

Mapping and Assessing Wi-Fi Network within PNG Unitech using GIS and 3D Visualisation of Signal Transmission Interference

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Abstract

This paper is the first known attempt in Papua New Guinea (PNG) at mapping Wi-Fi networks using GIS, although there are quite a good number of studies related to Wi-Fi mapping around the world. The striking difference between those previous studies and the present study is that, while other studies focused on wireless network coverage and signal strength they do so without identifying instances where some locations had poor signal coverage at certain locations compared to others. In the present study, the application of Geographic Information System (GIS) enables the assessment of an existing Wi-Fi network. The study was aimed at identifying potential sources of interference resulting in signal loss within the PNG University of Technology campus. The widespread use of GIS in various disciplines including wireless communication technology is not only because of its flexibility in linking thematic data to topological data but also to perform various analytical procedures on these thematic data in the system. This has enabled the prediction of the wireless network coverage range and identification of potential sources of interference. This paper investigates the factors that influence the performance of signal strength across the network coverage and assesses the existing Wi-Fi network at Unitech. Factors considered in the assessment were the material composition of buildings, trees, and channel or frequency configuration. The resultant findings can be used to support future network quality upgrade to enhance the performance of the Unitech Wi-Fi service and that of similar networks around the world.

Keywords: *Wi-Fi network, network interference, GIS mapping, frequency configuration, Unitech-PNG*

1. Introduction and Rationale for the Study

The networking of computers is vital when it comes to sharing of files, resources, etc., in any organization. With the rapid developments worldwide in computer technology, wireless networking has superseded the traditionally wired networking environments that allow limited numbers of computers to simultaneously communicate wirelessly and establish online connections. Wireless networks are suitable for homes, offices, and outdoor environments such as university campuses. The PNG University of Technology itself utilizes a wireless network for academic use, enabling the sharing of files and online connections between students and staff simultaneously with mobility. However, as wireless networking is an application of science and technology there are certain factors to consider when managing a wireless network, such as signal interference. These factors tend to have an impact on performance thus should be taken into consideration during preliminary radio site surveys before establishing a wireless network.

Building a wireless network requires proper site surveys and Radio Frequency (RF) planning utilizing instruments that can be quite expensive and provide a close approximation of the network coverage. The use of GIS in a number of applications has proven its potential in saving and reducing costs. GIS itself is an emerging technology with tools and capabilities to capture, store, display, manage and perform analyses using geographical data. At the Unitech, the reliability of Wi-Fi network seems to be an ongoing issue to students. The luxury of students accessing Wi-Fi from their dormitories is limited and is eventually raising a concern for the security of students. In most cases, due to the lack of signal coverage, students tend to move around the campus during nights just to find suitable Wi-Fi coverage. The main reason behind this is signal loss due to unidentified sources.

With the introduction of the new Google Classroom service at Unitech, the demand for an effective Wi-Fi service has increased. This will require further maintenance and extension of the current service for optimal performance. Hence, this paper seeks to demonstrate the potential of GIS as an analytical tool that can assist in site survey and RF planning when managing a WI-FI network. Using GIS techniques and capabilities, the paper identifies the number of access points (AP) currently placed within the campus with a view to assessing the effectiveness of the Wi-Fi coverage. Specifically, the paper seeks to (i) identify Wi-Fi coverage areas in order to understand WI-Fi performance, and (ii) sensitize authorities responsible for setting up these networks to the need for continuously monitoring and enhancing factors that detract from optimal WI-FI performance, such as interference. Accordingly, the paper attempts to answer the following research questions in order to contribute to the knowledge of WI-FI technology:

- (i) How can we map the locations of WI-FI access points, routers and antennas within the Unitech campus?;
- (ii) How can we assess the visibility of point-to-point connections within the main server building?; and
- (iii) How can we identify building composition and infer attenuation of Wi-Fi signal transmission using 3D visualization of buildings?

2. Materials and Methods

2.1 Study Area

The PNG University of Technology main campus is located 8km outside of Lae City in Morobe Province, within the UTM Zone 55. The residential campus covers an area of approximately 2 square kilometers, sharing its northern boundary with Telikom College. The campus itself comprises the administration offices, thirteen academic departments, students' dormitories and staff houses. However, the study area itself is a small portion of the entire Unitech campus (Fig 1).

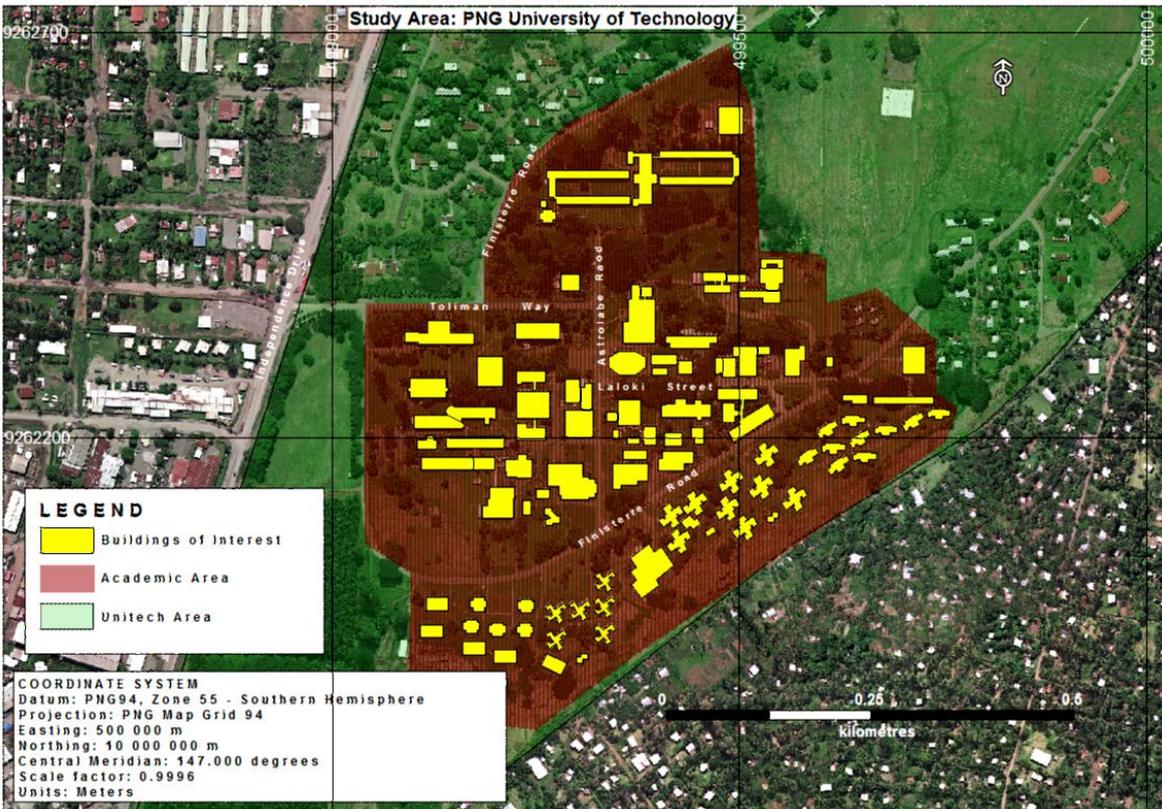


Fig.1: Map of Study Area: Portion of Unitech Campus (Scale: 1:5000)

2.2 Work Flow and Project Requirements

The study was done in several stages to accomplish its objectives. These included data collection and processing of data as illustrated in Fig 2.

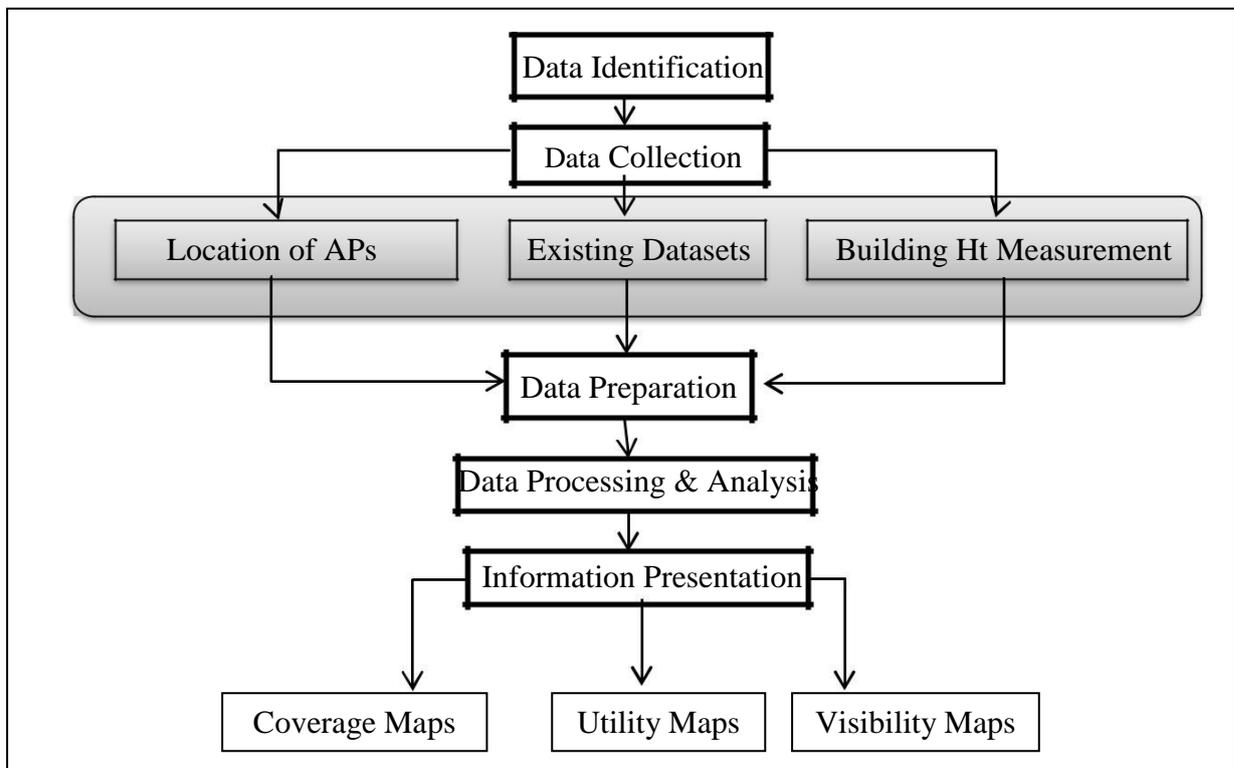


Fig. 2: The Study Workflow

2.3 Data Acquisition

2.3.1 Channel Information

Information about the current wireless network at Unitech campus including locations of routers was obtained through feedback from a questionnaire survey conducted on the Unitech campus. Using the information provided, each outdoor router placement was inspected, during which its operating channel description was identified and assessed using the Vistumbler software installed and running on the Acer Laptop. As stated earlier, the Vistumbler software is capable of detecting signal strength, channel information, etc. The Vistumbler interface operates as a scanning engine with a Start/Stop scan button. When running the scan a list of SSIDs and information on all routers and access points in the vicinity appear on the screen in columns with the nearest router's information at the top. However, for differentiating one router from another before recording the Channel number, all MAC address readings were ensured to be different from previous scans. Screenshots of every scanning session were captured and channels for the SSID 'UNISTD' were subsequently recorded and stored in an Excel Spread Sheet (Figure 3).

#	Active	Mac Address	SSID	Signal	High Signal	RSSI	High RSSI	Channel
1	Active	88:15:44:67:85:6A	UNISTD	74%	76%	-63 dBm	-62 dBm	11
2	Active	88:15:44:67:85:6A		74%	80%	-63 dBm	-60 dBm	11
3	Active	24:A4:3C:7E:A9:AC	STD01	14%	28%	-90 dBm	-86 dBm	2
4	Active	24:A4:3C:7E:AF:5F	STF01	44%	52%	-78 dBm	-74 dBm	8
5	Dead	E2:55:7D:AF:52:0F		0%	26%	-100 dBm	-87 dBm	6
6	Dead	E2:55:7D:AF:52:00		0%	28%	-100 dBm	-86 dBm	6
7	Dead	E2:55:7D:AF:52:01		0%	18%	-100 dBm	-88 dBm	6
8	Dead	88:15:44:67:85:6A		0%	74%	-100 dBm	-63 dBm	11
9	Dead	E2:55:7D:AF:52:0F		0%	26%	-100 dBm	-87 dBm	6
10	Active	E2:55:7D:AF:52:00		18%	28%	-88 dBm	-86 dBm	6
11	Active	E2:55:7D:AF:52:01		18%	18%	-88 dBm	-88 dBm	6
12	Active	00:02:6F:8B:FB:6B	MALEDORM-East	26%	30%	-87 dBm	-85 dBm	7
13	Dead	8E:15:44:67:8F:2C		0%	8%	-100 dBm	-93 dBm	1

Fig. 3: Screenshot of one scanning session by Vistumbler.

2.3.2 Description of Building Composition

An 'as is' description of the physical composition of each building in the study area (Unitech campus) was obtained and recorded using notepads. A total of 108 notepad records, each containing the name of a particular building and its material composition, were later transferred onto an Excel Spreadsheet. In the Excel spreadsheet, classification was performed according to the building's features and materials and the degree of signal strength attenuation (Very High, High, Low or Very Low) that may impact on the campus WI-FI network.

2.3.3 Raster Datasets

The raster datasets used included an aerial image of Lae and a Digital Elevation Model (DEM) and Digital Surface Model (DSM) of Unitech campus. The aerial image was mainly used to digitize router locations and relevant features of the system, while the DEM and DSM were also used in the construction of the 3D model and the visibility analysis component of the study. Table 1 describes the three datasets used.

Table 1: Description of Raster Datasets

Data	Data Type	Source	Spatial Resolution	Datum Registered
Unitech Image	Raster	LIDAR	20cm x 20cm	PNG 94
Unitech DEM	Raster	SRTM	1m x 1m	PNG 94
Unitech DSM	Raster	SRTM	1m x 1m	PNG 94

2.4 Data Preparation and Pre-processing

2.4.1 Digitizing and Translation

MapInfo 10 and ArcGIS 10 were used in pre-processing the primary datasets. The first stage was digitizing of classes of relevant features (buildings, spatial locations, etc.) from the aerial photos using MapInfo. After the digitizing process, the four emergent primary layers were: the buildings, positions of outdoor routers, positions of wireless transmission antennas and the study area itself. All of these layers were in MapInfo table format (.tab). Hence, using MapInfo’s Universal Translator tool, each of the table files was translated into shape files (.shp) to enable use of ArcGIS that was saved in a directory. The datum was then re-projected from WGS84 to PNG94 using ArcGIS 10.

2.4.2 Geo-database for Feature Class Storage

A geo-database was constructed in Arc Map, providing storage for feature classes that were used in the analysis. The geo-database was simply created within the Arc Catalog, placing it in the folder storing the shape files and which had a connection to ArcGIS to store and share files. The geo-database was named as Project.gdb. After creating the geo-database, the next step was creating feature classes representing each of the four primary feature shape files and the segmentation layer of the study area. The new feature classes created after this process are described in Table 2.

Table 2: Description of Feature Classes

Feature Class	Vector Type	Description
Buildings	Polygon	Feature class of 108
Outdoor Routers	Multi-point	Feature class of 7 outdoor routers
Wireless Observation	Multi-point	Feature class of 1 antenna location as observer point
Wireless Target	Multi-point	Feature class of 2 antenna locations as target points
Study Area	Polygon	Feature class of segmented portion of study area

2.4.3 Adding Attributes to Feature Classes

Two new fields were added to the Buildings and Outdoor Routers. In the Buildings feature class, the field added was for the material descriptions and the other for the degree of signal attenuation, with both data types saved as text format. For the outdoor routers, the new fields added were that for the channel descriptions with a float data format and the other for the coverage with a long integer data format.

2.4.4 Extraction of Height Values

Firstly, random sample points constrained by buildings were generated—three points to each building containing Case IDs that matched the Object IDs of the buildings. The set of random sample points and the DSM were both used as inputs to the ‘Add Surface Information’ function. In the process, the DSM’s surface information corresponding to the position of a point was extracted and added as an attribute to the point. This surface information extracted represented the elevation of the buildings to which the points were confined, however, in triples – as three points were constrained by one building feature.

After adding surface information to the points, a final elevation for each building was computed as three points store surface information of one particular building. This was made possible using the *Summary Statistics* tool in ArcGIS, where the mean Z value of multiple points representing the same building was calculated and stored in a new table. The new table contained mean Z values with OIDs that matched that of the buildings in the attributes table.

(a) Building_Z_Value

OID *	Shape *	CID	Z
1	Point	1	61.599372
2	Point	2	58.396325
3	Point	2	74.270293
4	Point	3	66.021516
5	Point	3	65.932134
6	Point	3	66.082894

(b) Mean_Z_Value

OID *	CID	FREQUENCY	MEAN_Z
1	1	1	61.599372
2	2	2	66.333309
3	3	3	66.012182
4	4	4	62.710158
5	5	5	65.548742
6	6	6	61.621357

Fig 4: Screenshot of newly added Z-information (a) and mean information for buildings after Summary Statistics (b)

2.4.5 Construction of TIN Layer

To generate the Triangular Irregular Network (TIN) Layer, a contour was created to be used as input. With the DEM (Digital Elevation Model) as the primary input, the contours were created and saved as a contour feature class. Using the contour file as the input, the TIN layer was created with its coordinate system imported from the DEM that was similar to the feature classes.

2.5 Secondary Data Processing

2.5.1 Proximity - Buffering

With the Outdoor Router feature class as input, having the units in meters, the 'Radial_cov' field representing the coverage of each router was used to define the buffer distance – 100m for all routers as specified by the manufacturer. The output of the buffer was saved as Coverage feature class and stored in the geo-database. In the output's attribute table, two additional fields were created – Coverage_ID and Channel. The first field stores unique values (Cn – where n = 1...7) that differentiates one coverage from another while the latter stores values representing the operating frequency class or channel at which the router transmits and receives signals.

2.5.2 Overlay

Two different types of overlay analysis were employed in the study – Intersect and Spatial Join. The Intersect tool generates an output feature class containing portions of the input features that overlap. In this operation, using the default parameters, the Coverage feature class was used as the input. The output was named as Channel Interference Zone with the Project geo-database defined as its storage location. In the output's attribute table (Figure 5), three new fields were added – Channels, Interference_Type and CInt_ID. The Channels field stored the channels that form the overlap (e.g. 611 = Channel 6 and Channel 1), Interference_Type (i.e. the type of channel interference (e.g. No-interference, Co-channel and Adjacent – channel), while the CInt_ID stored unique values or IDs differentiating one overlap feature from another.

Channel Interference Zone

OBJECTID *	Shape *	ID	Channel	Interference_Type	CInt_ID
1	Polygon	1	16	No-interference	C11
3	Polygon	2	611	No-interference	C12
5	Polygon	3	111	No-interference	C13
7	Polygon	4	11	Co-channel	C14
9	Polygon	5	16	No-interference	C15
12	Polygon	<Null <Null>		Adjacent-channel	C16

Fig 5: Attributes Table for Channel Interference Zone Feature Class

The *Spatial Join* tool was used to join attributes of one feature class to another based on their spatial relationship. The process involved selecting a feature class to be inputted as the targeted features and the other to be the *join* features where the attributes will be joined to the targeted features. In our study, two spatial join operations were performed. In the first spatial join operation, using the Buildings feature class as the targeted feature input and the Coverage feature class as the join feature input, the attributes of the latter were joined to the attributes of the previous. During the process of selecting the input features, the ‘JOIN_ONE_TO_MANY’ Join Operation and ‘HAVE THEIR CENTRE IN’ match option was selected. Selecting these parameters ensured that the attributes of the router coverages will join one or many buildings as long as these buildings have their centre within the particular coverage.

Before initiating the process, the option for keeping all the target features after the process was ensured to be checked and the attributes of the output feature class was selected. The output was stored in the Project geodatabase as *SpatialJoin1*. In the SpatialJoin1 attribute table, the buildings located within the wireless network coverage had a Coverage ID (a Coverage feature class field joined to the Building feature class) value for a certain coverage. All records having null values under the Coverage ID field were considered out of coverage range thus were selected and exported into a new table – ‘BuildingsOutOfCoverage.’ After exporting these records, they were deleted from the SpatialJoin1 feature class.

For the final spatial join operation, the SpatialJoin1 feature class was used as the Target feature class and the Channel Interference Zone as the Join feature class. All default parameters were used, except for the ‘Keep All Target Features’ which was unchecked. The default match option was ‘INTERSECT’. Thus all buildings which intersected with a channel interference zone were included in the output. The output was named as SpatialJoin2 and stored in the Project geodatabase.

2.5.3 Line of Sight

The line of sight between Haus Europa server antenna and two antenna stations – Duncanson Hall (DH) and Rose Kekedo Lecture Theatre (RKLT) - was observed for obstruction using the Create Line of Sight tool on the 3D Analyst toolbar with the DSM as the input surface in ArcMap. Making sure the Building, Wireless_Obs and Wireless_Targ layers were displayed on top of the DSM, the line of sight was created by drawing a line starting from the observer point to each of the two targeted points separately. The first line of sight was from the observer point at Haus Europa to the target point at RKLT and the second from Haus Europa to DH. Profile graphs were generated right after creating each line of sight by simply clicking the Profile Graph icon.

3. Results and Discussion

A reminder of our first research question: *How can we map the locations of WI-FI access points, routers and antennas within the Unitech campus?*

The results or outputs of the various analytical procedures reported earlier were presented in maps and 3D visualizations. Resulting maps include: (i) a utility map depicting Wi-Fi Network Coverage and locations of all outdoor routers as shown in Fig 6 (2) two maps describing the potential sources of signal loss as shown in Fig 7 and (3) a visibility map depicting the variations in surface heights within the area as shown in Fig 8. Furthermore, 3D Visualizations were produced as indicated in Fig 10. All maps produced were drawn to a scale of 1:3500 using the PNG Map Grid 1994 Zone 55 coordinate system. A brief description of these maps is as follows:

3.1 Utility Map

Useful information for any Wi-Fi user may be his or her location compared to the network coverage, which may grant him or her access to the available Wi-Fi network. Thus the utility map, *Wi-Fi Network Coverage and Outdoor Router Location* (Figure 6), provides Wi-Fi users with information about the locations of routers as well as the coverage these routers provide.

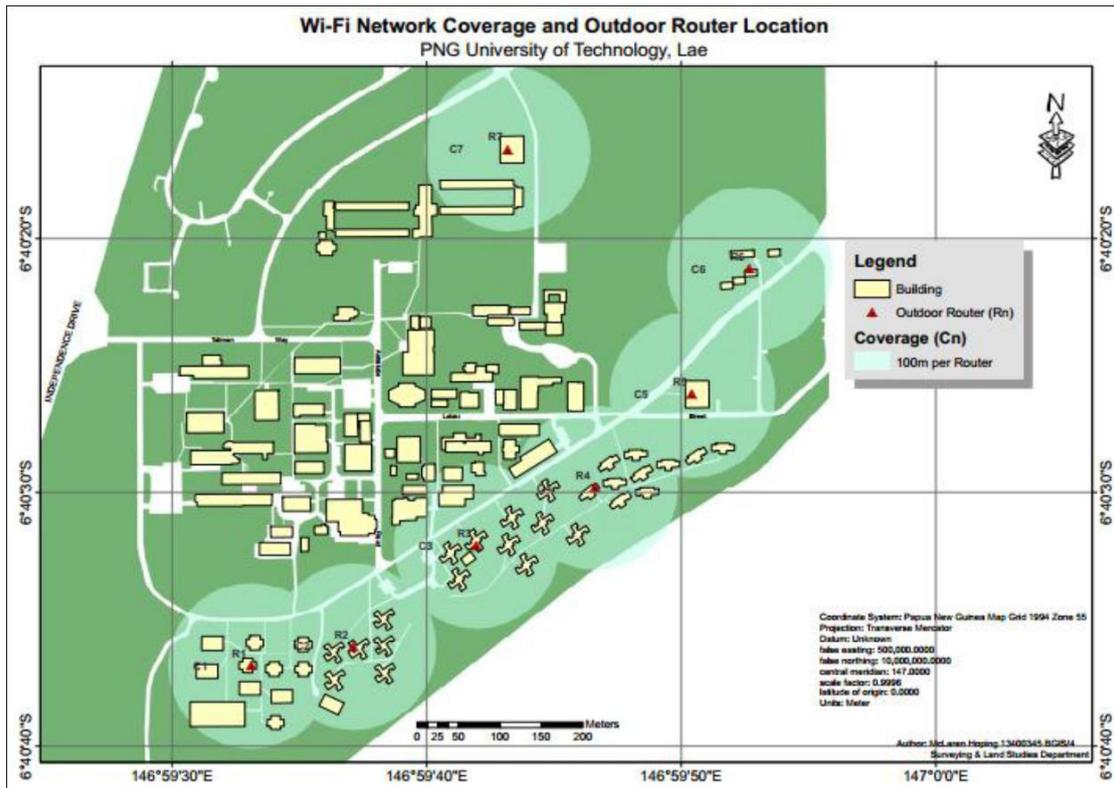


Fig 6: Wi-Fi Network Coverage and Outdoor Router Location

3.2 Potential Sources of Signal Loss Maps

The second set of outputs consists of two maps indicating the different potential sources of signal loss considered in this paper. These maps encompass the coverage and channels at which all the outdoor routers operate in; the degree of attenuation of each building within Unitech as categorized according to their material composition; and highlight portions or zones of channel overlaps. As trees are one of the potential sources of signal loss, one of the maps include an aerial image layer of the study area as the background to indicate presence of trees while all the information presented are the same on both maps.

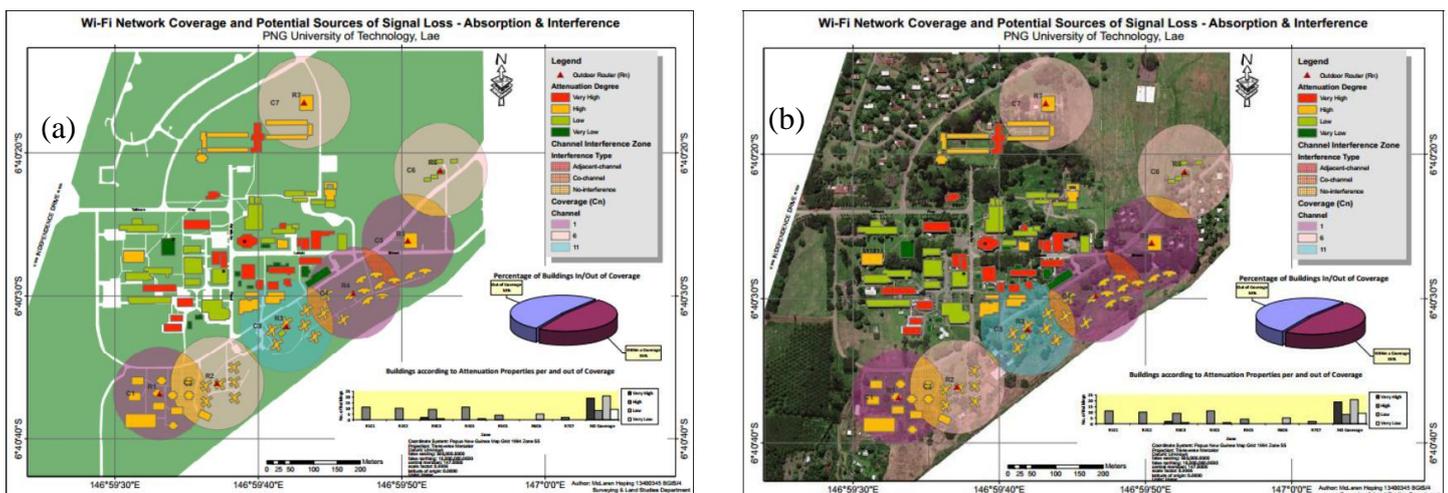


Fig 7: Wi-Fi Network Coverage and Potential Sources of Signal Loss – Absorption & Interference (a) and Wi-Fi Network Coverage and Potential Sources of Signal Loss – Absorption & Interference (Aerial Image as background) (b).

3.3 Visibility Map

A reminder of our second research question: *How can we assess the visibility of point-to-point connections within the main server building?*

The visibility map – *Wireless Network Point-to-Point Connection Visibility* - is the mapped output of the process in determining the visibility between the two antenna stations' (RKL and DH) lines of sight from the base station Haus Europa. The map was composed using the DSM as the background layer and the buildings layer displayed on top of it. The DSM provides a representation of the variation in surface heights of the ground, buildings, trees and all other features present in the vicinity while the buildings layer was used to provide a clear resemblance of the position of buildings in case there is any difficulty identifying them. Profile graphs of both lines of sights were also added as objects displayed on the map.

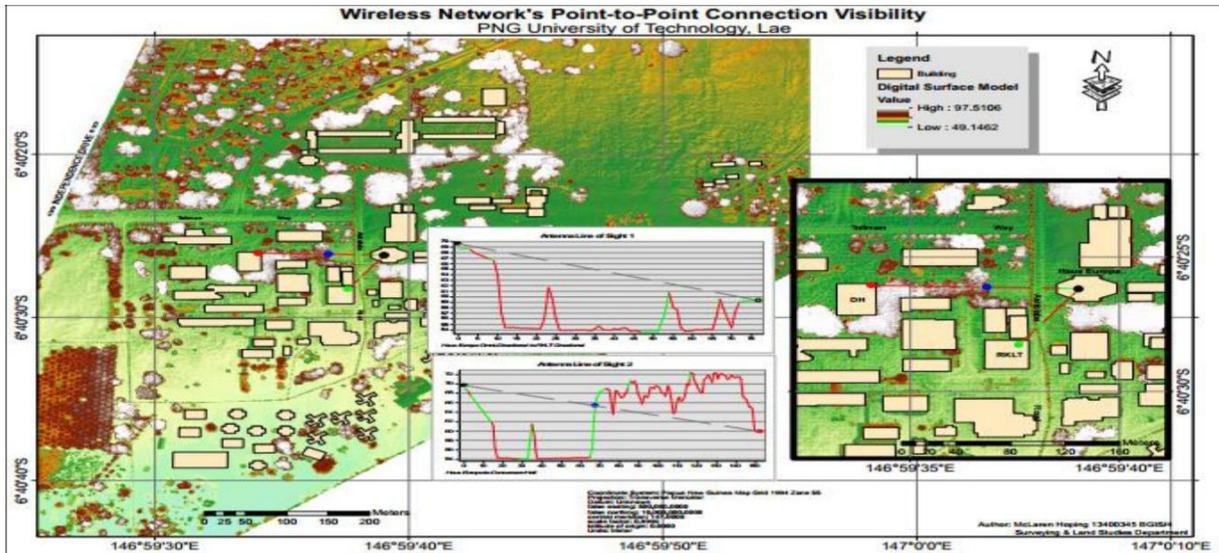


Figure 8: Wireless Network's Point-to-Point Connection Visibility

3.4 3D Visualization

A 3D model of the study area was also generated to provide a perception of the study area in the real world (Figures 9 and 10). The study area represented in 3D visualizes buildings and trees as they are in the real world thereby supporting analysis and discussions in terms of signal transmission interference by features resulting in the loss of signal strength.



Fig 9: Study Area – Portion of Unitech in 3D

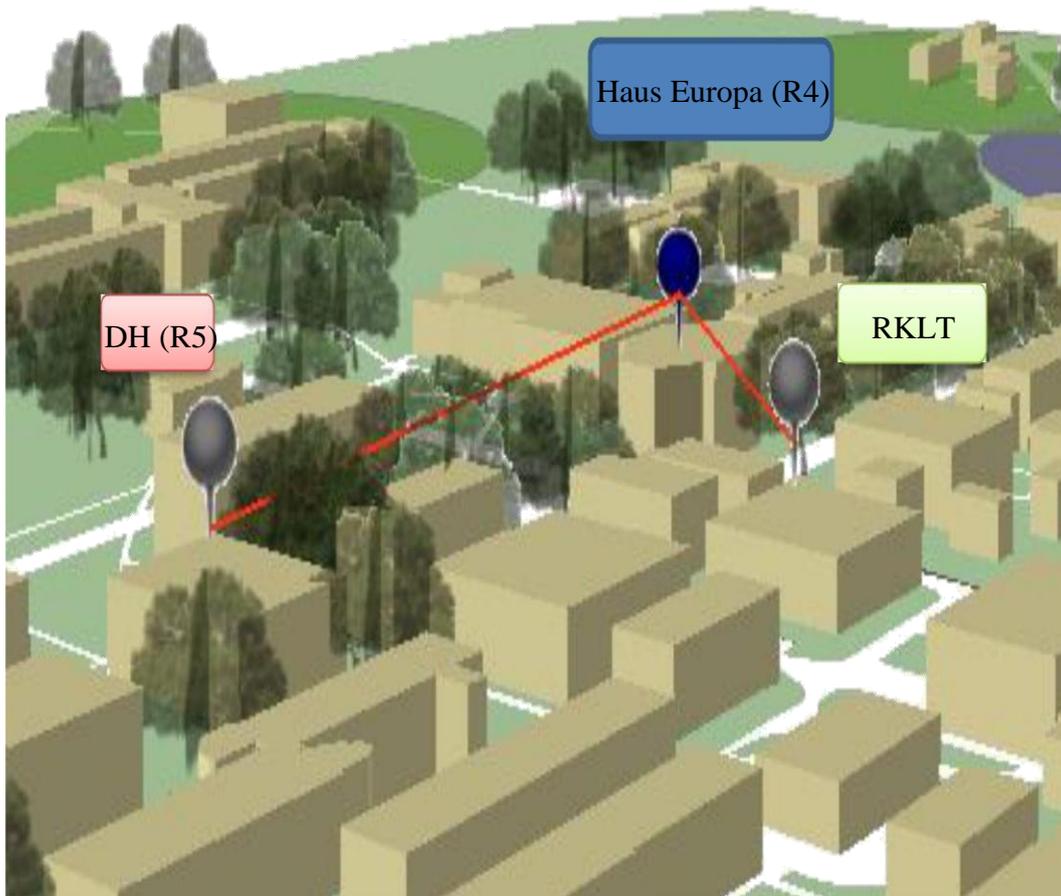


Fig. 10: 3D Visualization supporting Line of Sight Analysis

A reminder of our third research question: *How can we identify building composition and infer attenuation of Wi-Fi signal transmission using 3D visualization of buildings?*

The 100m circular buffer zones generated from each router visualize the Wi-Fi network coverage within the campus. As the study concerns only outdoor routers, indoor routers or access point placements were not considered. Thus it should be noted that a huge portion of the academic area on Unitech campus is outside coverage as most buildings within the campus area have indoor access points installed. From the Overlay Analysis, the Intersect operation has indicated four portions or regions of overlapping coverage. Overlapping router coverage is an indication of channel interference depending on the type of channel the concerned routers are operating in. Classification of these overlapping portions into the three channel interference types shows that Wi-Fi users in one of the four overlapped portions will experience co-channel interference while the others will experience no form of channel interference. This is because for the overlapped portion indicating co-channel interference, both concerned routers (R4 – Haus Europa and R5 - DH) operate in the same channel – Channel 1.

The output of the first Spatial Join operation has shown that from the 108 buildings included in the study, 56% are outside Wi-Fi coverage while 44% of the buildings are within the coverage. As all the outdoor routers are placed in student residential areas, 56% are located mainly within departmental buildings and lecture theaters whereas 44% are in student residential halls and lodges. From the 44%,

the second Spatial Join operation has further shown that 30% are within single channel coverage and 14% are caught within overlapping channel coverage.

The research has identified two main factors that affect Wi-Fi signal strength resulting in potential signal attenuation. They relate to (1) Physical Objects and (2) Electrical Interferences along the point to point connection visibility, which can be seen in Fig (8) and in Fig (7). Most of the outdoor routers in Fig (6) have a Point to Point visibility that passes through dense materials such as concrete and steel walls, which reduce RF signals between access points. Wi-Fi transmission signals may also be weakened by constant electrical interferences from computers, electrical fixtures such as lighting or power pole placements within close proximity of routers. This was based on observation, given that the academic and student residential area(s) are within zones that use a higher degree of electrical devices.

4. Conclusion and Recommendations

Our assessment of PNG University of Technology's existing Wi-Fi network, carried out in the face of certain limitations using GIS techniques and remotely sensed data, was a success. The findings have proven or provided an indication that the use of GIS in the assessment of wireless networks in such environments can be more than adequate as it provides results that are meaningful and realistic within the set objectives and with regards to the research questions answered by the paper. However, the preparation of all primary datasets in terms of conversion, transformation and storage using the set of GIS software available was the most crucial and challenging component of the study as it requires sufficient skills and expert understanding of the tools and their functions.

It has been observed that the overall design and configuration of the wireless network at the Unitech campus is fixed and effective, but unfortunately performance deficiency in terms of signal loss is highly likely. Results have indicated that although some of the sources of signal could not be tempered due to their nature, channel configuration can be reviewed. From the assessment of channels, it is recommended that one of the two routers, R4 and R5, is rechanneled to avoid co-channel interference. Rechanneling should be done in order to reconfigure router R4 to use channel 6 or R5 reconfigured to use channel 11.

Finally, future studies may consider mapping Wi-Fi signal strength around the vicinity of the campus. However, this would require suitable signal strength measuring applications and devices as well as required skills and expertise in operating them. One of the most suitable GIS techniques that can be employed in future studies is the IDW interpolation technique.

References

1. 7 Signal Solutions. (2006), *Antenna Selection and Positioning Guide*, USA, A 7 Signal White Paper.
2. Bell, S. and Jung, W. (2011), *Mapping WLAN Coverage as a Potential Complementary Source for GPS-Based Navigation in Indoor Environments*, Department of Geography and Planning, University of Saskatchewan, Canada.
3. Burrough, P. A., and McDonnell, R. A. (1998), *Principles of Geographical Information Science*, Great Britain: Oxford
4. Cisco Systems Inc., (2008), *Understanding SSIDs*, USA, A Cisco Systems Inc. White Paper.
5. Digi International Inc. (2008), *An Introduction to Wi-Fi*. USA. (A Digi International Inc. White Paper.

6. Dodd, H. M. (2001), *The Validity of Using a Geographic Information System's Viewshed Function as a Predictor for the Reception of Line-of-Sight Radio Waves*, Master's Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.
7. Esri (2014), *3D Urban Mapping: From Pretty Pictures to 3D GIS*. USA: Redlands, An Esri White Paper.
8. Fava, P. R., Fritz, S., Castellano, A (2010), *The Use of Geographic Information Systems for Disaster Risk Reduction Programs in Africa*. Cooperazione Internazionale, Malawi: Yalco
9. Gee, K.C.E. (1982), *Local Area Networks*, Manchester: NCC.
10. Goodman, L. (1997) *Wireless Personal Communication Systems*, Massachusetts: Addison-Wesely.
11. Huisman, O., de By, R. A., (ed.). (2009), *Principles of Geographic Information Systems*. The Netherlands: ITC, Enschede.
12. L-com Global Connectivity (date unknown), *WiFi Antenna Installation Best Practices*. USA, A L-com Global Connectivity White Paper.
13. L-com Global Connectivity (date unknown), *Wireless Network Applications Overview: Choosing the Right Wi-Fi Antenna for your Application*. USA, A L-com Global Connectivity White Paper.
14. LO, E. C. (2007), *An Investigation of the Impact of Signal Strength on Wi-Fi Link Throughput through Propagation Measurement*, Master's Thesis, Auckland University of Technology, New Zealand.
15. Longley, Paul. A. (2005), *Geographical Information Systems and Science*, 2nd Edition, Chichester: Wiley.
16. Mishra, A., Rozner, E., Banerjee, S., and Arbaugh, W. (2005), *Exploiting Partially Overlapping Channels in Wireless Networks: Turning a Peril into an Advantage*: Internet Measurement Conference: 2005. USENIX Association, USA.
17. Mishra, A., Shrivastava, V., Banerjee, S. and Arbaugh, W. (2006), *Partially Overlapped Channels Not Considered Harmful*, Internet Measurement Conference, USENIX Association, USA.

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