Fundamental of Data Integrity Check and Analytical Operations in Mapping

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Abstract: **Topology is fundamentally used to ensure data quality and aid in data compilation. Most users care deeply about the integrity of their spatial feature dataset, while others are more concerned with optimum performance of analytical operations. Topology aids in analyzing spatial relationships in many situations such as dissolving the boundaries between adjacent polygons with the same attribute values or traversing along a network of the elements in a topology graph. This paper seeks to model how the geometry from a number of feature classes can be integrated and these is referring to as vertical integration of feature classes and also carry out topological operations on satellite imagery of University of Lagos depicted as points, lines and polygons. Spatial integrity of feature datasets was checked and analytical operations such as queries were performed.**

Keywords: **dataset, topology, spatial integrity, georeferencing, geodatabase, integration.**

1.   INTRODUCTION

Topology describes the spatial relationships between adjacent features, and uses x, y coordinates to identify the location of a particular point, line, or polygon. Using such data structures enforces planar relationships, and allows GIS specialists to discover relationships between data layers, to reduce artifacts from digitization, and to reduce the file size required for storing the topological data.

Most users care deeply about the spatial integrity of their feature data, and geodatabase topologies help to better manage data integrity. Using a topology provides a strong mechanism to perform integrity checks on your data and will help you to validate and maintain better feature representations in your geodatabase.

Also, many users like to use topologies for various analytical operations (e.g., to find adjacent features, to work with coincident boundaries between features, and to navigate along connected features). Topologies enable richer analytical functions in GIS environment.

2.   STUDY AREA

The area under study is the University of Lagos, Akoka Campus located on the western part of Lagos metropolis in Yaba Local Government Area of Lagos State. The University is geographically located between Northings 721000N and 718500N, and Easting 542000E and 545000E and has an approximate area of $3.25Km^2$ (802 acres). On the western and south-western borders are located Iwaya community and Akoka village respectively. On the North and North-western flank, the University is bordered by Bariga (Shomolu Local Government Area), a canal which is non-navigable because of debris that is found in it, is located along the western flank stretching northwards and southwards while the famous Lagos Lagoon borders the eastern part of the campus.

OBJECTIVES:

The main objectives of this study are to;

▪   Carry out a comprehensive vectorization of the study area using satellite imagery as the Base map and highlighting points, line and polygon feature datasets.

- Building of a topological network of the feature datasets.

- Performing queries and other analytical operations.

DATA REQUIREMENTS:

Data requirements include;

- Quick bird satellite imagery covering the study area downloaded from Google Earth

DATA ACQUISITION:

The first step was the acquisition of the satellite imagery of the study area; this was obtained from Google Earth. The portion of the study area together with the environment was extracted and cropped out and the resulting imagery is as shown below;

Fig.1: Satellite Imagery of University of Lagos and Environs

3.   GEO-REFERENCING OF THE RASTER IMAGES

Geo-referencing is a process of allocating real time coordinates (i.e. ground coordinates) to points on the raster map or image. In this case, the satellite imagery of the study area was furnished with coordinates around the edges which were used to georeference the imagery using AUTOCAD 2010, in other to relate the raster image to their relative ground positions.

4.   TOPOLOGY BUILDING

The topology building process began with the demarcation of the study area into parcels using ArcGIS software; Fig 2. shows the demarcated parcels.
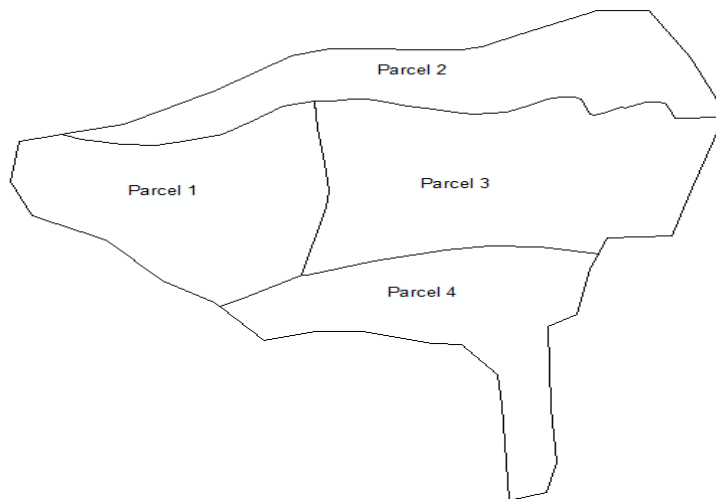
Fig.2:   Study Area demarcated into Parcels

The study area was then digitized in ArcGIS 9.3. An extension of ArcGIS called ArcCatalog was used to create "Shapefiles". These shapefiles represent the different spatial features that were going to be depicted in a vectorized format. These shapefiles were then projected to the same coordinate system as the Base Map and Satellite imagery, to ensure conformity and accuracy of results. The coordinate system used was the Universal Transverse Mercator (UTM) WGS 84, Zone 31^0N.

Creating Coverage:

Coverage is a georelational data model that stores vector data. It contains both the spatial (location) and attribute (descriptive) data for geographic features. Coverage use a set of feature classes to represent geographic features. Each feature class stores a set of points, lines (arcs), polygons, or annotation (text). Coverage can have topology, which determines the relationships between features. Arc-catalog was used to export the relevant feature class into coverage.
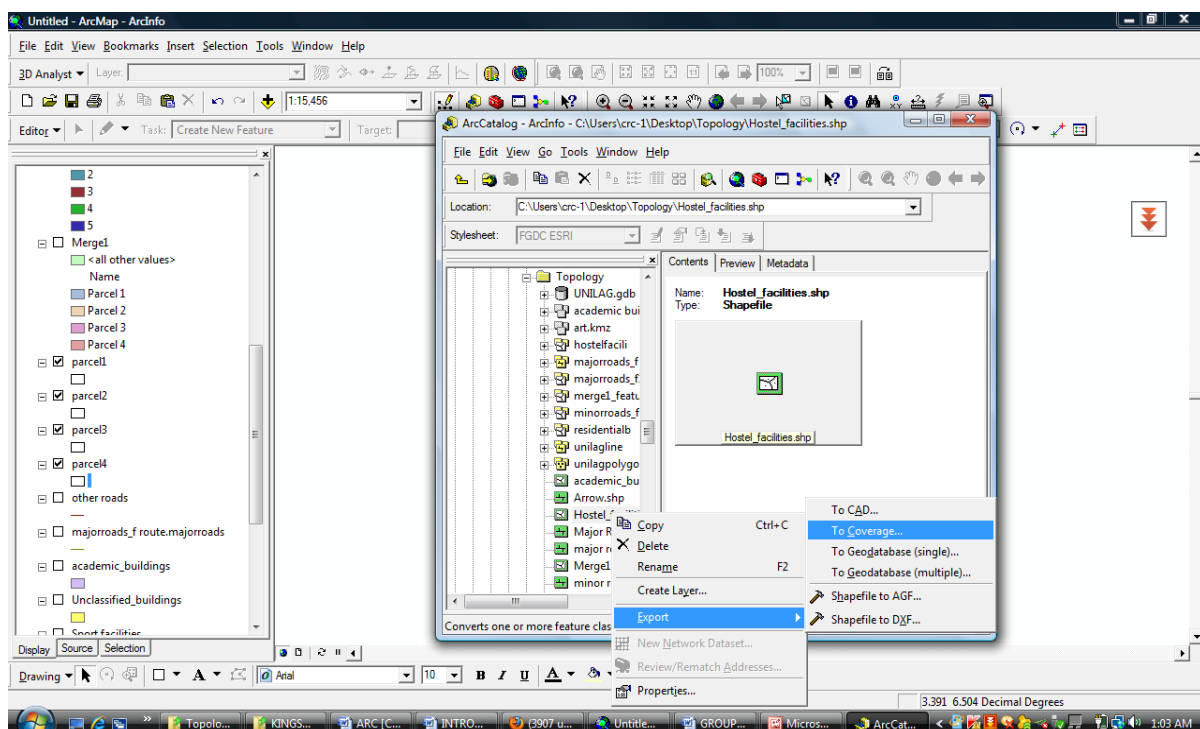

Fig.3: Feature class being exported to coverage

After feature class has been exported to coverage, a coverage feature dataset is created depicting Arcs, Polygons, Tics, and Labels. Fig 4 shows the coverage feature dataset
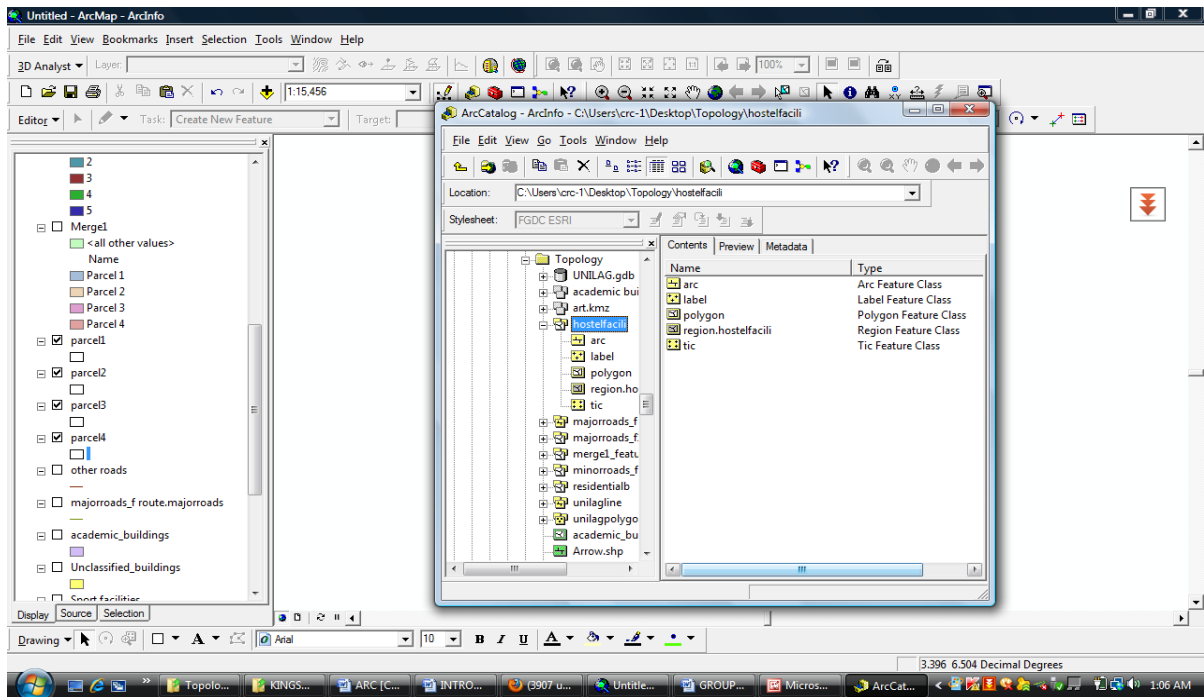
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Fig4: Coverage feature dataset showing the different feature class

Building Coverage Topology:

1. In Arc-Catalog, right-click the coverage for which you want to build topology and click Properties.

2. Click the General tab.

3. Click the feature class for which you want to build topology.

4. Click Build. You can click the Feature class drop-down arrow and change the feature class or annotation class for which to build topology.
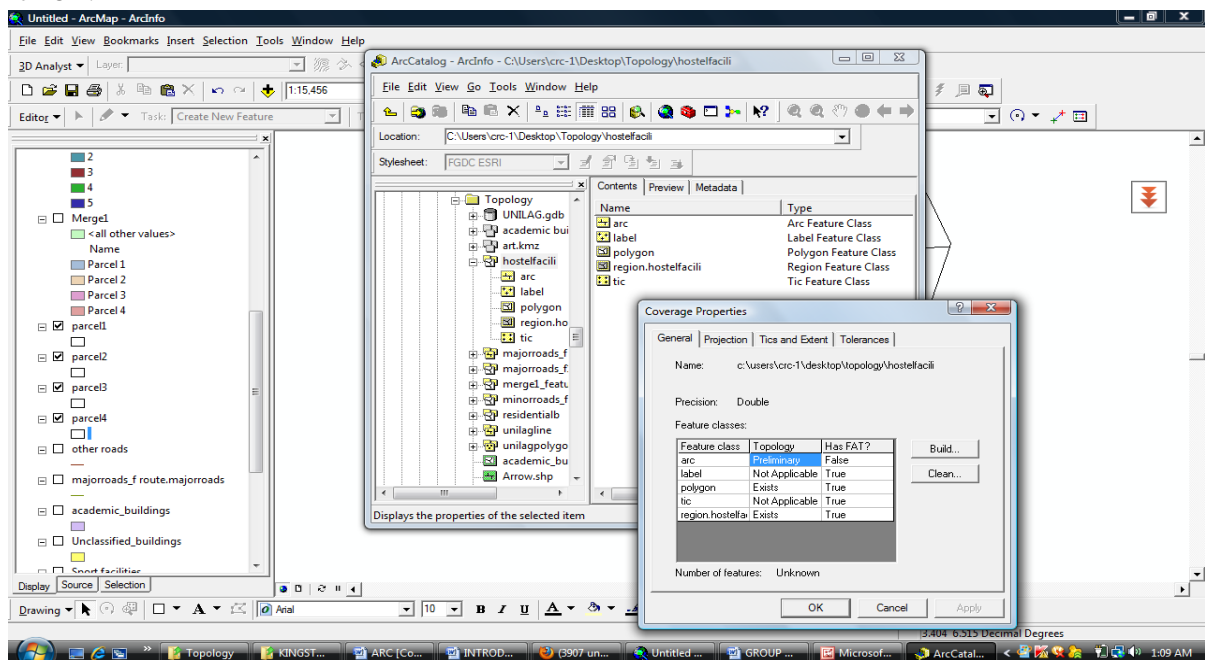
5. Click OK on the Build dialog box.

6. Click OK.

Fig5: Building coverage topology

Cleaning Coverage Topology:

1. In Arc-Catalog, right-click the coverage you want to clean and click Properties.

2. Click the General tab.

3. Click the feature class you want to clean.

4. Click Clean.

5. Type the fuzzy and dangle tolerances in the clean dialog box, if appropriate.

6. Optionally, check the box to clean lines only.

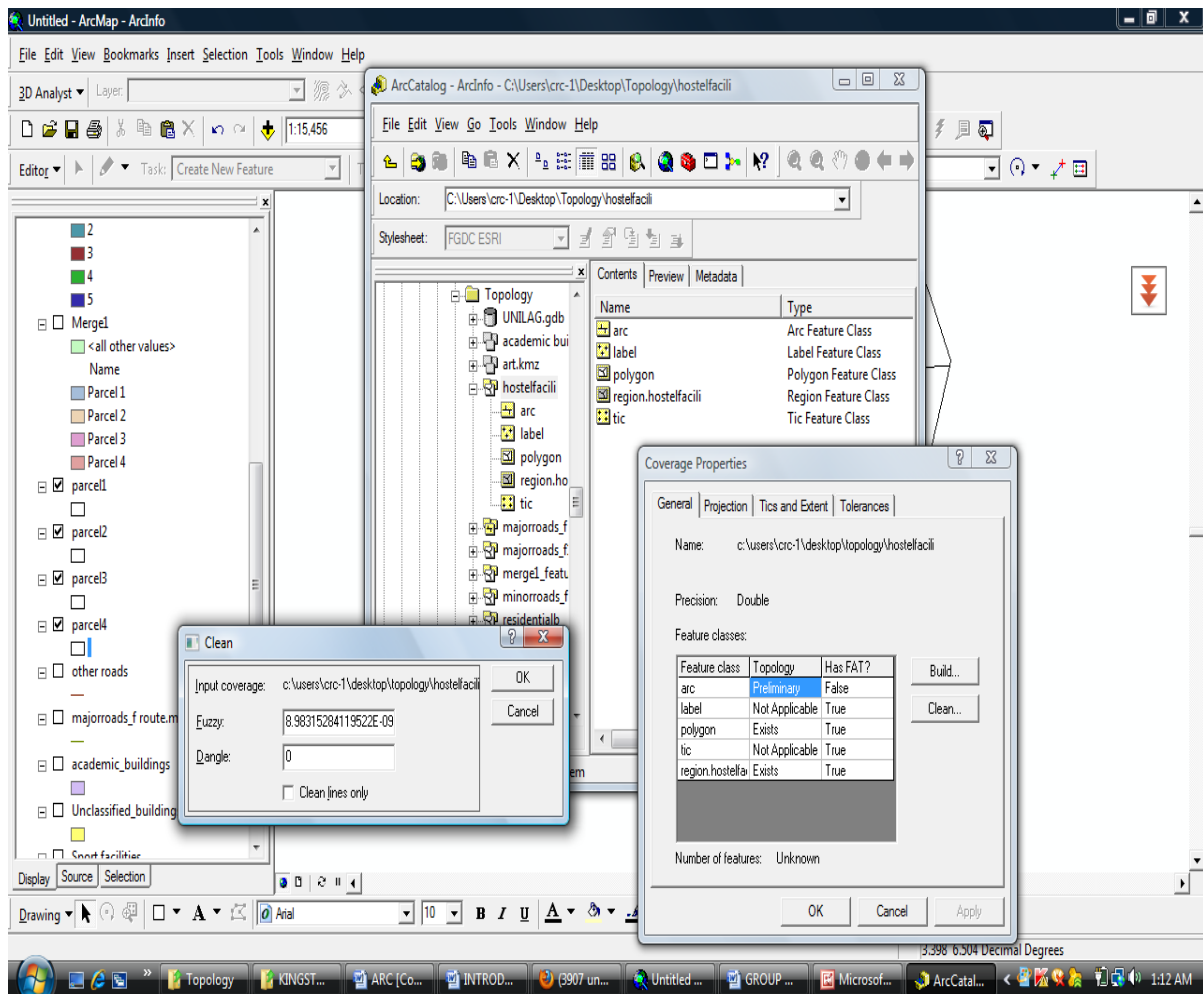7. Click OK on the clean dialog box.

8. Click OK.

Fig.6: Cleaning coverage topology

5.   RESULTS & ANALYSIS

The topological structure of coverage supports three major topological concepts:

- Connectivity: Arcs connect to each other at nodes.

- Area definition: Arcs that connect to surround an area define a polygon.

- Contiguity: Arcs have direction at left and right sides.

Some selected results shown will depict these three major topology relationships;
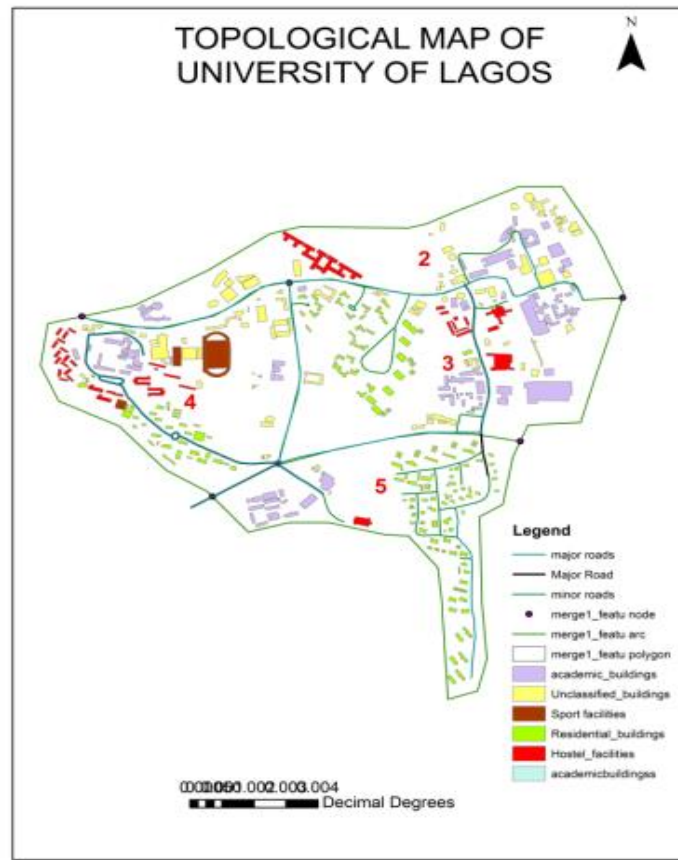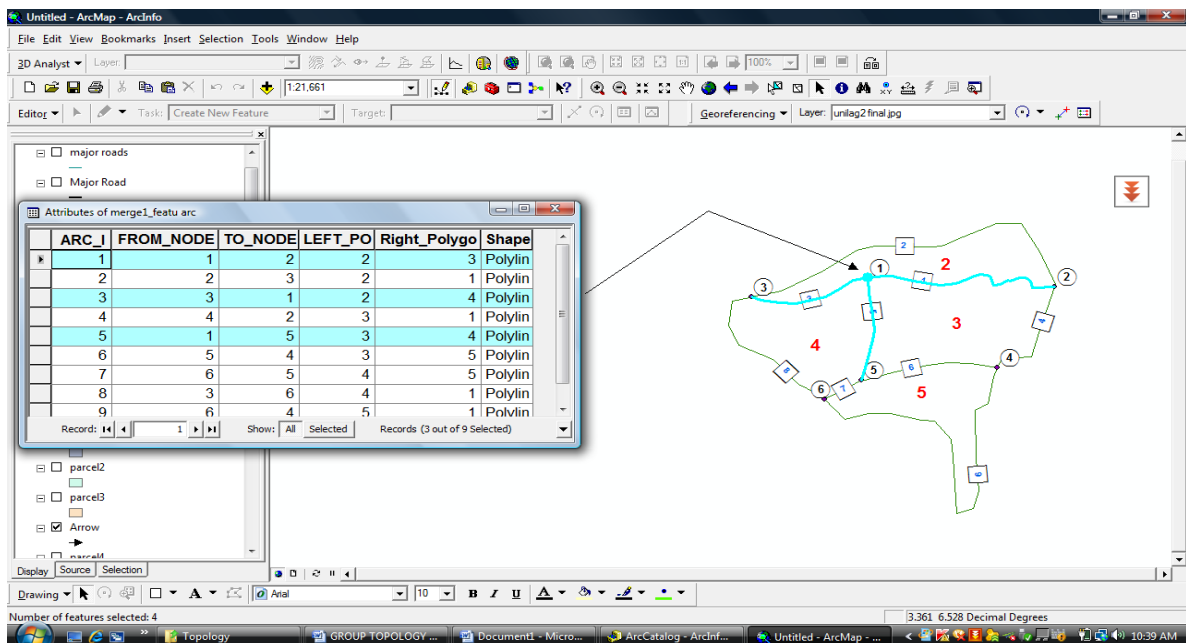
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RESULT 1:

Fig.7: Showing topological Map of study area

Fig.7 above shows the topological map of the study area. This map was created by digitizing the various features, representing them as points, lines and polygons and showing how these three features are related by geometry.

RESULT 2:

ARC - NODE Relationship

Fig.8: depicting arc – node topology query

Connectivity is defined through arc-node topology. This is the basis for many network tracing and path finding operations. Connectivity allows you to identify a route to the airport, connect streams to rivers, or follow a path from the water treatment plant to a house. In the arc-node data structure, an arc is defined by two endpoints: the from-node indicating where the arc begins and a to-node indicating where it ends. This is called arc-node topology.

Fig.7 above shows another connectivity query depicting **arc – node topology**. It indicates **arcs 1, 3 and 5** which all intersect at node 1.
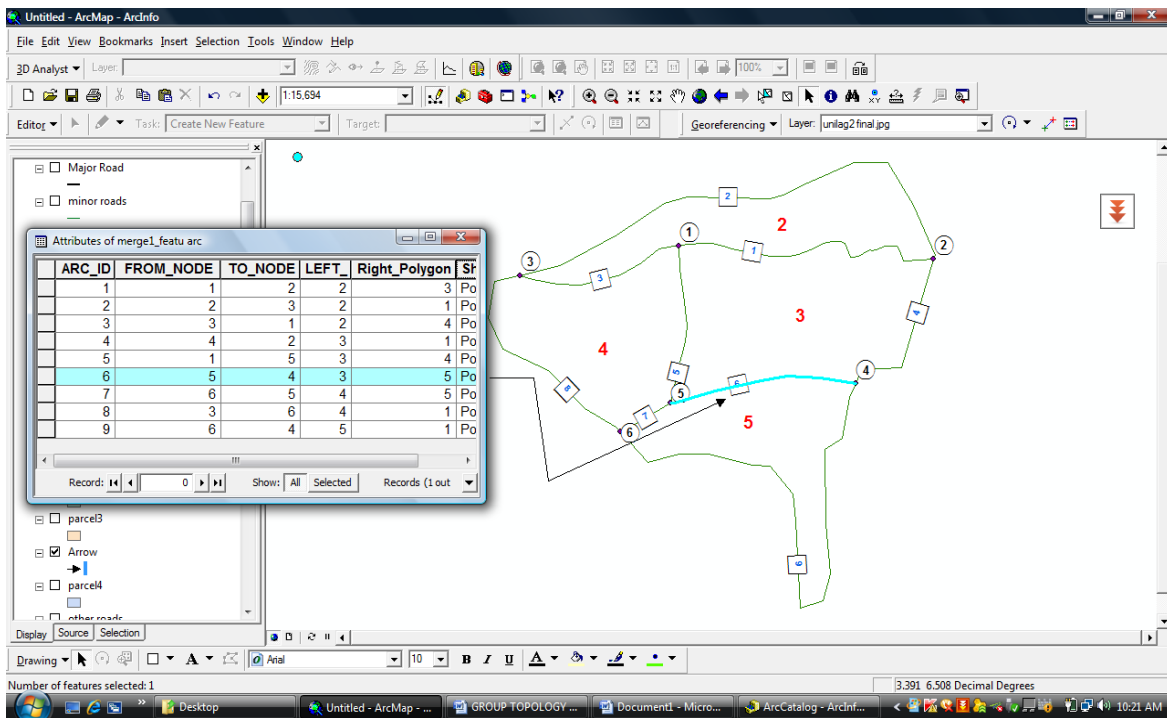
RESULT 3:

Fig. 9: showing a connectivity query depicting arc – node topology

Fig.9 above shows a connectivity query that defines an **arc – node topology**. The result indicates that arc 6 is bound by node 5 and node 4. Node 5 is the "from-node" and node 4 is the "to-node".
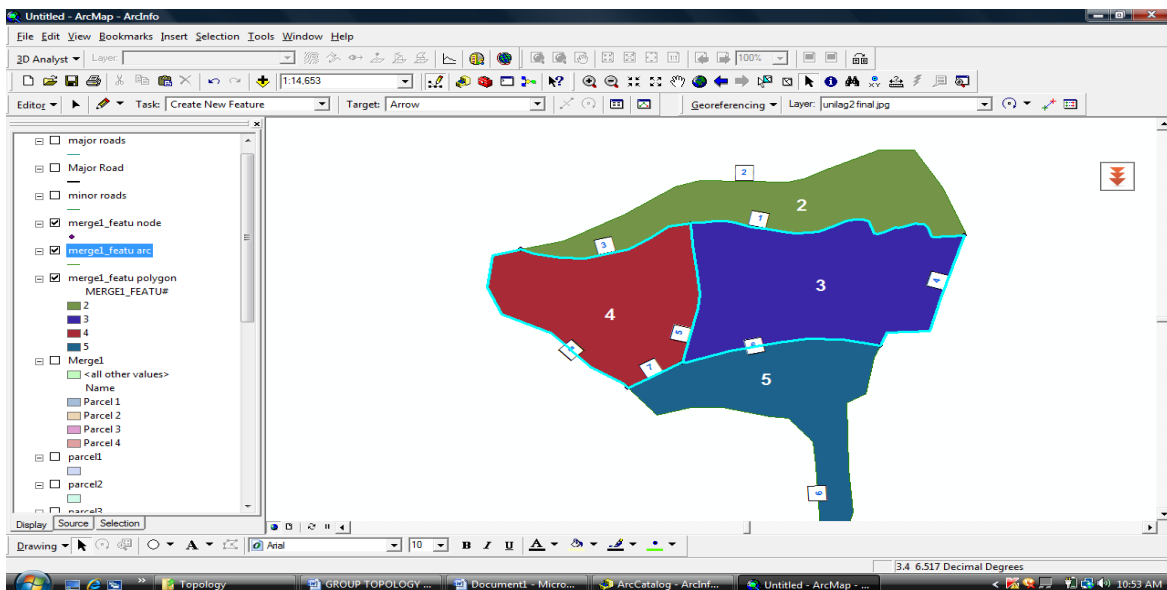
RESULT 4:

Fig.10: Contiguity topological concept showing a left – right topology

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Two geographic features that share a boundary are called adjacent. Contiguity is the topological concept that allows the vector data model to determine adjacency. Polygon topology defines contiguity. Polygons are contiguous to each other if they share a common arc. Left-right topology refers to the polygons on the left and right sides of an arc. In the illustration above in Fig.10, **polygon 4** is on the left of **arc 8**, and **polygon 3** is on the right. Thus, we know that polygons **4** and **3** are adjacent.
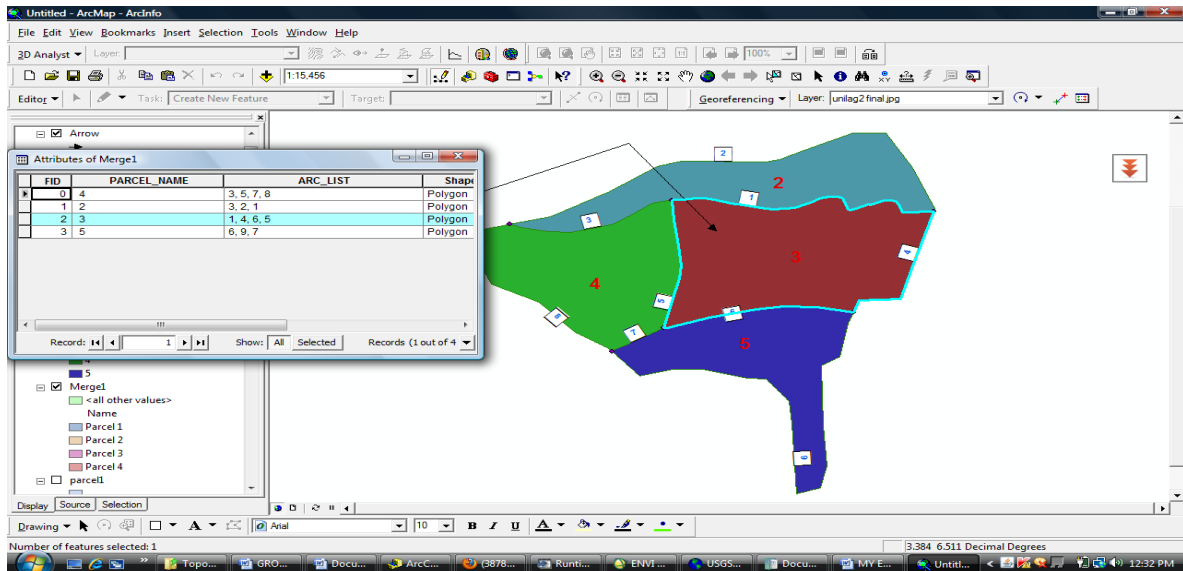
RESULT 5:

Fig.11: Area definition query showing polygon – arc topology

The arc-node structure represents polygons as an ordered list of arcs rather than a closed loop of x, y coordinates. This is called polygon-arc topology. Fig.11 above is a **polygon – arc topology**. In the illustration; arcs 1, 4, 6, and5 combined to form Polygon 3.

6.   CONCLUSION

The analyses carried out above shows how using a topology provides a strong mechanism for performing integrity checks on data and help to validate and maintain better feature representations in the database. The above operation also shows how topologies was used for executing various analytical operations (e.g., to find adjacent features, to work with coincident boundaries between features, and to navigate along connected features). This shows how topologies enable richer analytical functions in your Geographic Information Systems (GIS).

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