

Chapter 5: Analysis and Results

The aim of the study is to determine to what extent GIS software can be implemented in order to manage, analyze and visually illustrate an IT-network between buildings as well as inside buildings on a campus. Chapter 5 intends to address the problem statement by discussing the various analysis and information management methods offered by the data model. The analysis techniques presented by the data model are listed in Table 5.1 and will serve as the backbone to the layout of the chapter. The implementation method of each technique will be discussed individually as well as the analysis results of each one.

Analysis type	Description
Extracting attribute information	Opening the attribute table
	View attributes through the Identifier tool
Selection queries	Use the Unique_ID to select a feature
	Locating rooms that contain switches
	Locating the network ports that are connected to a certain switch
	Depict the location of an owner's office
	Depict a specific cable type that exceed 100m
	Highlight the features that was installed/upgraded by a certain contractor
Network analysis	Depict the route between a network port and switch
	Depict the optimum path between a new network port and the closest switch
	Find the common ancestor for ports in both buildings (zonal switch)
	Find the shortest route between the source and a network port
	Find the shortest route between two network ports and the switches that are along the route
Locating outdoor cables	Use the Fishnet to determine the outdoor cables
Statistics	Determine various statistics of features (such as cable length)

Table 5.1: The various analysis methods offered by the data model

5.2 Selection queries

In very large datasets it is sometimes difficult to locate a specific feature. When the information or position of an individual feature (or a specific group of features) is needed, it is important to distinguish the feature from the rest. The data model offers the ability to select the feature, thereby highlighting the feature so that it is easily located on the map. There are three methods of selecting a feature on a map. Firstly the feature can be selected manually by using the Select Features tool. The second method is to run a query on the layers according to its attributes. The final method that can be applied in order to select a feature is the Select by Location which highlights features according to spatial queries. A set of selected by attributes features can be compiled by implementing one or more of these techniques (ESRI, 2011).

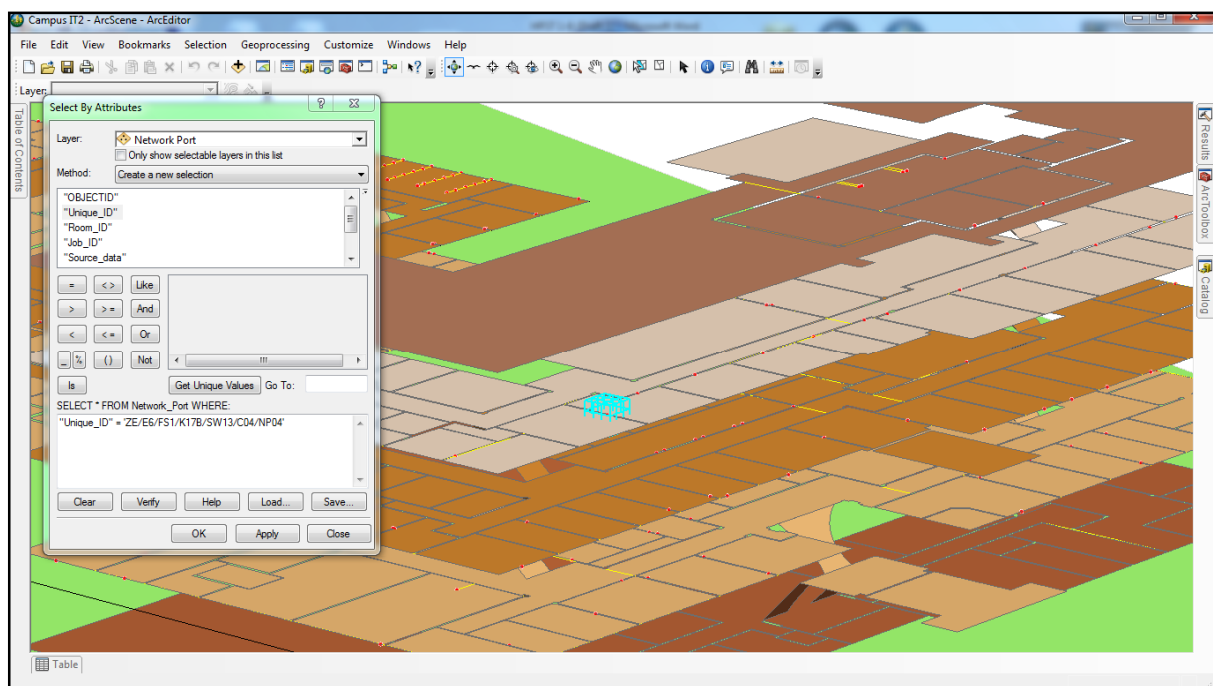


Figure 5.2: Selecting a network port by implementing the Select by attribute method according to its Unique_ID field

5.2.1 Use the Unique_ID to select a feature

When a feature's Unique_ID is known, the feature can be selected by running a Select by attribute query. The Select by attribute window is opened under the Selection tab on the main toolbar, and allows the user to create and run a query on any layer's fields. The query in the example displayed in Figure 5.2 is "Unique_ID = ZE/E6/FS1/K17B/SW13/C04/NP04". This query highlights the network port with that particular unique ID.

5.2.2 Locating rooms that contain switches

The Select by location method selects features according to their spatial position relative to other features. The example in Figure 5.3 illustrates how the utility rooms in the study area can be highlighted. The utility rooms are the location in a building where all the local switches for that specific building is stored. Some buildings may have more than one utility room. The example in Figure 5.3 implements the Select by location method to highlight the PUK_Rooms features which are 0.5m from switches. All three the utility rooms in the study area are highlighted. A kitchen that is located directly above the utility room for building E6 is also highlighted. The kitchen is selected due to the fact that the switches are located above one another and the top switch is located less than 0.5m from the kitchen above. The kitchen can be removed from the set of selected features when the selection is refined further.

The Select by attribute method is utilized to extract and highlight all the rooms that have a utility room space type from the selected features. This leaves the selection with the three rooms that contain the switches (Figure 5.3).

Once the utility rooms are highlighted, a new layer can be created from the selected features. This is done in the table of contents by right-clicking on the PUK_Rooms layer and choosing the Selection > Create layer from selection option. A new layer is added to the table of contents which only depicts the selected features. The utility rooms can be depicted even better by extruding the newly created layer. Figure 5.4 illustrates the location of the utility rooms within each building by extruding them.

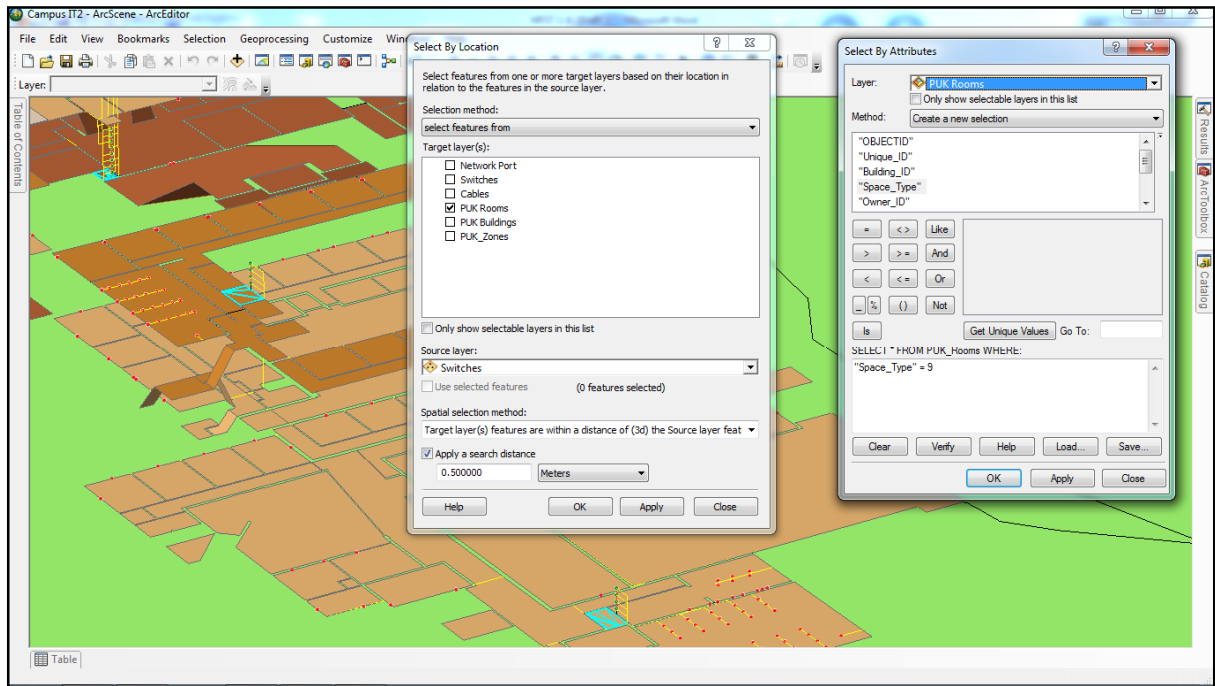


Figure 5.3: Selecting the utility rooms of the study area

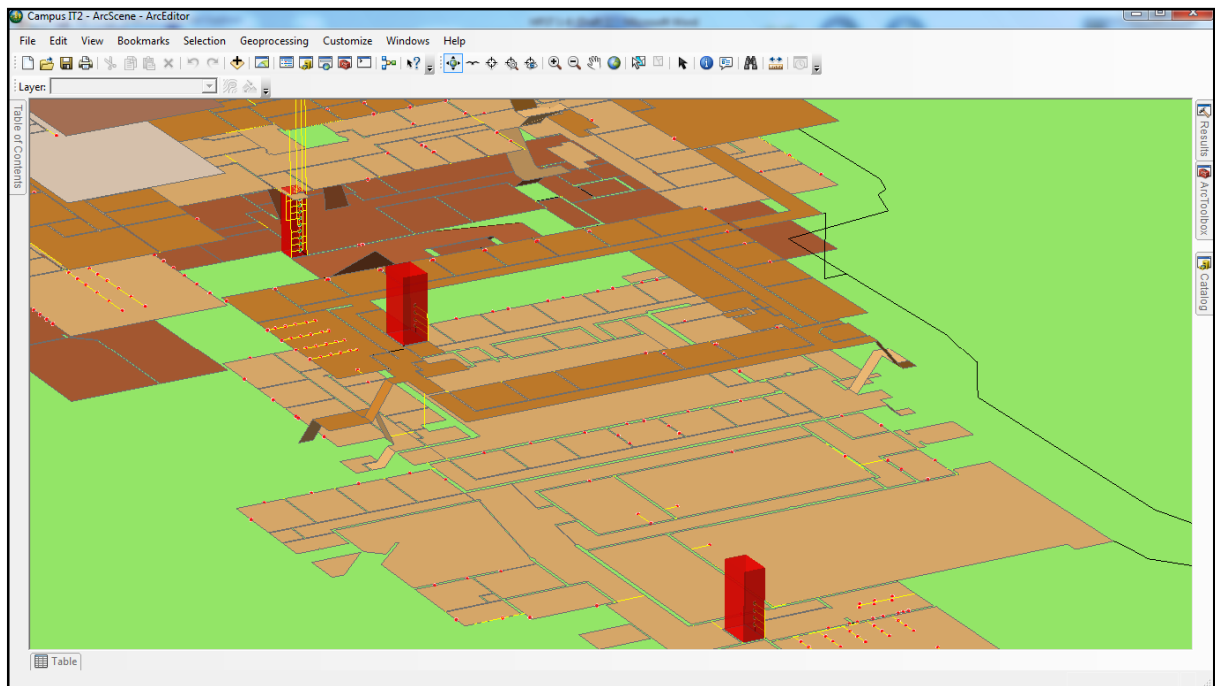


Figure 5.4: Extruding the utility rooms

5.2.3 Locating the network ports that are connected to a certain switch

It is important for the end-user to be able to determine which network ports are connected to a certain switch. For example if a switch malfunctions, IT management needs to know which network ports will be affected. This information is available by using the Identifier tool, but can be displayed visually by utilizing several analysis techniques.

In an example (Figure 5.5), assume that the switch with the Unique_ID of ZE/E4/FG/G56A/SW01 is offline, and IT management needs to determine which network ports are directly affected. The switches are linked to the network port through cables. It is thus necessary to highlight all the cables that are connect to the switch, in order to determine which of them are linked to a network port. These network ports are the ones that would be directly affected by the switch error.

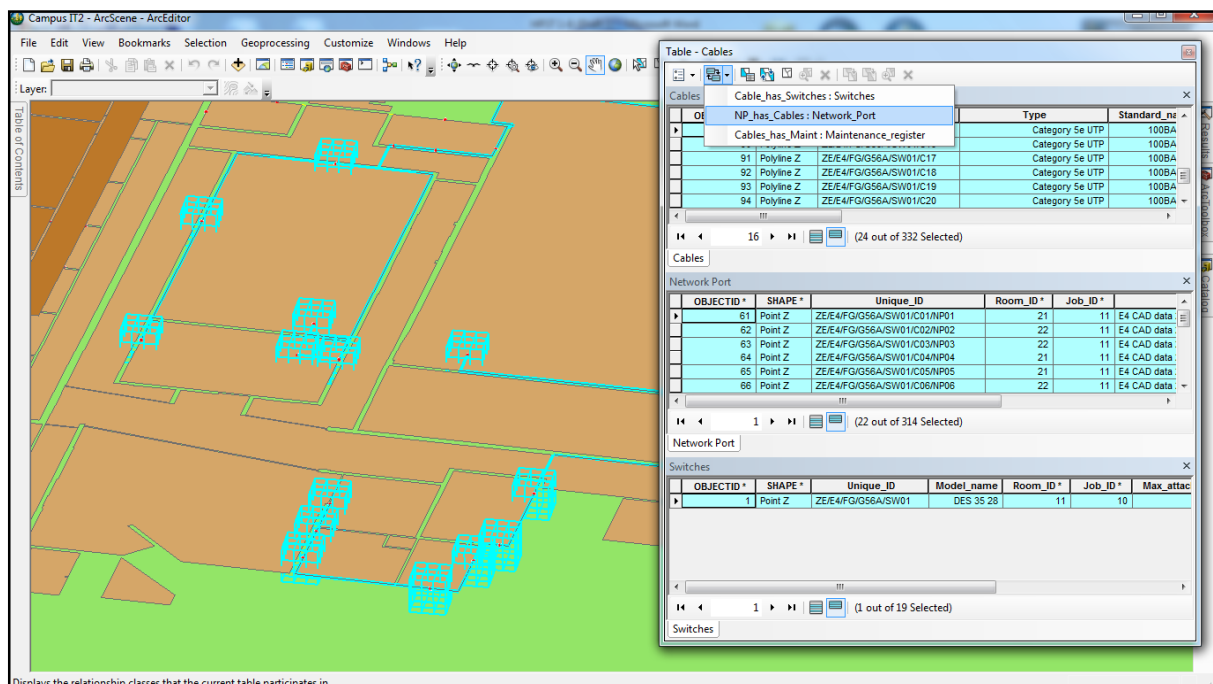


Figure 5.5: Displaying the network ports that are connected to a certain switch

The first step is to open the Switches attribute table and selecting the correct switch. The Related Tables tool is utilized to depict the related features from another table by opening the attribute table and selecting those features. In the example the relationship 'Cables_has_Switches: Cables' relationship is used to display the cables that relate to the

specific switch. In the same way the 'NP_has_Cables: Network Port' is employed by the Related Tables tool, thereby highlighting the network ports which will be directly affected by the switch malfunction.

5.2.4 Locating an owner's office

In the same way the location of an owner's office can be depicted. In the example in Figure 5.6, the Owners_Table and selects the entry of M. Mostert. When the 'Owner_has_Rooms : PUK_Rooms' option is chosen from the Related Tables, the room that related to M. Mostert is selected in the table as well as the map.

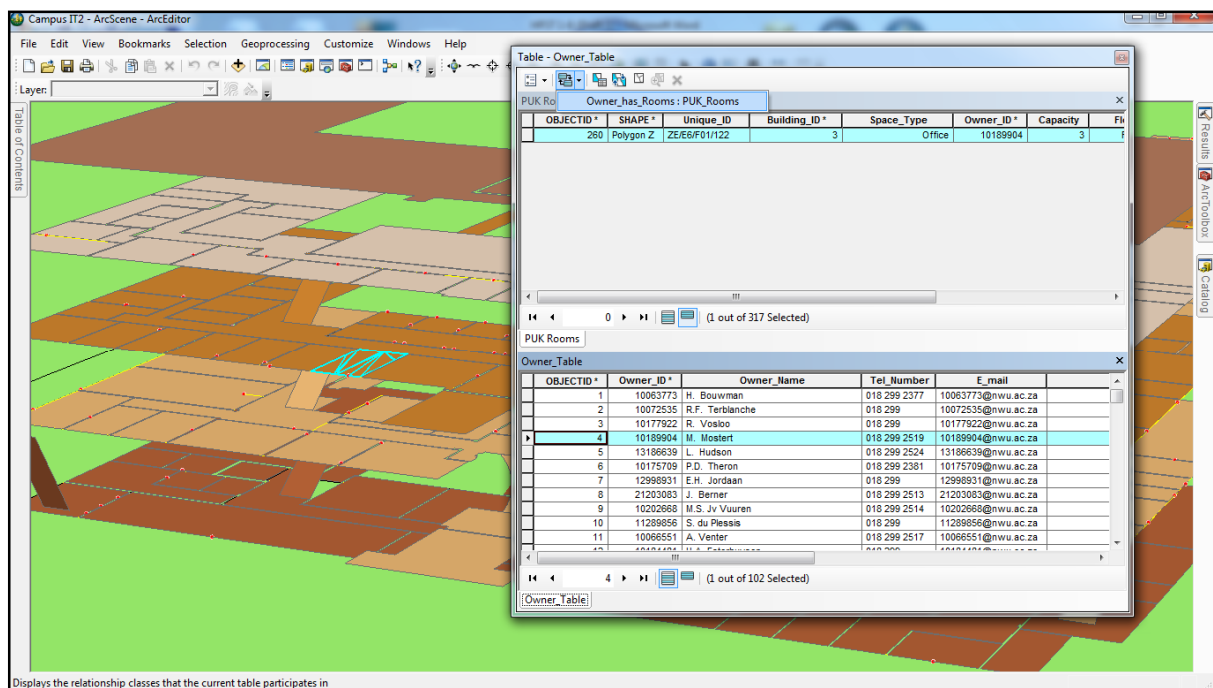


Figure 5.6: Displaying a specific owner's office

5.2.5 Locating and statistically analysing a certain cable type which exceeds 100m

One of the most important limitations is that a Category 5e cable starts becoming ineffective it exceeds a distance of 100m. It is important to determine which cables are longer than 100m and where they are located. A Select by attribute query can depict the cables on a

map. The query extracts the features from the Cables layer and reads as follows: "Type" = 2 AND "SHAPE_Length" > 100'. The query translates to extracting all the Category 5e cables which exceed 100m. The data model is accurate and does not deliver any features when the query is run. In order to illustrate the effectiveness of the query, it is modified to display all the Single-mode optical fiber cables that exceed 100m. The resulting map shows the location of three cables which meet the criteria (Figure 5.7).

The ArcGIS 10 software offers the ability to do statistical analysis on the attribute values of selected features. In Figure 5.7 the Selection Statistics window depicts the minimum-, maximum-, sum- and average length of the three Single-mode optical fiber cables that exceed 100m. Statistical analysis can be done for all features in the data model by accessing the Statistics tool under the Selection tab on the main toolbar.

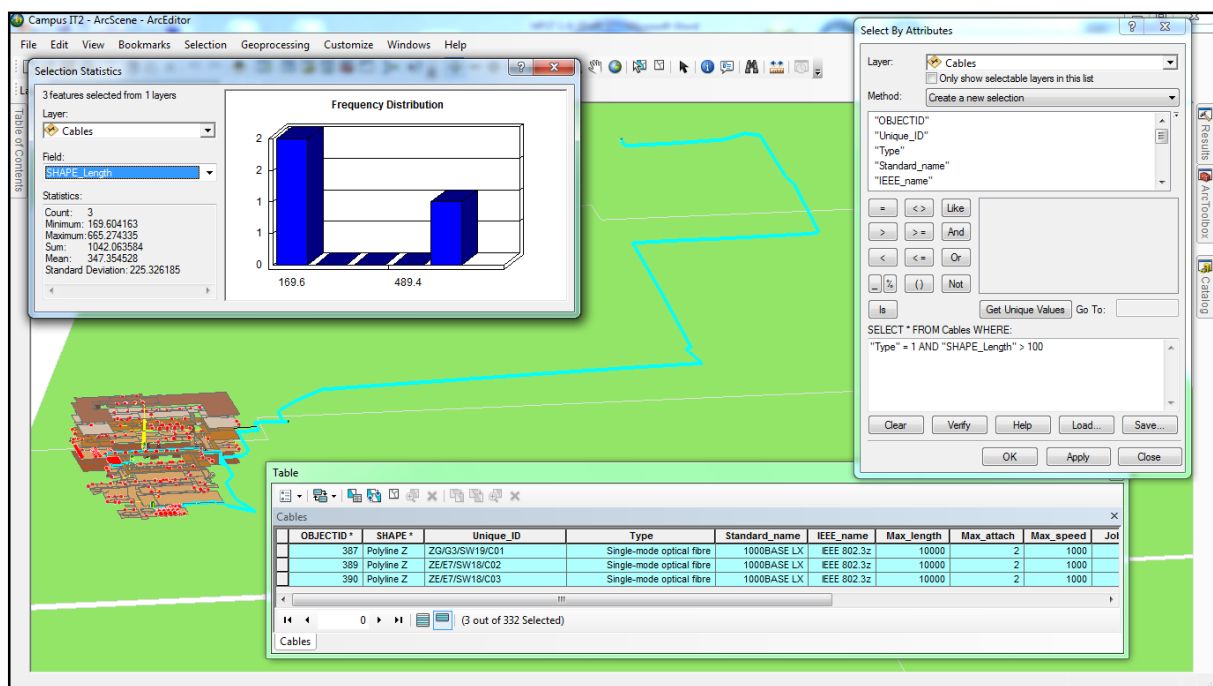


Figure 5.7: Selecting a Single-mode optical fibre cable type which exceeds 100m

5.2.6 Display the network features maintained by a specific contractor

In the final selection analysis example offered by the data model, assume that the end-user needs to view all the features that were upgraded or installed by a specific contractor. Figure

5.8 illustrates the example where the IT-management needs to locate all the network elements that were operated on by Mr. A. de Lange. The analysis method selects Mr. A. de Lange from the List_of_Contractors and uses the Related tables tool to select the maintenance jobs where Mr. de Lange was involved. In the example it appears that Mr. de Lange was only involved in one maintenance job. The network elements on which the maintenance task was implemented are selected and displayed by choosing the 'NP_has_Maint: Network_Port' option on the Related Tables option. The result, as seen in Figure 5.8, is that the all the network ports that were maintained by by Mr. de Lange are easily selected and displayed on the map.

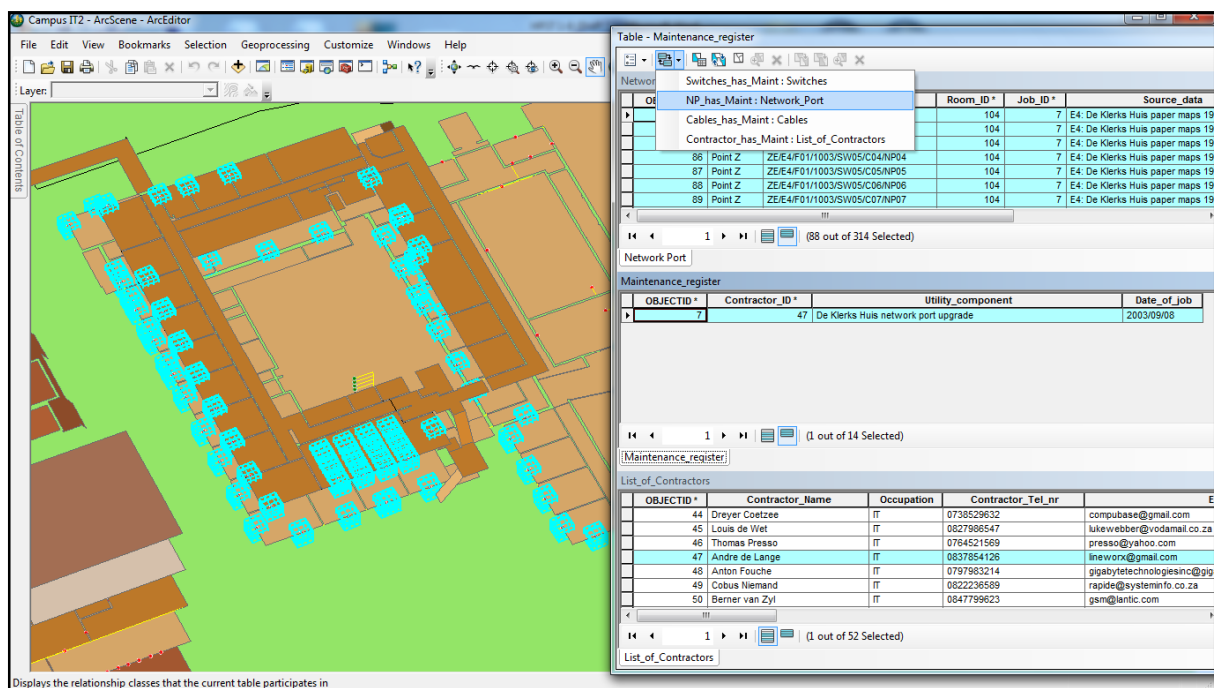


Figure 5.8: Locating the network elements that were upgraded or installed by a certain contractor

5.3 Network analysis

The data model also offers analysis techniques which are specifically focused on the network. The network analysis methods focus on the connectivity theme among the network infrastructure elements. The fact that each network element must be physically connected to the rest of the network creates the possibility to use the data model to apply techniques to represent the seamless integration of the network.

5.3.1 Display the route between a network port and a switch

Although the network analysis in 3D is limited, the ArcGIS 10 software, together with its Network Analyst extension allows the user to perform the network dataset analysis in ArcMap and then copy the layer to the 3D environment. The example illustrated in Figure 5.9 aims to display the route between a network port and the switch that it is connected to. The first step is to add the PUK_IT_ND network dataset to the table of content in ArcMap, which activates the Network Analyst toolbar. The New Closest Facility tool is used to execute this method, and creates a Closest Facility layer in the Network Analyst window. The Closest Facility layer is divided into Facilities, Incidents and Routes. The Facilities section is populated with all the switches in the network, while the Incident contains the specified network port. The Route section is created after the Solve function on the Network Analyst toolbar has been applied (Figure 5.9).

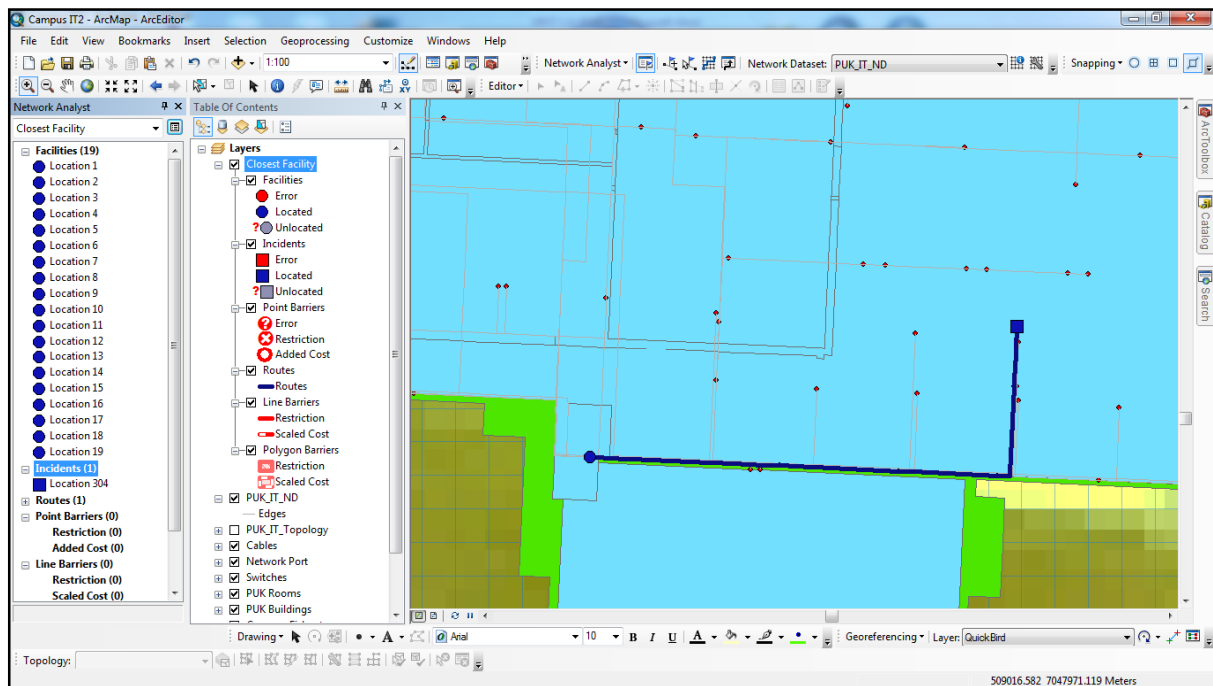


Figure 5.9: Finding the closest switch to a specific network port along the network in Arc Map

The next step is to copy the Closest Facility layer from the table of content to the table of content in the 3D environment. This route's z-values are taken into account in the 3D environment which creates a better representation of the route. Figure 5.10 illustrates the

same route, as it appears in ArcScene. The result is a better visual representation of the route in the 3D environment.

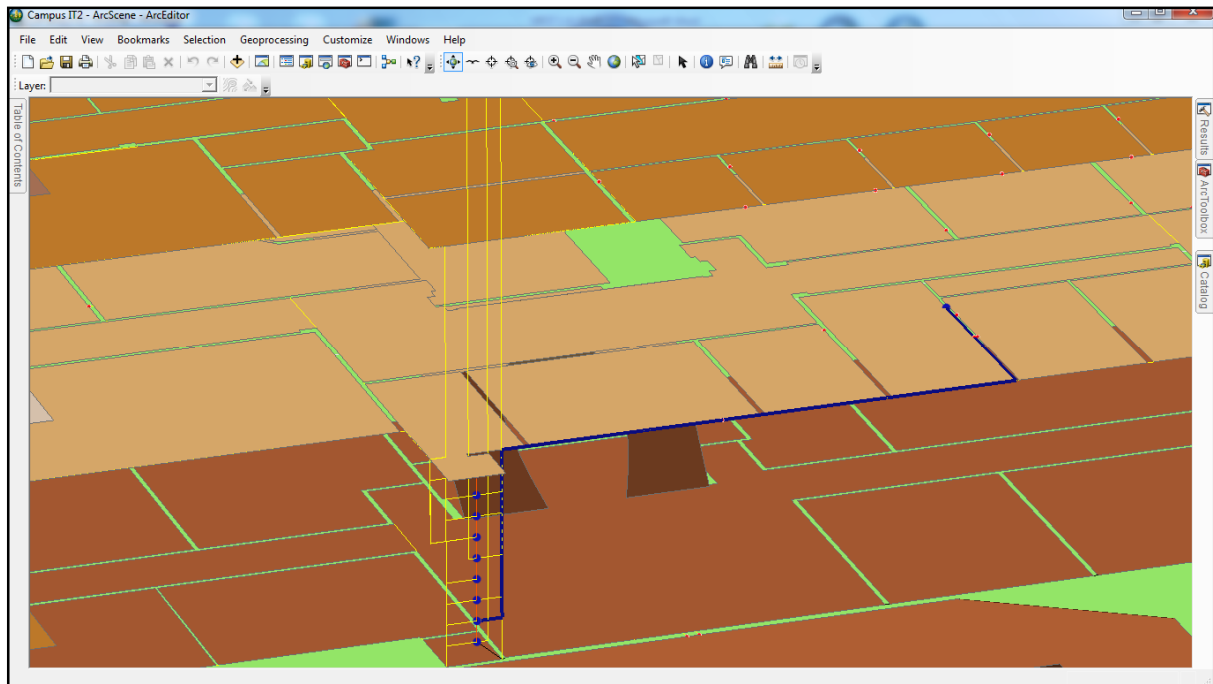


Figure 5.10: Displaying the route between a network port and a switch in ArcScene

5.3.2 Determining the optimum path between a new network port and an available switch

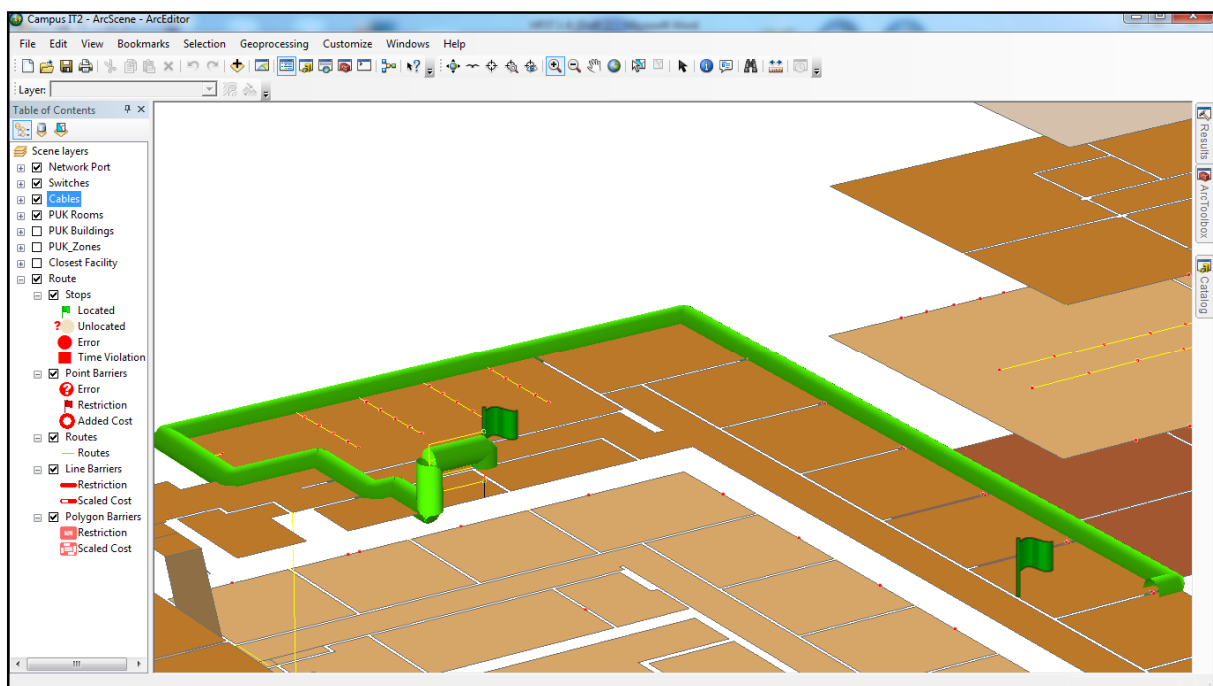


Figure 5.11: Determining the optimum path of a cable between a new network port and a switch

The data model offers the opportunity for IT-management to determine the optimum path of a cable between a new network port and the closest available switch. The example in Figure 5.11 illustrates how the 3D Shortest Route Model can depict the optimum path of the new cable. The two green flags in Figure 5.11 represent the switch and the new network port. The flag that is detached from the route represents the location of the new network port. Although the 3D Shortest Route Model does not depict the entire new path, it does illustrate the optimum path to the new network port along the existing network.

5.3.3 Finding the common ancestor of all the network ports in a building/zone

A common ancestor is the shared root node upstream of a hierarchical network between two or more points. Common ancestors are associated with geometric utility networks, but not with network datasets. Although the network presented by the data model is a network dataset, the New Location-Allocation function from the Network Analyst toolbar can be implemented in such a way that it mimics the common ancestor analysis. The Location-Allocation function takes facilities and demand points into account and determines which facilities most effectively serve the demand points. If the function is applied to switches (facilities) and network ports (demand points) it can determine which switch best serves all of the network ports in the same way as a common ancestor (ESRI, 2011).

Figure 5.12 illustrates how the New Location-Allocation tool is applied to all the network ports in the study area in ArcMap. The aim is to determine which switch serves as the common root for all the switches in the study area. The Location-Allocation layer is divided into two sections namely: facilities and demand points. The facilities section is populated by all the switches while the demand points part is populated by all the network ports, before the function is solved. The result in Figure 5.12 shows that the zonal switch 'ZE/E7/SW 18' serves as the common ancestor to all the network ports in the study area.

The effectiveness of the visual representation of the Location-Allocation layer is once again decreased by the limitations of ArcMap. Figure 5.13 shows the Location-Allocation layer in ArcScene.

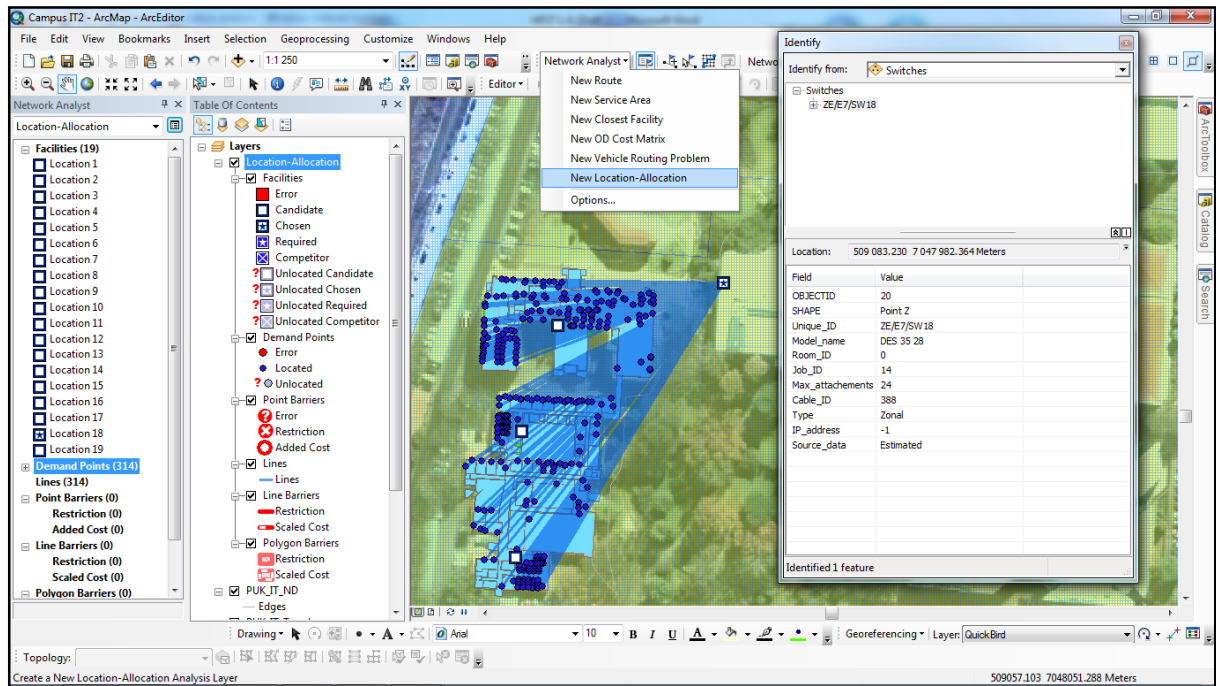


Figure 5.12: Location-Allocation function to determine the common ancestor of all the network ports of the study area

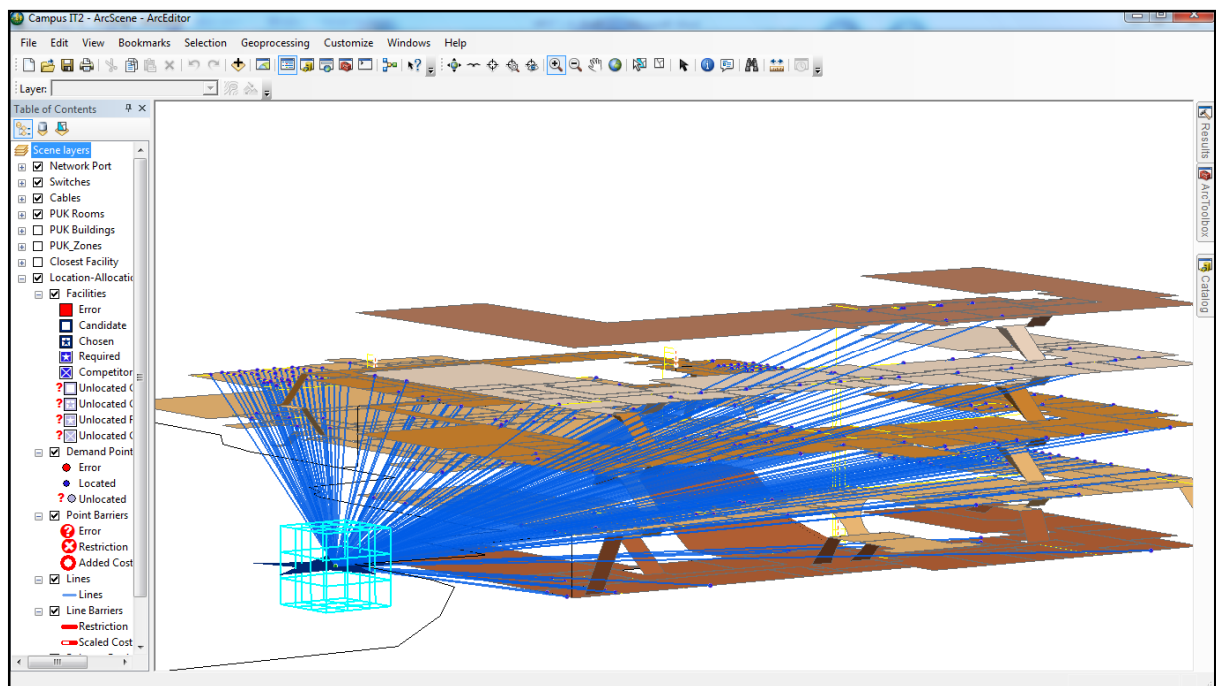


Figure 5.13: Displaying the common ancestor in ArcScene

The resulting visual representation of the common ancestor switch in ArcScene (Figure 5.13) is an improvement on the result delivered by ArcMap (Figure 5.12).

5.3.4 Calculating the route of data flow from the source to a network port

The example illustrated by Figure 5.14 describes how the 3D Shortest Route Model is implemented in order to show the route through the network from the source switch to specified network port.

While ArcScene is open, open the ArcCatalog window and navigate to the 3D Shortest Route Model (PUK Geodatabase> Toolbox > 3D Shortest Route Model). Double click on the model to open the 3D Shortest Route Model window. The window allows the user to interactively add the source switch with the Add Feature button. In the same way the user can add the specified network port feature as one of the route stops (Figure 5.14).

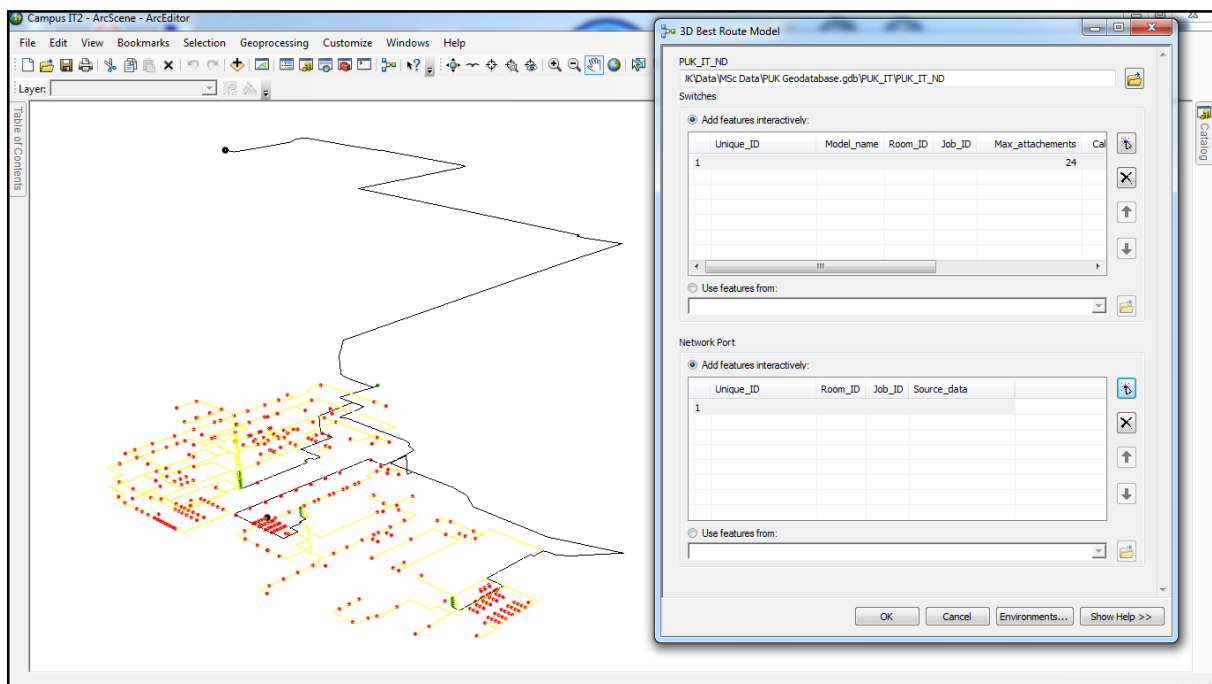


Figure 5.14: Selecting the route stops

Snapping in 3D is more complicated than in 2D, due to the inclusion of an extra dimension. A way to improve the accuracy of the model's snapping to the appropriate switches and network ports is to temporarily turn off the layers which are not participating in the analysis, such as PUK_Zones, PUK_Buildings and PUK_Rooms, as seen in Figure 5.14.

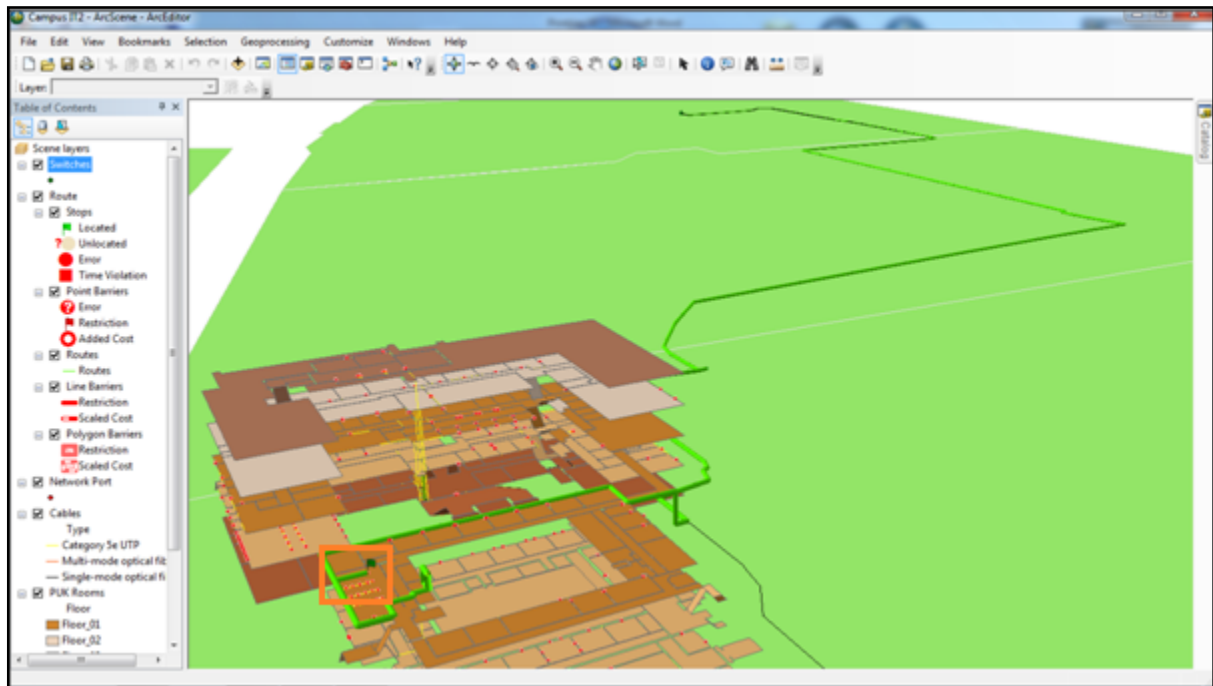


Figure 5.15: Route from the source to a network port

The result for the 3D route model is illustrated in Figure 5.15. The route is added to the table of contents as a layer. In some parts of the example, especially between the local switch and the network port, the route appears to back-track onto itself (the area enclosed by the orange square in Figure 5.15). This is because the cable that feeds the local switch and the cable that links the network port to the local switch share the same path. In essence the route illustrates the path of the single-mode fibre optical cable to the local switch and then depicts the path of the Category 5e cable. Due to the fact that the cable paths line up perfectly (due to a shared trunking), an optical illusion of a back-tracking or a looping route is the result. The optical illusion only appears in instances where the single-mode optical fibre which connects the utility room to network, share the same path as the Category 5e cable.

5.3.5 Illustrating the shortest path between two network ports and highlighting the switches along the path

The “3D Shortest Route Model” also allows the user to determine the shortest path between two network ports. This illustrates the route that data will follow between two of the network end-points, as well as describe the switches along the route. When the model is run and the “3D Shortest Route Model” window appears, the user can interactively add the two network port features as route stops (Figure 5.16).

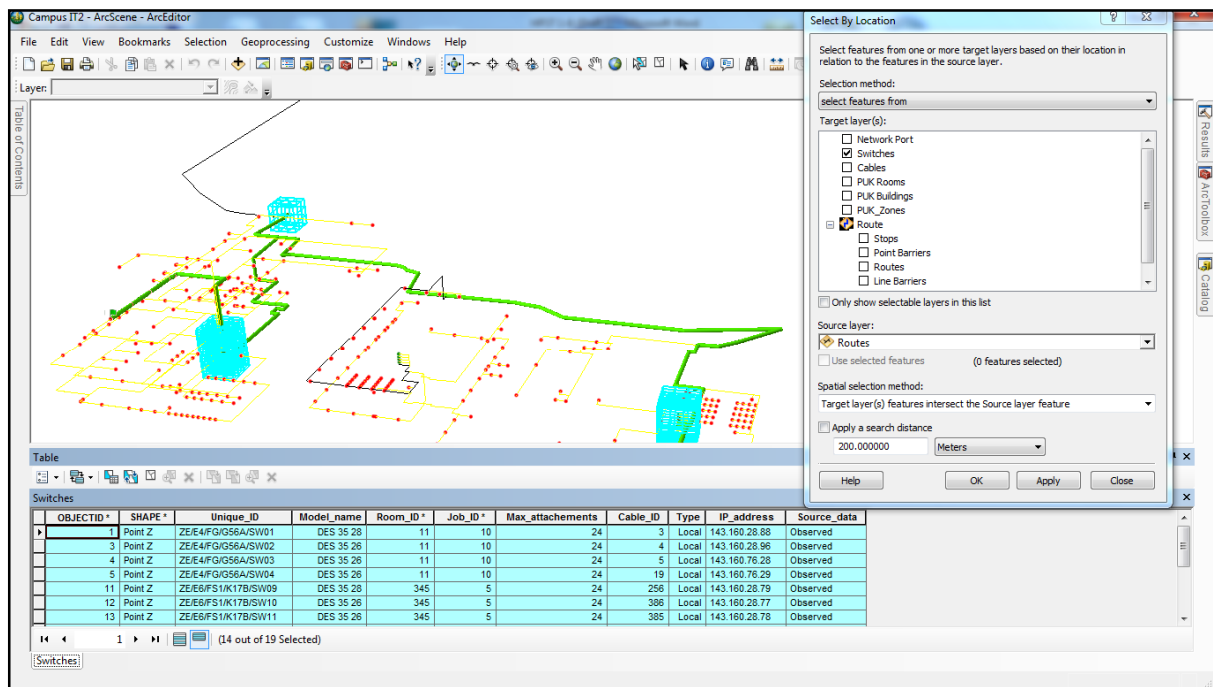


Figure 5.16: Shortest path between two network ports

The result illustrated in Figure 5.16 shows the shortest path between two network ports on the network. In the example the two network ports are in different buildings, but still share the same zonal switch. The route passes through a number of routing switches before it reaches its destination. The switches which are located along the route can be highlighted through a Select by location query. Figure 5.16 depicts that 14 switches intersect the route. The Switches attribute table illustrates the selected switches. The route's length can be viewed in its attribute table.

5.4 Outdoor cables

It often happens that outdoor facilities, such as cables that link buildings, become damaged. Contrary to indoor facilities, an outdoor facility's location cannot be narrowed down to a room, which complicates repairs. In order to overcome this obstacle, the data model offers an alternative method of locating the cables.

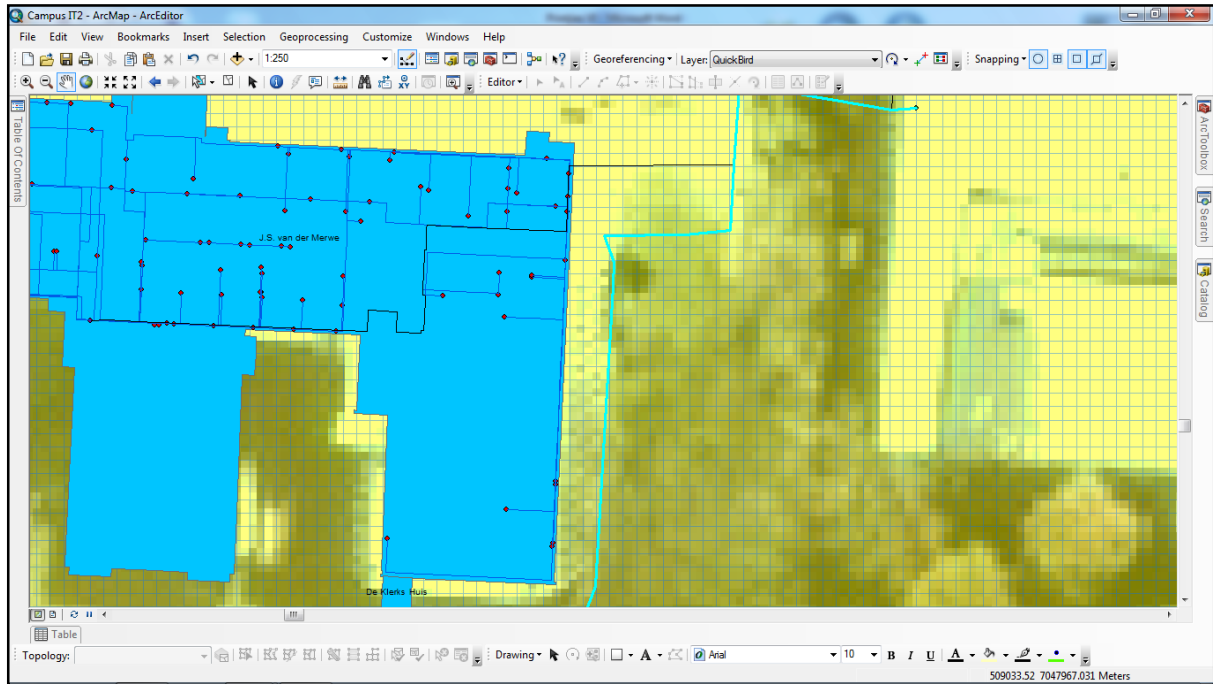


Figure 5.17: Utilizing the *Fishnet* in the data model

A Fishnet feature class was created as an ad hoc method to locate the outdoor cables. Although the Fishnet is not extremely accurate, it provides the user with an estimated location. The cell sizes of the fishnet are set to 1m x 1m, and allow the user to interactively create an understanding of the possible location of the features. Figure 5.17 illustrates an example of how a fishnet is used in the data model.

The highlighted cable in Figure 5.17 represents the feature in question that has to be located. The user can see that the cable runs parallel to the eastern wall of building E6 for most part at a distance of about 3 cells. The user can now estimate that the cable is parallel to the building's eastern wall and situated approximately 3m east of the building. Although this method is not accurate, it reduces the possible location options for the technicians.

5.5 Statistical analysis

The data model offers the ability to perform statistical analysis on all the tables in the geodatabase. The statistics of each field of the attribute tables (or regular tables) can be extracted individually. ArcMap offers built in features to summarize and view attribute data. In the example of Figure 5.18 assume that the network management needs to obtain

statistics about the length of all the cables in the study area. A right-click on the Shape_length field heading in the table accesses the Statistics tool. Immediately a Statistics of Cables dialog box opens which provides the following information (Figure 5.18):

- Total cable count: 332
- Minimum cable length: 0 (The 3D environment doesn't take vertical lines into account)
- Maximum cable length: 666m
- Total cable length: 12148m
- Average cable length: 37m

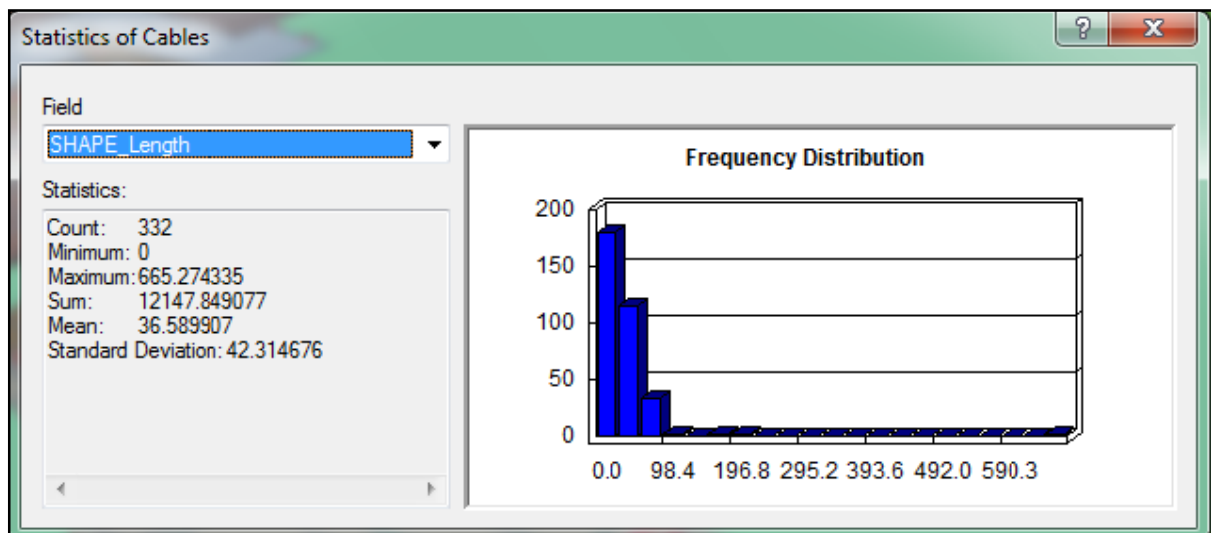


Figure 5.18: Cable statistics

5.6 Conclusion

Chapter 5 illustrates the various ways in which a GIS can be implemented in order to manage, analyse and visually illustrate a computer network on the inside of buildings as well as between buildings. The data model offers excellent visual representation of the data as well as feature querying and connectivity analysis on the network. The geodatabase of the data model further enhances the accessibility and organization of the different types of data. The data model also offers statistical analysis on the feature attributes.