for such integration. GIS is highly relevant to property marketing information system as real property is mainly about location. The new technologies, expansion in science, philosophical ideas and increasing number of populations drive to the complexity of the living environment. Business technology as well as other entities must be able to adapt constantly to the modernisation or be left in the dust of the society changes. The information system should intensify and strengthen the communication within the business activities. Internet has become a major communication tool used by commercial enterprise, and government agencies to support trade, operations, and interaction with customers and suppliers and in the property world by and large and property marketing in particular are no exception.

Today 3D GIS (Geographic Information Systems) applications are very useful not only for reducing the hardware costs and increased graphics processing capabilities but also for creating real-time 3D scenes directly from common geospatial and GIS data sources. In addition, there is an unprecedented amount of GIS data being accumulated and available from vendors, government agencies, data suppliers and users and much of this data is in the public domain. Transforming 2D map data into real-time 3D scenes allows users to extract more information from their GIS data. Although the integration of 3D and virtual reality to the GPMIS is not conclusive and contains some limitations, the initial results in this research can be used by the related agencies especially the real estate agents and property developers as the framework and references for future development of a better and conducive property marketing information system.

The development of GRPMIS underwent the standard system development lifecycle (SDLC). The black box and white box testing and evaluation are performed and they show that to complete the testing process is somewhat infeasible. Testing is complex and expensive as it requires expertise and longer time-frame. However, knowing that at some point the developed system has to be delivered, the testing process need to stop. The stopping point can be decided based on time-frame and budget or the developed system reliability meets the requirements. Besides the conventional system testing, the alternative method, such as system or software inspections and clean-room engineering are worth to be evaluated for testing purposes. This is an are for further research.

Finally, GRPMIS design and construction have established and proved that GIS, 3D and virtual technology can be integrated into a property marketing system. Although, the findings have stated some limitations, the research has found that there are technologies available to be integrated and to improve the efficiency of the existing property marketing system. The integration requires four main softwares i.e MapObject 3.2, Microsoft Visual Basic 6, ArcGIS 9 and Sketch-Up 5.

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Table 1. Succeeded User Requirements

No.	User requirements	Succeed
1.	The system should enable users to perform database query and view tabulated result.	/
2.	The system should allow user to perform location query and view projected map on the screen.	/
3.	The system should allow user to perform visual query and visualize query result on-screen and report.	/
4.	The system should provide user with the facilities information for the housing area.	/
5.	The system should allow user to obtain information regarding the housing property e.g. price, built in area, address, owner/developer, etc.	/
6.	The system should provide user with the topographic information of the housing area.	/
7.	The system should allow user to view inside and outside the house in 3D and perform virtual analysis (walk through/fly through and shadow).	The function works with some limitations
8.	The system should allow advertisement (permitted to certain users).	/
9.	The system should enable users to print out the report.	/

Table 2. Comparison of 3D Integration Methods

No.	Advantages/Disadvantages	Method 1	Method 2	Method 3	Method 4
1.	Elevation Model	/	/	X	/
2.	Complete layer properties	/	X	/	/
3.	Simple 3D Features Placement	X	Inconclusive	/	/
4.	Time-consuming	/	/	X	/
5.	Import Process meet Interruption	X	/	X	X
6.	Poor Visualization Performance	/	/	X	X
7.	Affects by machine capacity and memory	/	/	X	X
8.	Dragging Processes	/	/	X	X
9.	Orientation Issue	/	/	X	/

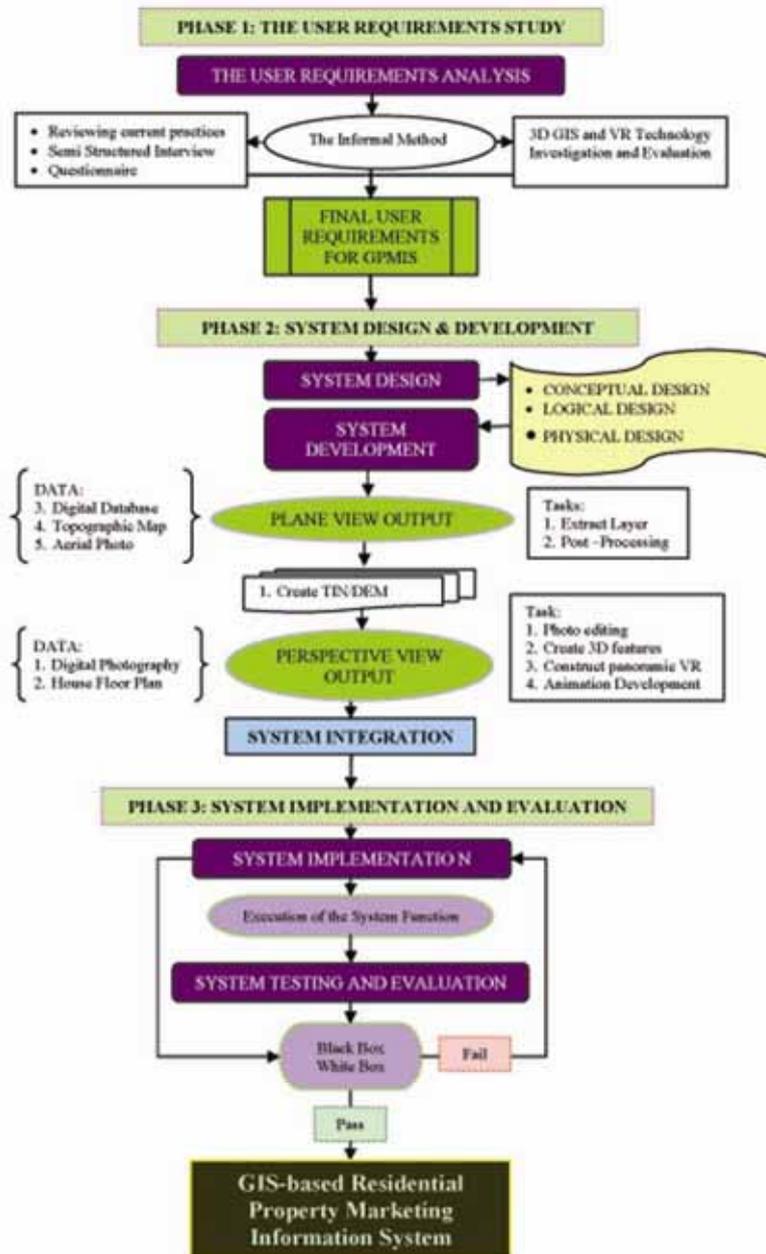


Figure 1. Research Methodology

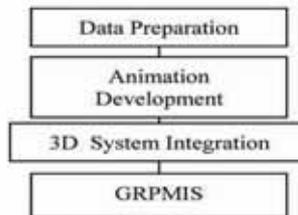


Figure 2. The System Development Workflow

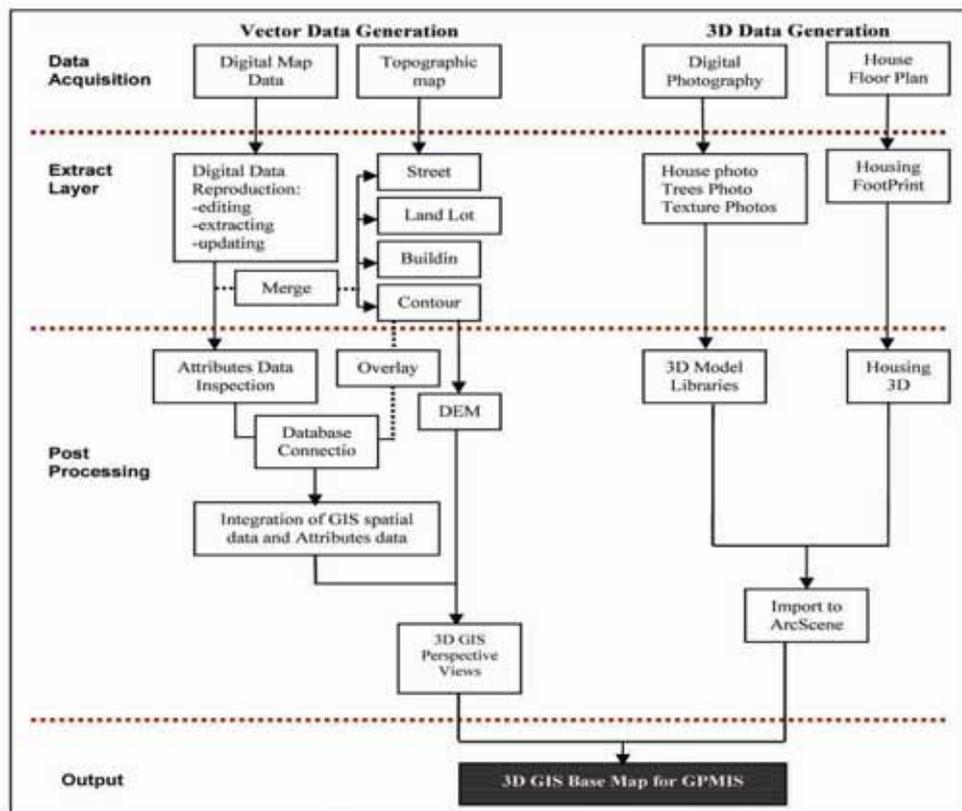


Figure 3. Data Preparation Workflow

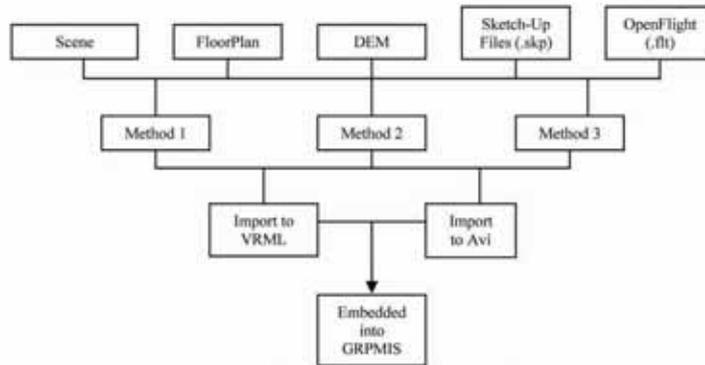


Figure 4. Animation Development Workflow

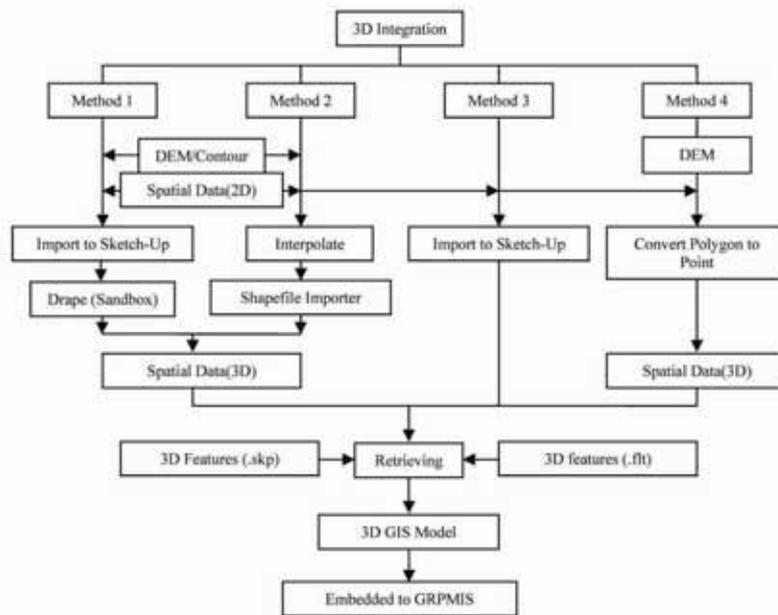


Figure 5. The Four Proposed 3D Integration Methods Examination Workflow



Figure 6. Starting Window

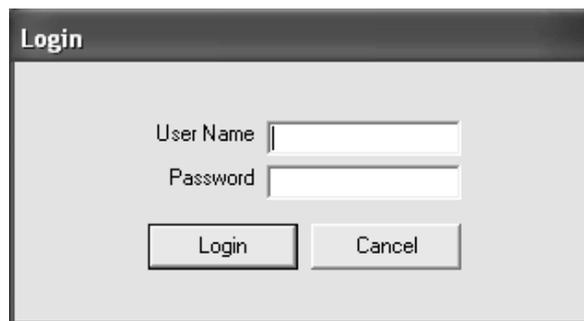


Figure 7. Log In Window



Figure 8. State Selection Menu

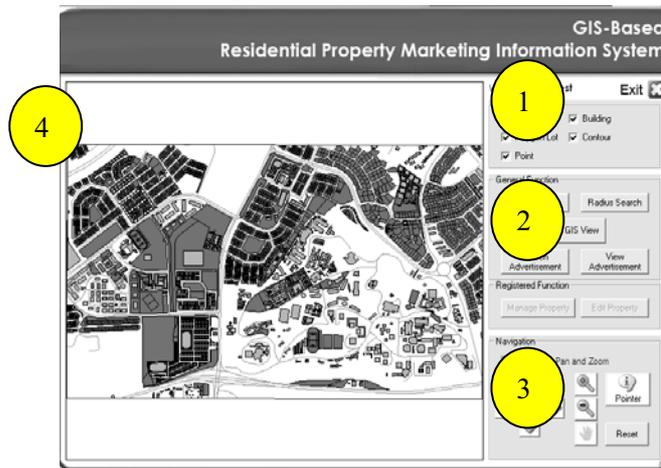


Figure 9. GRPMIS Main Menu

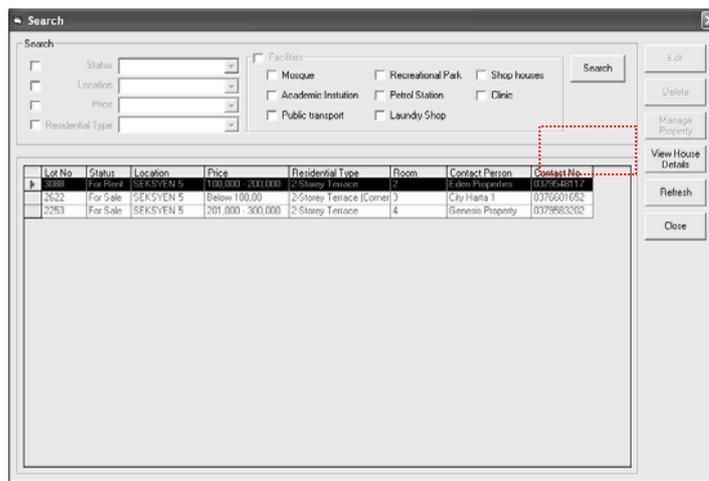


Figure 10. Search/View Advertisement Window

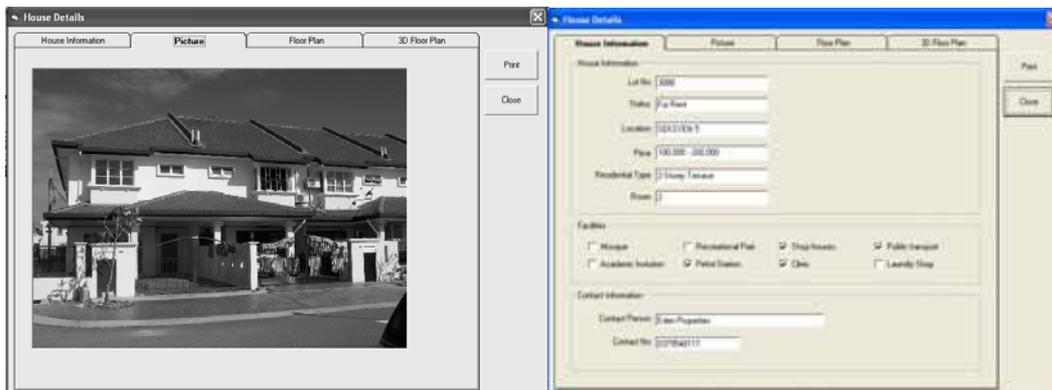


Figure 11. House Details Window (House Information Tab)

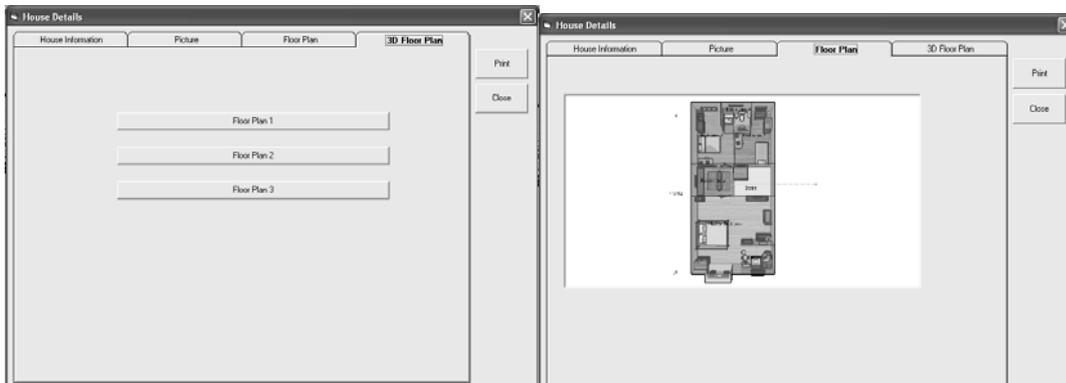


Figure 12. House Details Window (Floor Plan Tab)

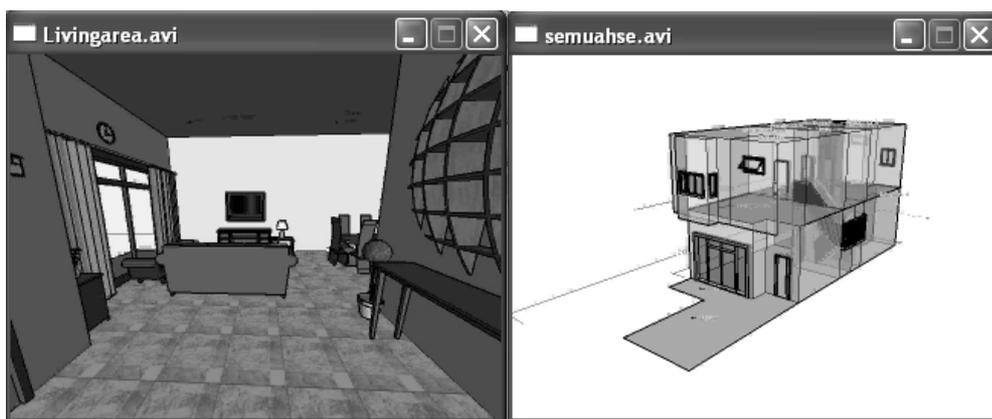


Figure 13. 3D Layout Plan



Figure 14. Access to Property Info from Pointer Menu

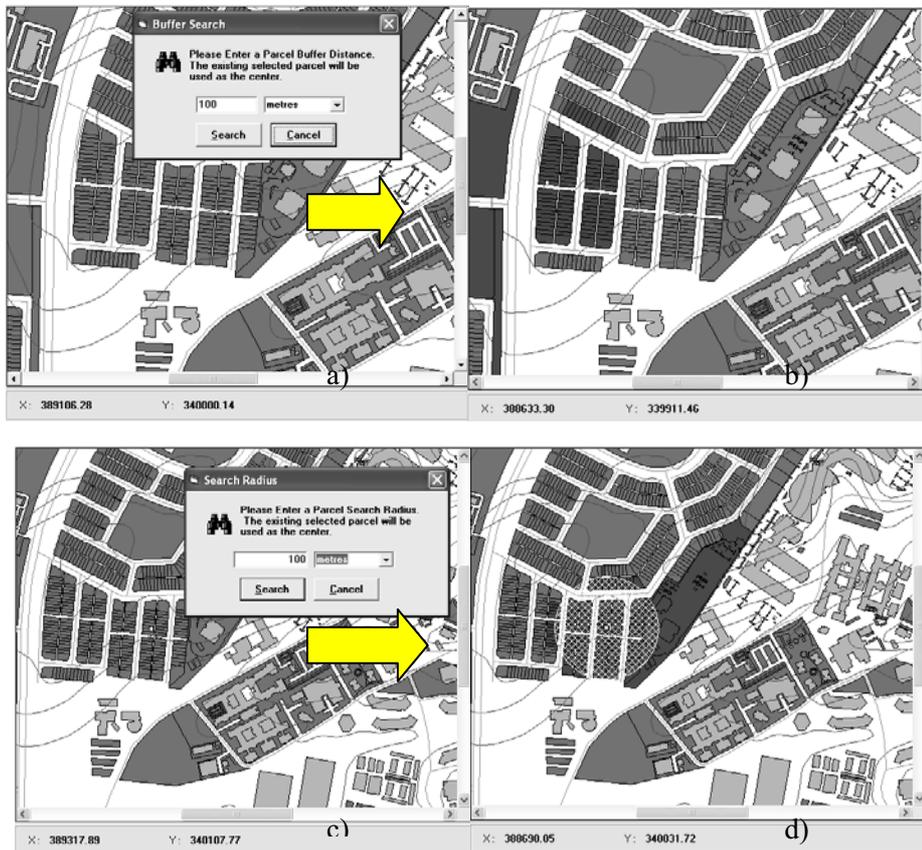


Figure 15. Buffer and Radius Function

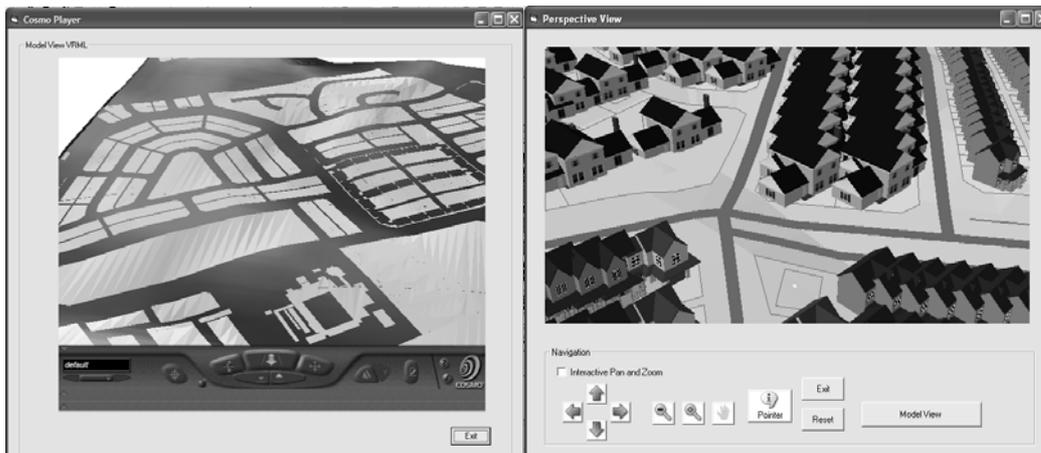


Figure 16. The Perspective View Window

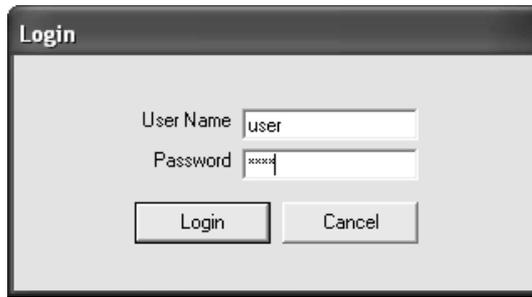


Figure 17. Registered User Login

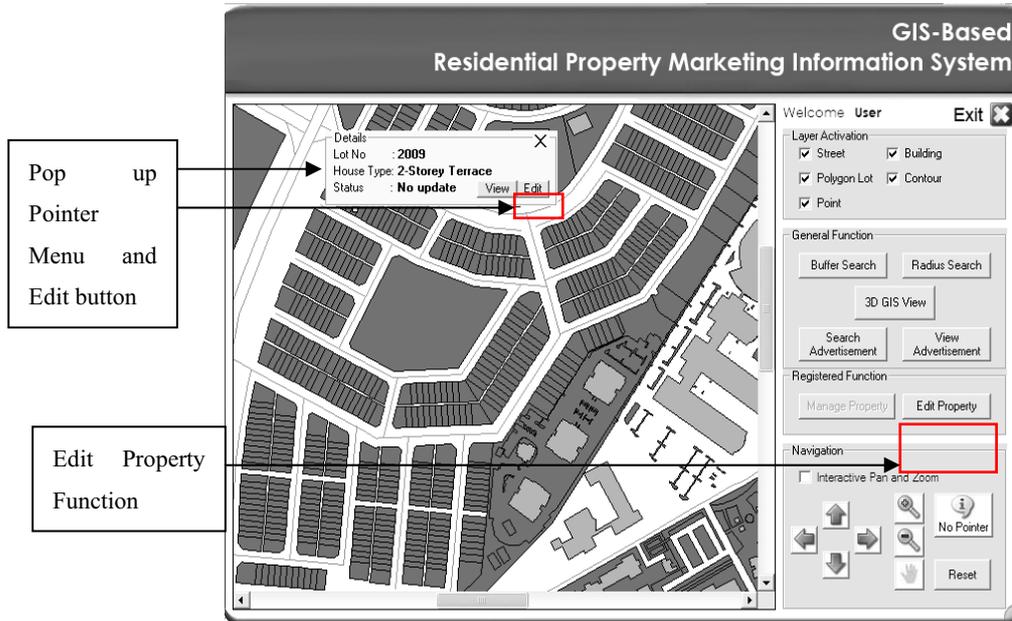


Figure 18. Registered User Main Menu

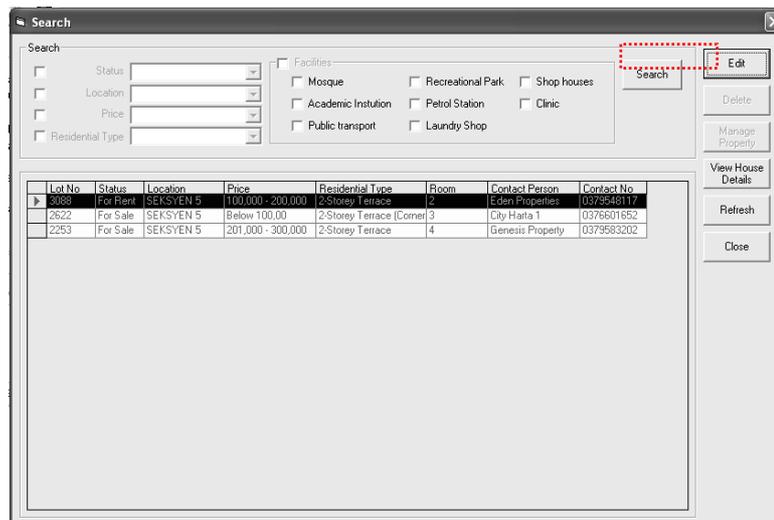


Figure 19. House Details Window/ Edit Button Activated

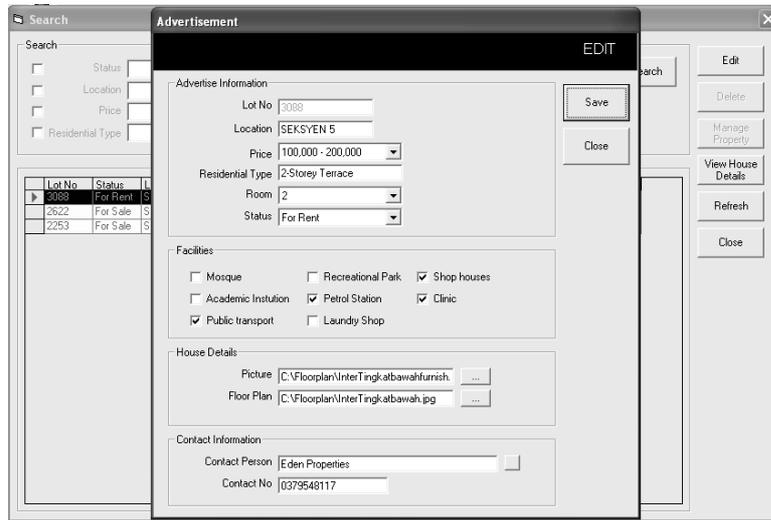


Figure 20. Advertisement (Edit) Window

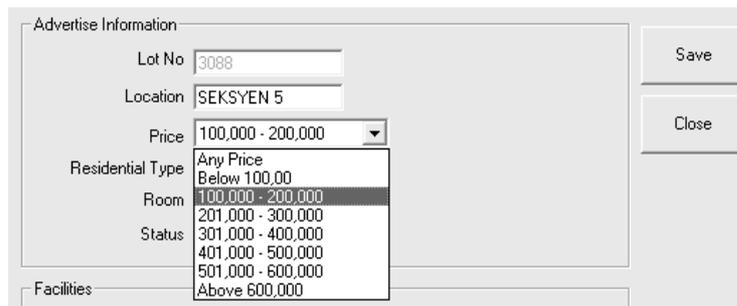


Figure 21. Price Range Drop-down Menu

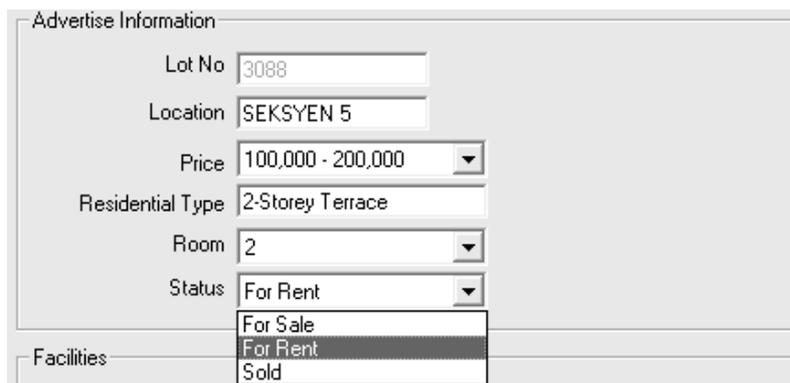


Figure 22. Status Drop-down Menu

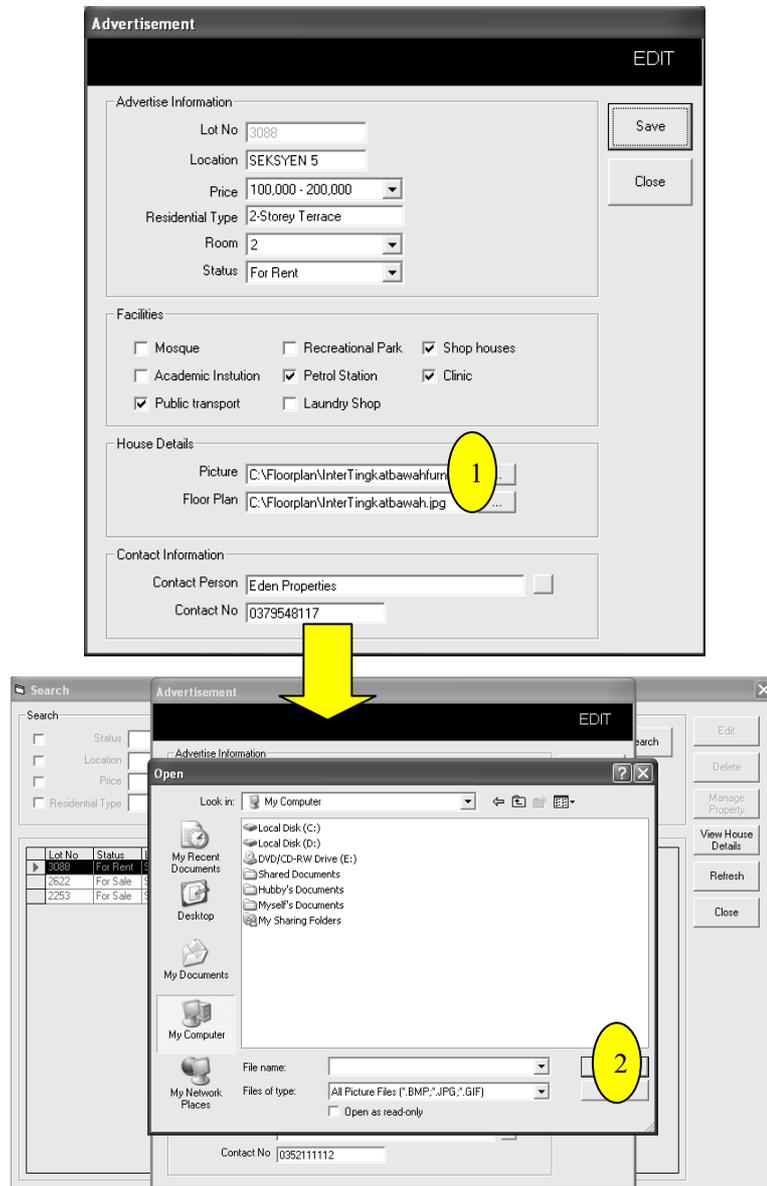


Figure 23. Housing Pictures Uploading Step

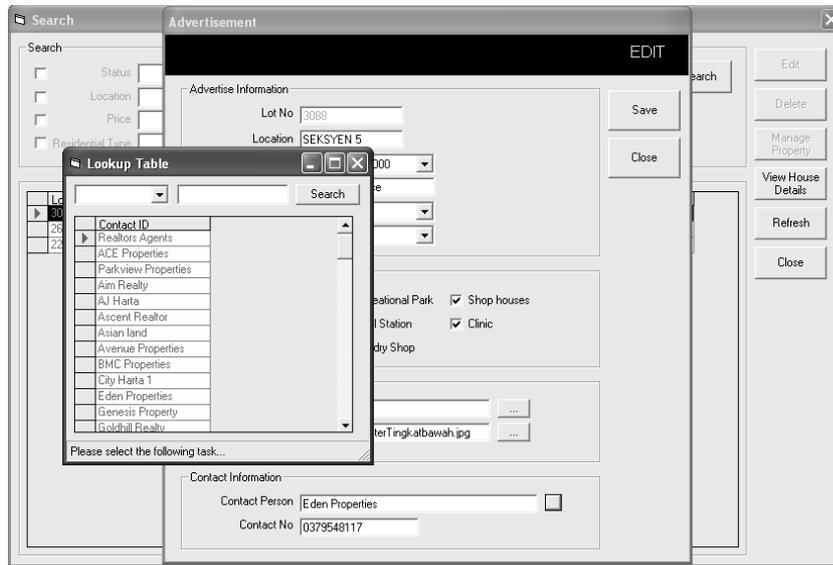


Figure 24. Contact Information Lookup Table

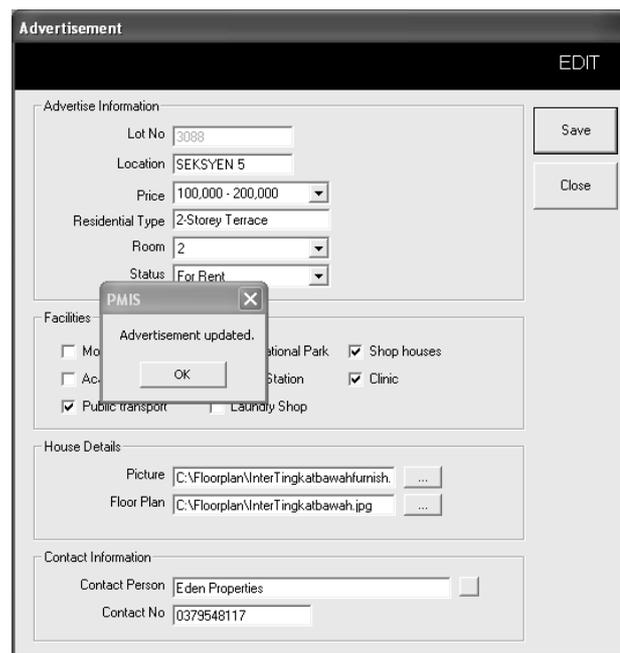


Figure 25. Information Updated Message



Figure 26. Admin User Login

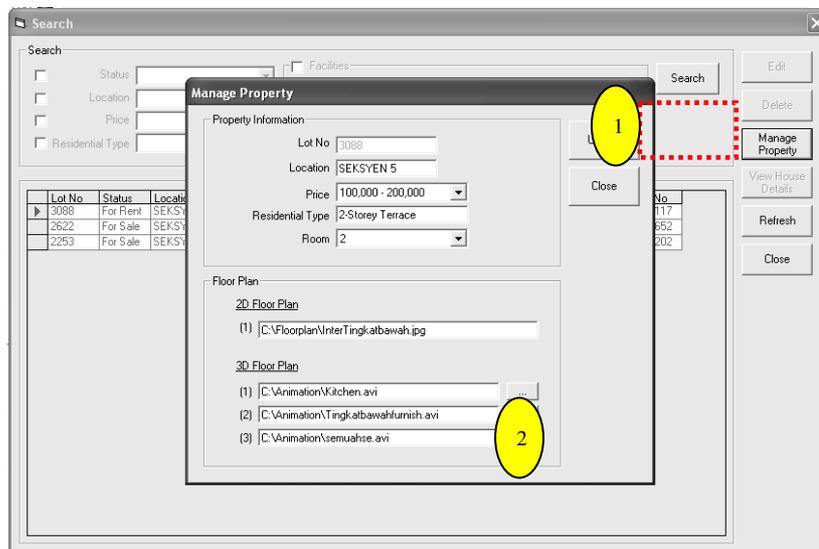


Figure 27. Manage Property Window

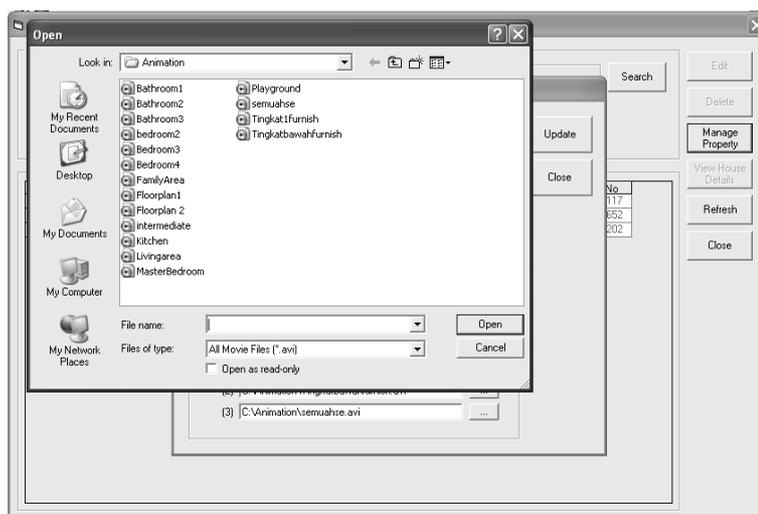


Figure 28. Open File Explorer

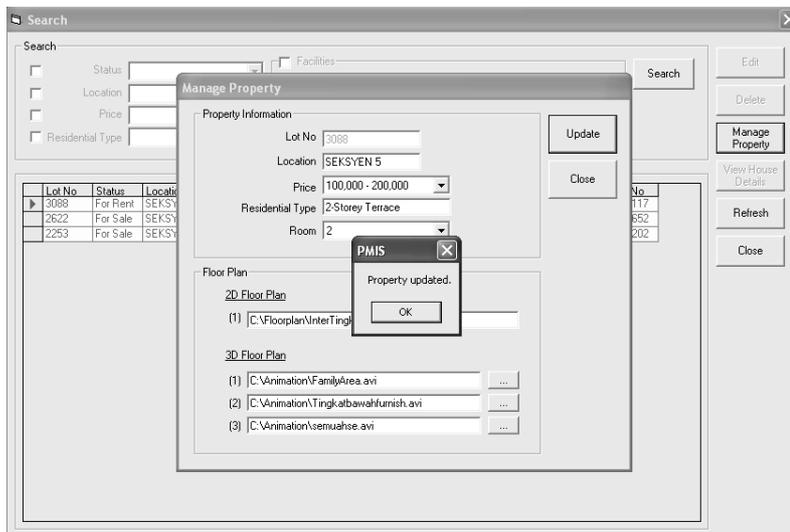


Figure 29. Property Updated Message