

## Increasing the Detail and Realism in Web3D Distributed World

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### Abstract

*A complex and detailed Web3D world which represented the physical form of an institution is very difficult to be built. To simplify the work, raster images taken from the real structure were heavily utilized. However, this method has resulted in Web3D sites which were low on detail and having minimum level of realism. To overcome this deficiency, it is proposed to maximize the use of polygons. Experiment was done by re-developing the sample world with minimum use of raster images and applying polygons to 92% parts of the site. Site elements were also distributed to three servers to cope with bottleneck problem often occurred when using only one server. The result was evaluated in a series of tests to see its viewing capabilities when displayed inside the web browser against various conditions, and it also evaluated in an acceptance test carried out by site users. The majority of testers felt immensely familiar with the details shown by the model as they were able to grab a more close-to-realistic experience like a real-world walk around inside the actual building complex. Problems that often occur when using only one server can also be reduced by using distributed world method.*

**Keywords:** web3D, realism, detail, distributed, world

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### 1. Introduction

Institutional websites are largely built as 2D sites, while they can provide interesting display and useful features, they are not capable to provide any visitors the immersive feeling of being at the particular place. Users want an alternative style of look and interactivity that allows them to appear as if they are in the institution and do activities in it. Virtual reality (VR) became an option because of its increasingly widespread use and thus become an important part in the development of computer technology [1]. Education providers are one of the institutions expected to have the ability to make visitors feel like they have been present at the representation of their campus. Online virtual representation in 3D style is needed for the main purpose of giving students and visitors a way to virtually interact with others as if in the real world inside the physical properties of the campus by utilizing the web [2]. Online representation using 3D VR can become a new way to interact with the environment [3]. Furthermore, 3D interaction can provide a better experience to visitors of the website [4]. An online campus in 3D can be a way to better understand the many aspects of it [5] in terms of the VR principle.

The online version is intended to become a representation of the real world campus structure, so a highly detailed model has to be created as the main content for the site. In addition, the 3D view must have an interaction style like in the real world so that the visitors can navigate inside as if they walk around inside the real campus [6]. Furthermore, the site can be used as a base for real-time online learning activities which will enable the students and lecturers to meet each other virtually, in a visual scene that can be designed as if they have a session in an actual classroom. Classroom using 3D virtual worlds [7] can provide a different learning experience compared to online 2D virtual classroom which relies mostly on text, audio, and/or video.

Common problems have been found on the development of Web3D sites which attempt to visualize very large and complex objects. One of them is the need for large amount of time to create the model in full 3D [8]. The problem is getting bigger when all resources for such complex site were placed in a single web server, since detailed object descriptions usually need

larger files [9]. Large-sized files can create bottleneck in file transfer [10]. Although file compression technique can be utilized to reduce 3D object file size [11], not all Web3D formats can take advantage of it [12].

The purpose of this research is to find out the effects of intensive use of polygons to create large scale high-detail models in order to build a close-to-real online representation of campus structures using Web3D technology. Primary requirement for the site was that it has to be able to be traveled by visitors in high detail as if they actually cruised inside it, without too much noticeable degradation in visual performance caused by intensive use of polygons and their visual effects. The previous experimental research has developed a world which relied heavily on images to create impression of shapes on low-poly base models. The world has quick loading time and fast response due to its minimum use of polygons. However, responses of the visitors were far from expectations because the display of model with minimal detail has failed to make visitors felt like they were visiting and interacting in the campus building complex they have known. Further research need to be done to increase the visual quality which will in turn enhancing the overall experience of visitors, by using more and detailed polygons as the primary objects representing the campus buildings. Additional details must not slow down the transfer of files from server to user's computer.

This paper presents the result of applying very large portions of polygons to a world in order to create a more realistic view of the modeled structure from any range of view. Furthermore, this paper also presents the steps that have been done as an attempt to reduce the possibility of file transfer problems by spreading the files that form the world to separate servers and thus creating a distributed world [13], a world where its forming components were originated from two or more different servers. The results have shown that the world comprised of almost entirely polygons has provided much more immersion and familiarity for visitors compared to the world which comprised of lower detailed polygons even though it was using rather high-resolution texture images. Despite slower responses in navigation and interaction were observed, overall experience felt by the testers were much better and more realistic.

## 2. Related Works

To develop a complex world and also avoid the long development time, most developers took the shortcut by using images taken from the real objects. The images will be added as a skin on the surface of simple polygons. This method of using texture map would show a small resemblance because it has some similarities with the real objects [14]. However, many developers used low resolution raster images for the skin to release the strain on browser rendering process and the network load [15]. This is why when visitors of such Web3D site approach some particular view displayed in its world, the visualized display of the object does not look decent to be observed at close range. The Web3D world which seemed fascinating at first, turned out to be enjoyable only when viewed from afar in terms of navigation distance. This pixelization problems can be seen on some campus Web3D sites such as [16] or [17]. Figure 1 shows pixelization problems on one of the worlds.

In order to provide a better browsing experience, Web3D site content walk around by visitors has to be done in a close range navigation type. Thus, the Web3D site need to have a high level of detail by using high numbers of polygons to make sure that the 3D objects are still in acceptable view level or at least still looked smooth and realistic when the visitors get up close to watch the object at the minimum range of view. Texture map should only be utilized as an addition and not the primary forming view, and for some specific places only (such as floor, ceiling, and similar other objects). However, full realism will always be very resource-demanding, due to the natural complexity of real world [18]. As shown in Figure 2, in a low detailed world, a wall with a window can be formed from a simple low-poly primitive box. A texture image which depicting the wall with its window can be laid on the surface of the box. In a high detailed world, the wall object will be formed from polygons which follow the real-world shape down to its indentations, bends, and curvatures. The window will be depicted as a separate object also with its indentation and all other properties. Its wood, glass, and metal portions will also be made as specific objects.



Figure 1. Pixelization in a 3D model of a campus [17]: (a) when viewed afar, (b) when viewed at close range

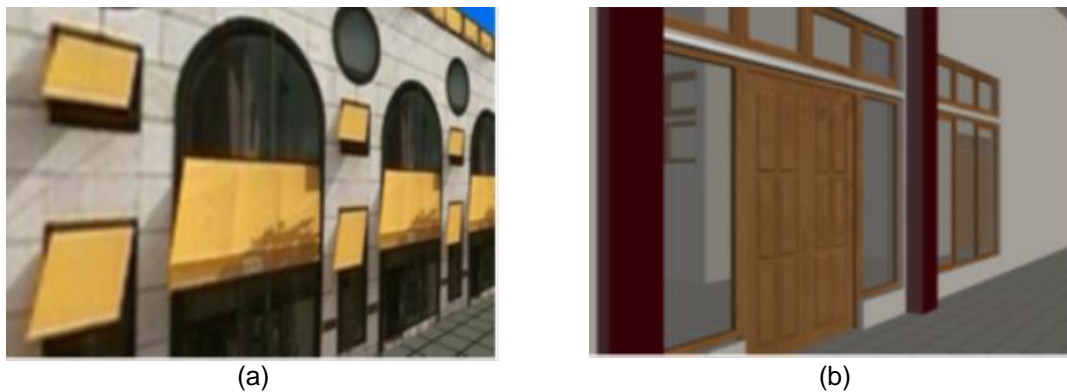


Figure 2. Comparison of low detail object against high detail object that intensively uses polygons: (a) a wall formed from one simple polygon with a texture image covering the whole surface, (b) a wall which is actually a set of objects which were all polygons, the glass materials on the windows have been set to show their transparent properties

As high detail polygons provide a better experience to users, larger files were usually created as the result of adding more details to the 3D models used for the world [19]. There are effects on the overall file transfer performance when large files were used in a server [20]. Other effects came from server load, network load, and network path. The aforementioned research has shown that regardless of server load, delays came from large files always happen in the network traffic. The research also suggested that performance improvements should be possible by using small files. Performance can be improved more by distributing the files to a number of web servers using distributed file systems [21] so that more visitors can get the files simultaneously with small performance degradation. However, as the basic properties of distributed file system [22] in the server used for this research were not fulfilled, and to simplify the development process, this research has not utilize any specific distributed file system.

### 3. Site Development

The research has been done by experimental method. For the experiment, the third campus of Universitas Ahmad Dahlan (UAD) has been chosen as the sample object. Initial step begins with determining the format to be used. It needs a format that is currently widely used and easy enough for visitors to use it in their browser. Nevertheless, the selected format should also allow development in a shortened time.

### 3.1. Format Selection

Web3D technology used in this research is the VRML format of the latest generation which is VRML97 as described in the [23] and [24]. VRML files are text based [25] ASCII format [26] so it can be easily read and modified by users. VRML was chosen for this research instead of the newer X3D mainly because it offers many simplicities in development processes. VRML97 language technology are still adopted by many 3D modelling softwares. These softwares enables any developers to export the model they created to VRML97 format which in turn will enable it to be modified in much more detail as needed by the requirements [27]. Since the sample campus is a large complex of buildings, the use of modelling software is imperative to shorten the length of world development. Therefore, to make sure the development time in VRML format as short as possible, the rapid development method [28] has been adopted. This method relies on some support tools including modelling softwares which support VRML format. However, since X3D is the more recent standard format developed by Web3D consortium for future needs [29], a study to utilize the X3D technology for the campus world have been initiated by using the result of comparative research on both formats [30] to prepare for full conversion in the future.

### 3.2. Basic Visual Design

To add more immersion to the potential visitors, a set of lighting has been added to the main document configuration. With this built-in lighting, site visitors do not have to set their headlight on to get the most realistic view. Also, a simple Level of Detail (LOD) visualization technique [31] was incorporated for some certain viewing range so that the scenery can be rendered faster. The technique was implemented in 3 levels, (1) the first level displays full polygon at the viewing range of 0 to 10m; (2) the second level displays a lower detail of polygon at the range of more than 10m and up to 30m; and (3) the third level at the range of more than 30m, in order to minimize the use of computing resources, all details will be removed, leaving only simple polygons with simple details. There were no raster images in the form of texture map used as polygon replacements on any level of the LOD. Transparent object properties as in window glasses are still retained for all viewing range, nevertheless texture maps were removed from the second level.

A set of additional customization has been included to limit the viewing distance, which is also expected to reduce the computing load on the visitor's computer. Using this visibility restriction, when the distance of visitors with objects exceeds 60 meters, then the object will simply disappear from the view. This is particularly useful since the world is a representation of complex of buildings, some specific objects such as a part of the building is generally covered by other objects in the form of buildings so it does not need to always be rendered in the browser.

As the whole world was modeled from the real-world structure, the measurements and scale of all models were also adjusted to accommodate the appearance of large objects. To offset the surface of large size polygons, textures used for the skins are high-resolution images. This approach resulted in a very large rendered models with their high details which made the navigation speed significantly dropped. To overcome this problem, the default navigation speed was multiplied 200 times from normal/default speed. The result is a close-to-fair in-browser viewing speed with some noticeable loss of frames, depending on the computer system used to browse the world.

### 3.3. Interaction Plan

Active interactions with full 3D contents were designed in two ways as described below. This interaction selection is based on tasks in 3D Web UI which based on viewpoint control, selection and manipulation, and system control [32].

#### a. Manual Navigation.

Manual navigation method allows any visitors to completely control their navigation and movement inside the 3D world using standard keyboard or mouse.

#### b. Pre-defined Automatic Navigation.

In the automatic navigation method, visitors are no longer fully control their own navigation and movement inside the world. This navigation method enables any visitors to automatically explore certain areas in the world within a predetermined exploration path.

Pre-defined navigation was needed since there were chances that the visitors might not have the idea on where to go after they landed inside the world. Leaving the user unassisted can lead to a number of usability problems, ranging from navigation issues (e.g., wayfinding) to difficulties in figuring out which operations can be performed on the objects in the world [33].

### 3.4. Object Sampling

Sampling was done by scanning some design drawing scrolls supplied from the principal contractor. This work produces the basic sample model planned to be use in the first phase of development using AutoCAD software before being refined using 3D Studio Max [34].

In addition to modeling, sampling was carried out by taking sample pictures of objects with minimum need of detail but has many repeating use (e.g. tile, floor, concrete block, iron fences). The raster images/bitmap were used as references in creating the necessary high resolution texture maps for particular 3D objects created in development.

### 3.5. Documents Preparation

Development of the modified Web3D world for the campus site produced the main model file constructed by 3DStudio Max which has 228MB in size. This single world file is then broken down into separate files to reduce the total size of the world components. The later steps produced a total of approximately 162.6 MB file size which consists of 391 files, thus forming an overall basic model which can be considered as a modular world. The overall file size was deemed too large since all components have to be downloaded before the rendering process took place in the browser. Figure 3 shows the development process sequence before the site was ready to be uploaded and tested online. This sequence was based on rapid development method as aforementioned in previous section.

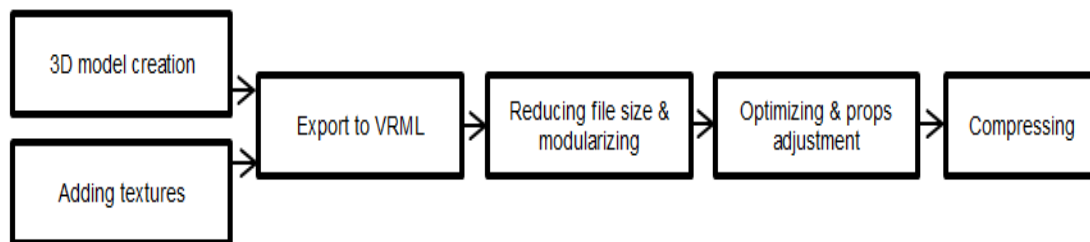


Figure 3. Development process sequence, first phase

The next step was partitioning processes, modification of objects definition to decrease their complexity by reducing the detail of polygon coordinates. Some files went further splitting process since some parts are reusable by additional scale, orientation, dan position attributes. The result was reduced segment details to speed up the rendering process, but the overall view was almost identical to the previous version. Once the model files have been optimized, the compression step can be done using GNU zip [35]. This step produced 452 files in VRML97 format with the overall file size is 51.7 MB. When added with raster image files for the texture map, overall size is increased by about 14.9 MB.

### 3.6. Initial deployment

Resource map were depicted in Figure 4. Included in the primary file were references to the constituent resource files, each file can refer to other constituent files, and so forth. The rightmost of each section consisted of referenced files and configurations which were the basic objects and nodes forming the bigger and more complex objects.

First deployment test puts all the files into a single web server outside the internal network used for the research. The web server used in the deployment test were actual internet web hosting, with the aim to see how the results if the world accessed by visitors through the internet network. Complete loading of all objects for initial view took 19.62 seconds in average

on the test computers, 16 computers equipped with consumer 3D graphic accelerator card specifically used to test the site component transfer simultaneously. These test computers were part of multimedia computer laboratory with high-speed network access. High-end computers were selected for this preliminary test since it was focusing on transfer and loading time, the use of high-end computers will render the world in very short time leaving the remaining time for transfer and loading of constituent files only. Actual rendering time values were only measured using low-end computers.

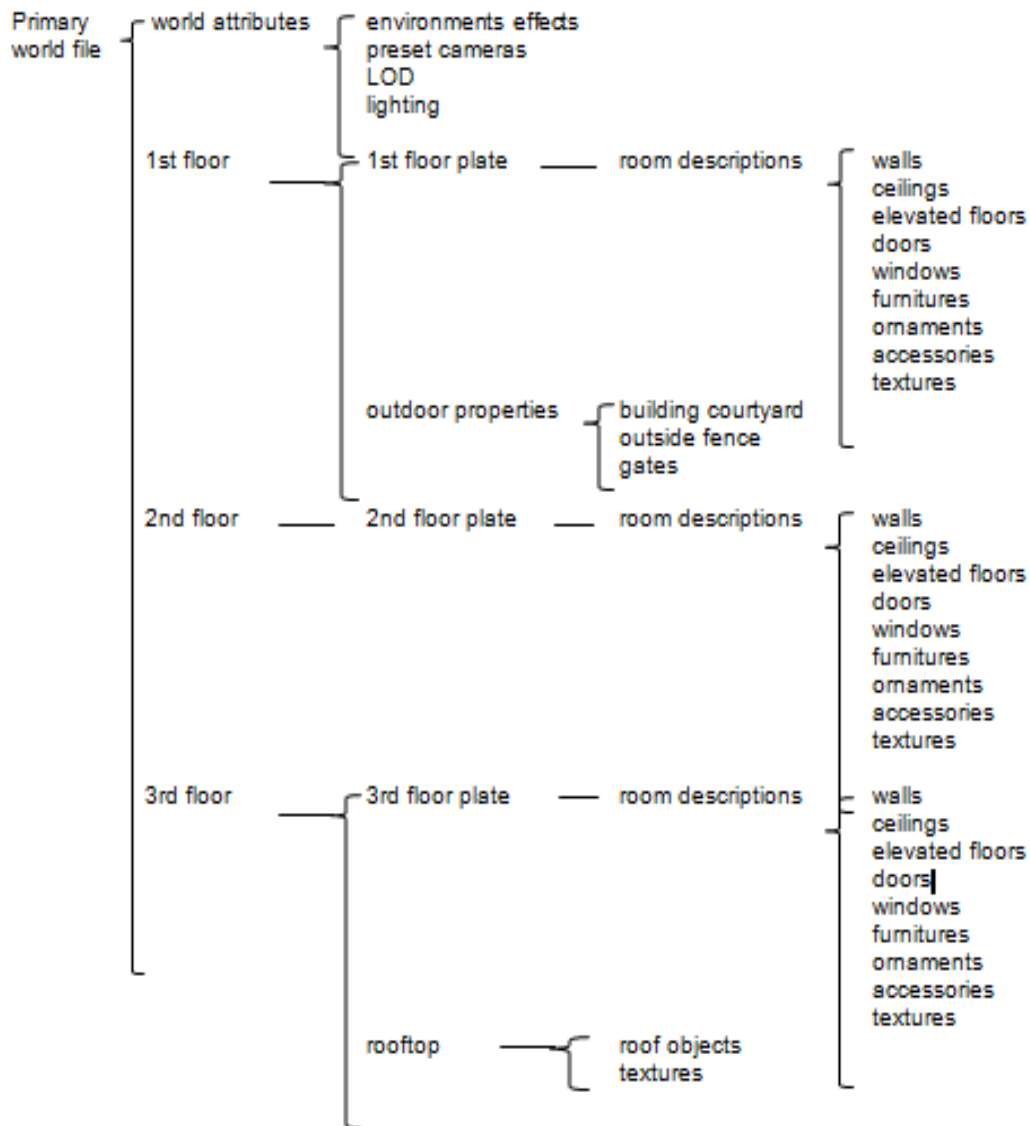


Figure 4. Mapping of resource files

Figure 5 shows a detailed sample of 3D model in the form of a set of windows and door that are used repeatedly at various locations in the world. This model set were created from all polygons. Images were only used to characterize the material, and not to give the impression of shape or form. Seen on the sample are ornaments, door panels, detailed indentations, transparent material on window glass, wood texture addition, metallic door handle, detailed and precise trellis shape, and shiny material on the trellis. High accuracy is obtained because the model used the size and shape of real objects in the real world.



Figure 5. A sample window-door set used in the world

Unless configured properly using additional world properties, static Web3D sites like the one used for this research use all constituent files to draw the entire world so that any visitors can explore any location inside the world any time. Therefore, all resources that constitute the world must be delivered first to client computers before it is displayed in the browser, regardless of any features added to the world. The use of LOD, viewing distance, and other properties were basically to make the navigation process smoother for visitors, only after the resources have arrived locally in the visitors' computer. Properties defined above will assist to limit the rendering process so that the most processing resource can be focused to provide the best display at close range to visitors.

Based on the characteristics of Web3D site mentioned above, potential problems can arise since the number of site visitors may increase in the future. Nevertheless, a world can be composed of many worlds or other objects that can form the world and can come from many servers at once. This distributed world feature of Web3D technology can be useful not only for the purpose of building a single big world in a shorter time [36] but also to share the file transfer load. Therefore, constituent files have been placed in different servers so that the file transfer load could be shared among servers. Moreover, resource file distribution was also to cope with possible problems due there are many large 3D model files.

The file must be sent completely to the client computer in order to be displayed in the browser, since a slight error in the received file will make the object in the file unable to be rendered by the browser. First deployment tests on a single server has shown that in some point, rendering process have to wait for the entire file to be transferred, and these events have made some of the testers wondered that perhaps the browser has failed to load the scenery or even crashed in the process. Based on the observations, average stops for a minimum of 10 seconds were as much as 16.2 times from 40 attempts to explore the world on each computer. Nevertheless, actual average loading failure were 11.4% from all attempts.

### 3.7. Distribution of Resource Files

Before the constituent files of the world are deployed to a separate server, some substantial changes must be made on most of files used by the world, particularly on the component references and also on the ordering of components that has to be adjusted in order to gain maximum advantage from deploying resource files to different servers. The 3D model files needed to form the complete world consist of 41 larger size files, 170 medium size files, and 239 smaller size files. All files have been distributed to 3 different servers from the same hosting provider. First server holds the smaller files which are 10KB or less, along with primary document and all raster images. Second server holds the medium size files which are more than 10KB and up to 100KB, and third server holds the larger size files which are more than 100KB. With only 36 files of raster images, 3D model files comprises 92% of all resource files used in this world.

Figure 6 shows the next process sequence that has been done to prepare the resource files before distributing them to the servers. This second phase concluded the whole world preparation process. All world files produced from this phase were re-compressed to minimize the space and to ease the transport process between networks. To make sure the files can be identified as compressed files, the extension of all world files were changed to .wrz.

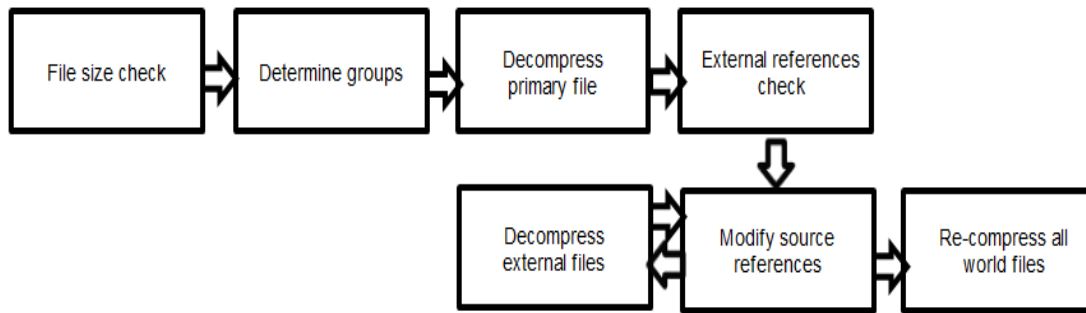


Figure 6. Development process sequence, second phase

In order to minimize the time to get the other server which host the separated files, referenced server name was using the servers' IP addresses instead of their name. After all files were modified and uploaded to 3 servers, another sequence of deployment test then took place. Figure 7 shows the distribution of file transfer load to the 3 servers.

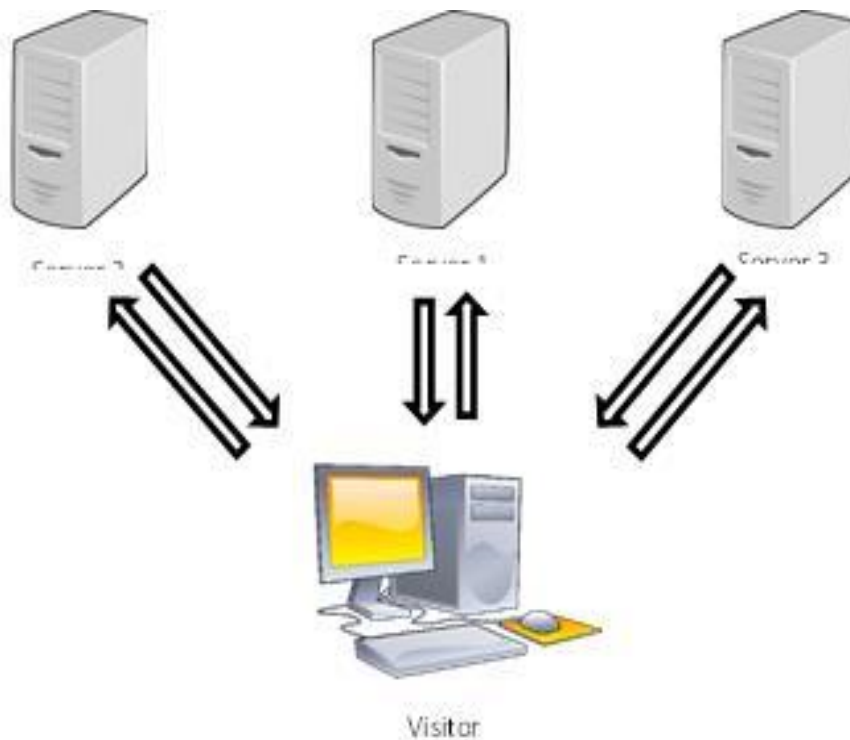


Figure 7. Distribution of file transfer load

#### 4. Results and Discussion

Polygons used on this research were entirely made from triangles. As a default type of polygons for Web3D, triangles provides the fastest speed of rendering inside the browsers. Therefore, either Quadrilateral, N-gon, nor Visible Edge were selected as the rendering mode. As the world is using real-world measurement unit and scale, and there were many high detail small objects in the world, all polygons defined in VRML documents have three digits precision on all coordinates. Additionally, there were no specific normal value defined, no color information on all vertices used by the objects, and no coordinate interpolator inserted. These



settings were meant to minimize graphics processing loads to the browser since all those values would add more calculation for rendering process.

Basically, the distributed world feature implemented in this research works like the following: (1) Browser calls for the primary world file from the first server; (2) First server send the primary world file to the browser; (3) Browser loads the primary world file; (4) Browser sets up the general environment according to the settings found on the primary world file; (5) Browser starts to look for constituent files according to the order specified in the primary world file; (6) If the required files are in the first server, a request for the files will be send to the first server; (7) The first server then send the required files; (8) Browser loads and renders the files; (9) If there are any texture map needed, browser will ask for the image files from first server; (10) Browser will map the image to the surface of the object; (11) The same applies to constituent files located on the second and third servers; (12) If the constituent files require other files to form a complete object before being rendered by the browser, browser will send a request for the files to the appropriate server; (13) The server that gets the request then sends the required file; (14) Browser will continue to look for any other required files on the primary world file and all constituent files received from any server until the last constituent file has been rendered in the browser.

Table 1 shows the comparison between the original world with low detail and polygons, the re-developed world deployed on single server, and the distributed world version of the re-developed world. The same test which has been done on the first deployment was carried out again for the distributed world version as the sample result of this research. These deployment tests were also done previously on the original version of the world from the past research. Overall deployment test gave better result in average stops and loading failures, although the average loading time is slightly longer. Figure 8 shows full rendered world from different camera views in the browser used for testing purposes. Some of them were captured with headlight setting off.

Table 1. Comparison between Base World, Re-developed World in Single Server, And Further Modified World In Distributed World.

	Base world (original)	Re-developed world (single server)	Distributed world
Number of files	172	488	488
Overall file size	19.4MB	66.6MB	66.6MB
Percentage of 3D models	31%	92%	92%
Loading time	4.38s	19.62s	22.40s
Average stoppages	2.19	16.20	11.51
Loading failures	1.67%	11.4%	8.6%



Figure 8. Screenshots from various camera view

The distributed Web3D sites were tested on the capability and acceptance aspects. Capability aspects of tests were performed on a variety of environment, e.g. a variety of operating systems, browsers, plugins, hardware, screen resolution, and color bit depth. Each test performed within three automatic navigation mode with preset movement coordinate that has been encoded in the world (around the floor 1, 2, and 3). The test criteria were as follows:

- a. Capability tests for viewing  
This test was basically to find out whether or not the world is successfully displayed in the browsers, assuming that the plugin has been installed properly.
- b. Test of conformance with the preliminary design of 3D object.  
The test was performed to find out:
  1. whether all objects would appear as designed or not.
  2. whether there is object deformation or not.
  3. whether there are anomalies in the display/navigation or not (e.g. no jitter/scrolling effects, chaotic rendering, wrong embedded bitmap texture or bitmap does not appear, etc.).
- c. Test of display consistency  
This test was performed by varying the display window while navigating the browser in auto-cruise mode. Tests were carried out in a different renderer device (software, D3D, and OpenGL).

Selected testers of eight students in their final years were free to use any computers provided to test the world. All the test performed using the provided computer network courtesy of information systems department computer laboratory. Since there were no specific objective of optimization on the experimental site, particular performance test were not carried out. Therefore, there were no measuring or comparison of fps, spf, amount of objects rendered per time, percentage of deformations (whether for specific single or multiple objects, scenery, event, or overall world), loading error, or other tests. The only measurement test carried out was loading time, for the purpose of knowing the differences by comparing the first and second deployment tests.

The computer hardwares and softwares used on the test were of the older types (using older CPU, integrated GPU, with lower capacity memory and hard-drive), as seen in Table 2. The reason for the selection of low-end systems was backward compatibility test, if the resulting Web3D world can be displayed properly in the older systems, then the site would be more likely succeed when displayed in the current system. From overall test results, computers with less than 512MB memory did not succeed to show the Web3D world. The world's large complexity requires large memory resources in order to be displayed completely on the user's browser, primarily because there are enormous number of polygons used in the model. From the operating system (OS) test results, it can be concluded that all type of OS used on the tests were able to display the world without significant problems to the systems used. The OS used in the test were older Microsoft Windows operating systems specifically installed for research purpose, ranging from Windows 98 to Windows 7, as seen in Table 3.

Table 2. Computers used for Testing

Processor	Memory	Display Adapter	Hard-drive
Intel Pentium4 LGA 2,8 GHz	512 MB	Intel GMA, 32 MB	80 GB
AMD Sempron PR 2,4 GHz	768 MB	ATI Radeon 9250, 64 MB	40 GB
AMD Athlon PR 2,5 GHz	1024 MB	nVidia GF 6600, 128 MB	80 GB
AMD Duron PR 1,8 GHz	256 MB	ATI Rage II XL, 32 MB	40 GB
Intel Pentium4M 1,7 GHz	256 MB	nVidia GF4, 64 MB	40 GB
Intel Pentium4 2,0 GHz	512 MB	Intel GMA, 32 MB	40 GB
Intel CoreDuo 2,66 GHz	512 MB	Intel GMA, 128 MB	80 GB
Intel Centrino 1,8 GHz	256 MB	Intel GMA, 32 MB	40 GB

Table 3. Operating Systems used for Testing

Operating Systems	Variant
Windows 98	SE
Windows XP	Home Edition RTM SP2
Windows XP	Professional Edition RTM SP2
Windows Vista	Ultimate

Table 3. Operating Systems used for Testing

Operating Systems	Variant
Windows 7	Professional SP1
Windows 7	Ultimate SP1

From the browser test results, basically all browsers used in the tests as seen in Table 4 were able to display the Web3D world. Exceptions appeared on some particular browsers which made the display of Web3D site incomplete on some small parts. Although not as more featured as newer browsers that are currently widely used, older browsers can still display the world which used the VRML97 format according to the latest VRML standard. It is assumed that if the older browsers with lower compatibility and feature can display the world properly, then the display results would look similar or better when displayed in newer browsers. From the plugin test results, the world was experiencing problems when attempted to be displayed using Blaxxun Contact plugin.

The cause of these problems has not been evaluated yet, although the world is compliant to VRML97 standard, and can be displayed properly on the other plugins used for this test purpose, as seen in Table 5. A later attempt on BS Contact plugin which is Blaxxun Contact's successor, using other computer system that was not designated for the test in this research, has been able to display the world in the browser. Improvement on the newer plugin from the same developer might have eliminated the cause of error that occurred when using the older one.

Table 4. Browsers used for Testing

Browsers	Versions
Microsoft Internet Explorer	6.0
Microsoft Internet Explorer	7.0
Mozilla Firefox	1.5.0.1
Mozilla Firefox	2.0.6
Opera	8.53
Opera	9.01
Netscape Browser	8.04

Table 5. Plugins used for Testing

Plugins	Version
Flux Studio	2.0
Cortona	5.0
Blaxxun Contact	6.1

In addition to the above capability aspects, acceptance aspect of the test has been carried out that the given results is subjective, depending on the consulted tester when trying to access the site which contains the Web3D world. The test conducted not only with the automatic navigation mode which has been hard-coded within the main world, but also with free navigation as needed by testers. The acceptance aspect of test was done to compare the level of closeness of the model shown in the browser with what they feel during day-to-day real interaction, as well as the visual quality of the Web3D world. Especially for this test, testers were consisted of graduates familiar with the campus.

Graduates were selected for the test phase of this research since 3D models used in this study were based on the original design before the campus undergone many modifications, especially after the destruction caused by earthquake in 2006. They have to answer 28 questions, for each questions there were 5 options of answer values, ranging from 1 (completely disagree) to 5 (completely agree). Testers were required to use at least the minimum type of computer system which comply to site requirements. 12 testers were selected for this purpose and each of them perform the test with their own systems, not the computers in the laboratory. Overall result from the acceptance aspect have shown that majority of testers have accepted the Web3D site by 77,28%, higher than the acceptance percentage of the original low-poly world which scores 53.16%. Figure 9 shows the overall result, measured as the average of each section of the test from all testers.

The result suggested that users can accept the 3D model in sample world shown in the web browser as the representation of UAD third campus physical structure on the internet. Intensive use of polygons has made their navigation experience inside the building and between rooms so enjoyable and realistic, as they can watch almost all elements of the campus up and close and also able to observe all objects in high detail as they did in the real world. They were especially admired by the object details provided in the world since they did not get the same experience of close-distance navigation from the previous low-poly world or other Web3D worlds which depicting a complex of campus buildings. They were also admired by the fact that overall 3D models used in the world are very large in terms of real world size since it modeled all buildings inside the campus and many of their properties, including the furnitures. Although the browsing and navigation experience were felt heavier due to the use of polygons in very large numbers, they prefer the modified distributed world since they could get the immersion of being in the campus much better than the previous low-poly world.

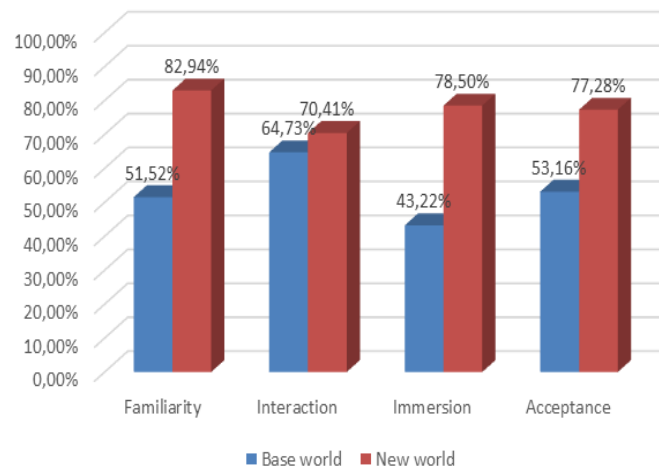


Figure 9. Comparison of the test results between base world version with minimal detail and the newly re-developed world with distributed feature. Values were taken from average of each section of test from all testers

## 5. Conclusion and Future Works

Based on the research that has been carried out and its results, intensive use of polygons to visualize the sample world conducted in this research has produced a Web3D world which resembles closely to the actual structure, and it also has resulting in an experience as if the visitors actually made the walk-through inside the real-world campus. Higher visual quality achieved by intensive use of polygons can produce a visually close-to-real Web3D world which displays the physical aspect of an institution in a more detailed way that it can become a qualified representation on the Internet. Overall visual display results of the world with its highly detailed constituent elements can provide more realistic, dynamic, and interactive aspects to provide a browsing experience closer to the actual navigation in its real-world counterpart. Increased load on server and network caused by larger files can be addressed by applying distributed world principles so that site visitors do not retrieve site resource files from one server only. For the future works, a plan to utilize the X3D format has been devised. The use of X3D is expected to open some opportunities to implement more features to the Web3D site since X3D is the successor to VRML.

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