Integrated Facility and Assets Management using GIS-Web Application

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Abstract. Facility and assets management has to become a crucial practice in the era of income generation in an education institution, the need to provide better service to the client/student or public as well as minimizing the maintenance cost has become a challenge to the institution. The aim of this paper is to develop a web GIS to store, manage, and manipulate the data in order to maximize the use of space and assets as well as making sure the assets is in good condition. Also, to determine the higher value assets to optimize its use for income generation. The methodology of this study is asset and space data acquisition to store in the GIS database and integrate with another native database (Structured Query Language-SQL) to ensure the efficiencies of data updates. The findings of this study focusing on the capabilities of the GIS to manage, store and manipulate as well as display all the online data with such query, searching and analysis widget in the application. In conclusion, asset and space management in universiti with the modules included in the application has become useful for personnel and assets officials to query, searching and make analysis for preliminary planning and decision making.

1. Introduction
Assets and space are amongst the crucial part in Assets and Facility Management (AFM) of any institution as it is involved in the management and optimizing the space for good use. The management of AFM is a systematic decision-making process about the acquisition, utilization, maintenance, and disposal/renewal of assets that are continually improving over the life cycle of an organization in maximizing social, environmental and economic value [1]. Space management, on the other hand, is an operation of identifying the quality of space, determining the space necessities, and organizing available space to the user, observing the use of the space, accommodate the user with space utilization and resolving space issues [2].

The Universiti Kebangsaan Malaysia (UKM) is a university with vast land and unique geographical conditions with varying terrain. With the vast land to manage, spatial management and development planning needs to be done in more detail and effectively to produce a quality work system including object information (spatial) as well as basic information (attributes).

Geographical Information System (GIS) has the functionality and tools to store, analyze, and display various geographical or position-based information. GIS is a term that refers to a framework for
gathering, store, manipulate, managing, analyzing, present and display layers of information into a visualization of geographic data using maps [3-5]. GIS use spatial data and attributes (additional information about the spatial features) to manage, plan, maintain and making a decision in various application such as development of an area, health related, facility administration, asset governance, inventory operation, land administration and other managements task. In the context of space management, GIS technology is often used as the capabilities of the system to handle and manage such mass data and sophisticated analysis to assist in decision making and strategic planning for decision-makers.

Nowadays, the integration between facility and space management using GIS can be seen as emerged cross-discipline development through many GIS software developments such as ESRI ArcGIS or open sources platform such as QGIS that can assist in handling mass data and implement strategic planning for assets and facilities that available in the organization. Figure 1 shows the applications of GIS across the discipline.

Thus, this study aims to establish an integrated GIS operated platform which integrates spatial database information that consists of the spatial element with traditional database information that consists of assets information in the building space. The objectives are to establish a spatial database of space in the building, to connect between non-spatial data and spatial databases, and to design and develop a GIS system for Asset and Facility Management for internal use.

2. The Literature
This section describes the Assets and Facility Management as well as GIS. It is divided into four subsections.

2.1. Assets and Facility Management
In Malaysia, asset and facility management can be defined as strategic management to conserve the value of the asset and facility in its cycle. The term of asset and facility includes the asset either built environment or nature environment [7-8].

The development of FM in Malaysia was introduced back in the middle of the year 1990 with an aim to optimize the national facilities and its life cycle [9-10]. It is also believed that public sector institutions at that time have no structured way of optimizing public assets, which in turn decreases the value of the assets [11] because of a lack to identify the high performance and high-value assets. The approach of using GIS to manage space and assets is to tackle the issues of identifying abandoned, under-used and

![Figure 1: GIS across disciplines [6].](image-url)
surplus accommodation assets in the organization. Good performance and better asset value are always depending on the asset life cycle as illustrated in Figure 2.

![Figure 2. Asset Life Cycle adapted from Hishamudin, 2018 [1].](image)

The FM discipline covers all aspects of the property, building condition, planning, financing, operation, construction, maintenance and support services. Thus, GIS technology is used in this study in order to provide better maintenance, specifically preventive maintenance to the assets that require a good strategic planning to achieve its highest values, which can give benefit to the organizations [12-13].

Therefore, the scope of these assets and facilities management in this study is subject to the establishment of a spatial database and web-GIS for the assets and space in building in UKM Bangi main campus as the other campus is still undergoing pilot study. For the overall project status, all UKM assets and space (land, building, structures and others) in the main campus or another campus will become a centralize integrated database system for efficient management and minimize the cost of maintenance with preventive maintenance and periodic maintenance in the future as well as the strategic planning to maximize the use of assets and space in order to increase the value of the assets which in turn will benefit the organization in the context of revenue generation.

3. Methodology

The study was conducted to develop the geospatial database, web GIS application and to link the geospatial database with the non-spatial database. The study will cover the main campus of UKM and will be focusing on the GIS application, namely as SEPADU which stands for the Integrated University Asset Management Information System.

3.1. Primary data. The primary data in this study consist of ground measurement where data need to be gathered on site to measure the building and space consisting of coordinate and attribute of the spatial elements such as the location of the building footprint using a Global Positioning System (GPS) with reliable accuracy. Another essential point, remote sensing also played an important role in obtaining reliable and accurate data in this system, which the process of gathering data remotely. In other words, the process of deriving the data from satellite imagery, unmanned aerial vehicle (UAV) or photogrammetry remotely [14-15].

3.2. Secondary data. Secondary data is the data that exist and can be utilized to enhance the quality and accuracy of the system either in digital or hardcopy format. The existing data in UKM mostly is in the form of hard copy format, all the floor plans and as-built drawing plans were scanned and digitized.
according to scale and based on the primary data. There are also data in the form of CAD format already, for this data, the transformation and conversion can be done after some drawing cleaning has been done. Figure 3 illustrates the example of CAD drawing for an as-built plan.

3.3. Data Processing and Preparation
The process is divided into three phases; Phase 1: Data collection, processing and preparation; Phase 2: System and Application Development; Phase 3: User Application. This data can then be used for mapping, analysis, mapping display and the development of web GIS.

Phase 1 is a phase of data collection where all the data needed for GIS Web development will be obtained through fieldwork and documentary studies. For space information, site verification using an as-built drawing on the site has been initiated to obtain reliable data. Assets information data was obtained from the Treasury Department in UKM.

Phase 2 is the phase in which GIS database design has been established according to the data and user requirements that will be displayed in the Web GIS [16-17]. Search and data filtering functionality for users will also be tested [18] and user feedback should be taken into account to maintain the stability and sustainability of the developed applications.

Phase 3 is the final phase of the GIS Web development, as this phase is the system implementation phase as well as application development and evaluation.

3.4. Database Design
Database design is very crucial in the development of a database it is because the design will influence the data that will be presented to the user and ensure that every operation and analysis performed will be smooth [19]. There are differences between a traditional database and GIS databases, where GIS databases store spatial and non-spatial data in a single database, while ordinary databases only store non-spatial data such as text files, tables and etc. This distinction makes GIS an extremely powerful software or tool for storing, displaying, manipulating and analyzing data. There are three phases of database design which are conceptual, logical and physical.

3.4.1. Conceptual Design Conceptual database design is a crucial process in designing a GIS database [20]. In this study, the database that been used is hosting in the UKM server through ArcGIS Server as web service. All the spatial data and attribute that consist of information such as space area, function, height, name, the person in charge and etc. has been stored in the database located at the UKM server. The data will be sorted out in the ArcGIS server, then the data will be published in the hosted services which are the medium to display information to the client [21]. The objective of storing the data in the server is that it is more secure and saving space as the spatial data and the attribute will be converted to the services in the format of URL. Figure 4 illustrates the concept.
3.4.2. Logical Design

Logical design is a process to sort and manage all the attributes and information one entity in one environment to the structure of the spatial database as the table or database connection [22] or, in general, it is a point of view of end-users in the environment. Figure 5 shows the diagram of logical design.

![Diagram of Logical Design]

**Figure 5. Logical Design.**

3.4.3. Physical design

The physical design is the process of implementation and realization of the conceptual design and logical design of the GIS database before the physical design has been done. Physical design can be defined as the process of implementation to produce a GIS database based on user requirements. The GIS database has been linked to the native database (SQL), which stored the data for assets. The primary key for the joined and relate is the MySpata field, which will allow access to the SQL database which holds the data of assets in another department in UKM. Figure 6 illustrates the physical design of the GIS database.

![Diagram of Physical Design]

**Figure 6. Physical Design.**
3.5. Application Design and Development (online map)

The conceptual design of the application is based on the database design, it is because the designing phase in the application is based on the data that has been acquired. The application developer needs to follow all the user requirement specification such as type of query, type of function needs to be included and the best design of GUI need to be used. Figure 7 shows the modules of the application.

![Diagram of Application Modules](image)

**Figure 7.** Application modules in Web GIS.

3.5.1. Information Viewing Module

Information viewing module is the basic module in the development of GIS web applications. In order to display the data and provide the user with the most efficient delivery, the interface selected for this application is Operation Dashboard, which provides the overall view of the data, which includes summary or statistics on the right side of the display. The use of such
interface themes can deliver information to users more quickly as this theme will display information as a panel operation, in other words, all information is summarized and displayed in a summary form without the user having to click and select the menu in the application.

With this summary or reporting information in the application, the end-user can use it as a reporting tool and have the basic information such as total block, gross area, building category and physical audit progress. These features make web GIS a great medium to deliver the information efficiently, especially in manage, planning and decision making for the authorities. Figure 8 illustrates the Web App editor to edit and chose the themes.

![Operation dashboard in WebApp editor](image1)

**Figure 8.** Operation dashboard in WebApp editor.

The development of the application is using the Web App Builder for ArcGIS, which allow the developer to customize all the widgets or functions in this editor according to their needs and requirement. In this phase, all the process of connection between GIS database and native database needs to be done in order to display the assets in the space to the end-user as easy as it can be. Figure 9 shows the GIS web-based.

![The operation dashboard](image2)

**Figure 9.** The operation dashboard.

Based on Figure 9, the layout of the menu from the selection of the layer is located on the right side since it is the GIS web that was developed to make it more user friendly by locating the menu at one
side, which is in the right side of the screen. Summary of the information for total block also has been key in as to give quick information to the user that used this application and also the statistics of the building category as the information. This is suitable for the themes as this theme is often used to give a quick summary report and not only limited to the summary report but also suitable for reporting the overall entities in the form of interactive mapping. Figure 10 and Figure 11 show the menu in the GIS web.

![Figure 10. Layers menu](image)

![Figure 11. Query function / analysis](image)

Figure 12 shows the study area involved in this study, the base map is a fusion between ESRI base map and UAV imagery. The building footprint also has been overlaid to deliver the information about the location to the end-user. The user was also able to use the basic function of zoom in and out to get a better image resolution. Figure 13 and Figure 14 show the space and assets information.

![Figure 12. The study area in the Web GIS](image)

3.5.2. Query Module  
Query module is the core module in the development of GIS web applications and as a crucial module in the application. The reason is most GIS application is developed to access to the information as quickly as possible thus the development of this module requires a good research in order to link the database so that the display can be accessed quickly. The search menu is placed on the right side of the screen to make it easier for users to use the menu function if needed in order to find an asset based on the criteria set by the system developer.
4. Conclusion

In summary, this project sets out the aim to establish the spatial database and relation between databases and to develop the Web-GIS with various modules based on user needs. The integration between spatial and non-spatial databases to display in the Web-GIS shows the capabilities of the GIS system to integrate facility and space management and delivered the information effectively. It has been shown that the current implementation of the GIS system in UKM Bangi are very useful in asset and facility management which to plan, manage and auditing, although the system is still in developing mode. The good facility management system will benefit the institution to optimize space and asset utilization in order to determine the high value assets to be the cost-efficient solution in the long term. Thus, UKM facility management (SEPADU) will be integrated with other UKM branches in the future for the efficient and cost-efficient in FM maintenance.

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