# Implementing Advanced Visualization Techniques for CIT Business Intelligence

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## Abstract

Business Intelligence (BI) is a broad category of applications and technologies for gathering, storing, analyzing, sharing and providing access to data and information to help executive users make better decisions. Implementing effective BI solutions became crucial in the Egyptian government in order to provide decision makers deep insight in their domains and efficiently support their decision making process. In an earlier work, we have proposed MCIT_BI, business intelligence solution for the Ministry of Communication and Information Technology (MCIT) in Egypt, focusing on the business domain of Information & Communication Technology (ICT) infrastructure capacity planning. The previous work covered the back-end parts of the solution, namely the ETL, the Data Warehouse, and the OLAP cubes. In this paper, we proposed advanced visualization techniques in on top of the BI system stack, in order to complete the picture and provide a complete end-to-end solution. We discuss the design and implementation of three different multi-dimensional visualization applications, such as OLAP Reporting, Intelligent Maps and Trend Analysis, which utilize a wide spectrum of techniques and provide the user a rich and flexible analytical experience.

**Keywords:** *Business Intelligence, Multi-dimensional Modeling, OLAP, Visualization, User Interface (UI).*

## 1. Introduction

According to W. Inmon and E. F. Codd, Online Transaction processing (OLTP) in the operational-level applications and Online Analytical Processing (OLAP) in decision support applications cannot coexist efficiently in the same database environment, mostly due to their very different orientation and transactional characteristics [1] [2].

The author have recently proposed [14] a case study of delivering a a data warehouse, and Business Intelligence(BI) solution to the Ministry of Communication and Information Technology (MCIT), which tackled business domains of fixed telephone usage, mobile phone usage and internet usage [14]. This previous work covered the back-end parts of the solution, namely the data integration and transformation process (ETL), the data warehousing approach and design, and the multi-dimensional OLAP cubes implementation. In this paper, we extend the BI solution introduced in [14] by proposing an advanced visualization techniques on top of the BI system stack, in order to complete the picture and provide a complete end-to-end solution.

The combination of data warehouse, BI, data mining and data visualization is gradually becoming an indispensable organizational weapon for achieving competitive advantage in many data-driven domains[16]. We discuss the design and implementation of three different multi-dimensional visualization applications, such as OLAP Reporting, Intelligent Maps and Trend Analysis, which utilize a wide spectrum of techniques and provide the user a rich and flexible analytical experience.

The rest of the paper organized as follows. Section 2 gives a background on BI basic concepts. In Section 3, we give an overview of our MCIT_BI solution proposed in [14]. Section 4 describes the design of our proposed visualization components architecture. Our three proposed visualization application, namely OLAP Reporting, Intelligent Map, and trend analysis, are discussed in Section 5, 6, and 7, respectively. We conclude with general remarks in Section 8.

## 2. Business Intelligence

Due to the quick evolution of information and communication technologies and dissemination of computer use, many organizations use automated system to implement their important processes, which are known as OLTP. A lot of data are being produced during the OLTP operations, but the data is not integrated. Such data are stored within one or more platforms and constitute the resource for the organizations. However, OLTP systems are not suitable to manage and store strategic information. They are formed by operational data needed for daily transactions. In terms of decisions, data are empty and without any transparent value for the decision process of organizations. Decisions are taken based on administrators experience and sometimes based on historical facts stored in different information systems[3],[4],[5],[6].

## 3. Overview MCIT BI Solution

MCIT_BI [14], recently introduced by the authors, is aBI solution for the MCIT infrastructure business area. In MCIT_BI, we focused on several domains of concern, such as Fixed line phones indicators,Mobile phones indicators, and Internet usage indicators. We aimed to build a BI solution platform to facilitatefindinga good understanding for the ICT service's penetration inside the Egyptian society based on the available hard data which can lead at the end, for better forecasting for the future capacity of the ICT sector. Understanding the ICT infrastructure capacity can help in; understanding the required governmental future investments into ICT infrastructure. Additionally, it shows the size of the market for more private sector investments in Egypt. This may help the strategic governmental decision makers to take required actions towards increasingthe quality of the ICT sector infrastructure.

In order to reach this level of understanding, it is crucial to have accurate, and consolidated statistical understanding by means of numbers and ratios of the IT sector data that could be navigated in multidimensional hierarchal manner using the, Time, Geographical location, and host. In order to fulfill this objective; an integrated business intelligence solution has to be built to plot the data over a visualization dashboard that delivers the information to the decision maker in an informative shape.The outline of our proposed MCIT BI solution architec-

ture is shown in Figure 1. The architecture illustrated in the figure highlights the main layers in MCIT_BI. Note that in our previous work [14], we discussed all the back-end layers, including, ETL, Data Warehousing and OLAP cubes layer, and we focus on the Web dashboard and visualization layer. However, we give a brief overview of the whole solution for the sake of making this paper self-contained.
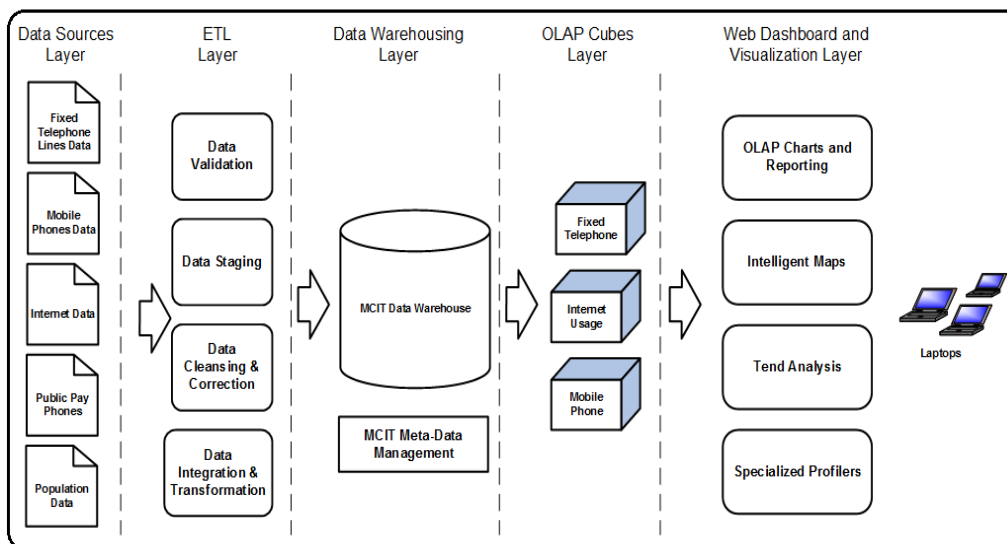


**Figure 1 - MCIT BI Solution Architecture**

The proposed MCIT BI solution consists of 4 layers. The main tools and characteristics used to in each layer are defined as follows.

**ETL Layer:** The ETL layer serves as the data integration and transformation in our BI solution. The input for this layer are the excel sheets that include data about the latest operational updates in the fixed telephone lines, the mobile phone lines and the internet usages domains, along with the up-to-date population census. The output of this layer is clean and consistent data to be loaded in the data warehouse.

**The data warehousing layer**: The MCIT data warehouse is the multi-dimensional repository for the integrated and consistent data that serves the analytical and reporting methods. Complex queries usually require a vision of the data from different perspectives. Answers to this type of questions can lead to correct or wrong decisions. The MCIT implements the Star Model, where dominant tables exist in the center of the model. The table in the center is called Facts table. This table has multiple junctions connecting with other tables called Dimension tables. Each secondary table has only one junction with a fact table. The star model has the advantage of being simple and intuitive for analytical purposes. Figure 2 shows a consolidated Entity Relationship Diagram (ERD) for the data warehouse with the current MCIT domains of concerns.
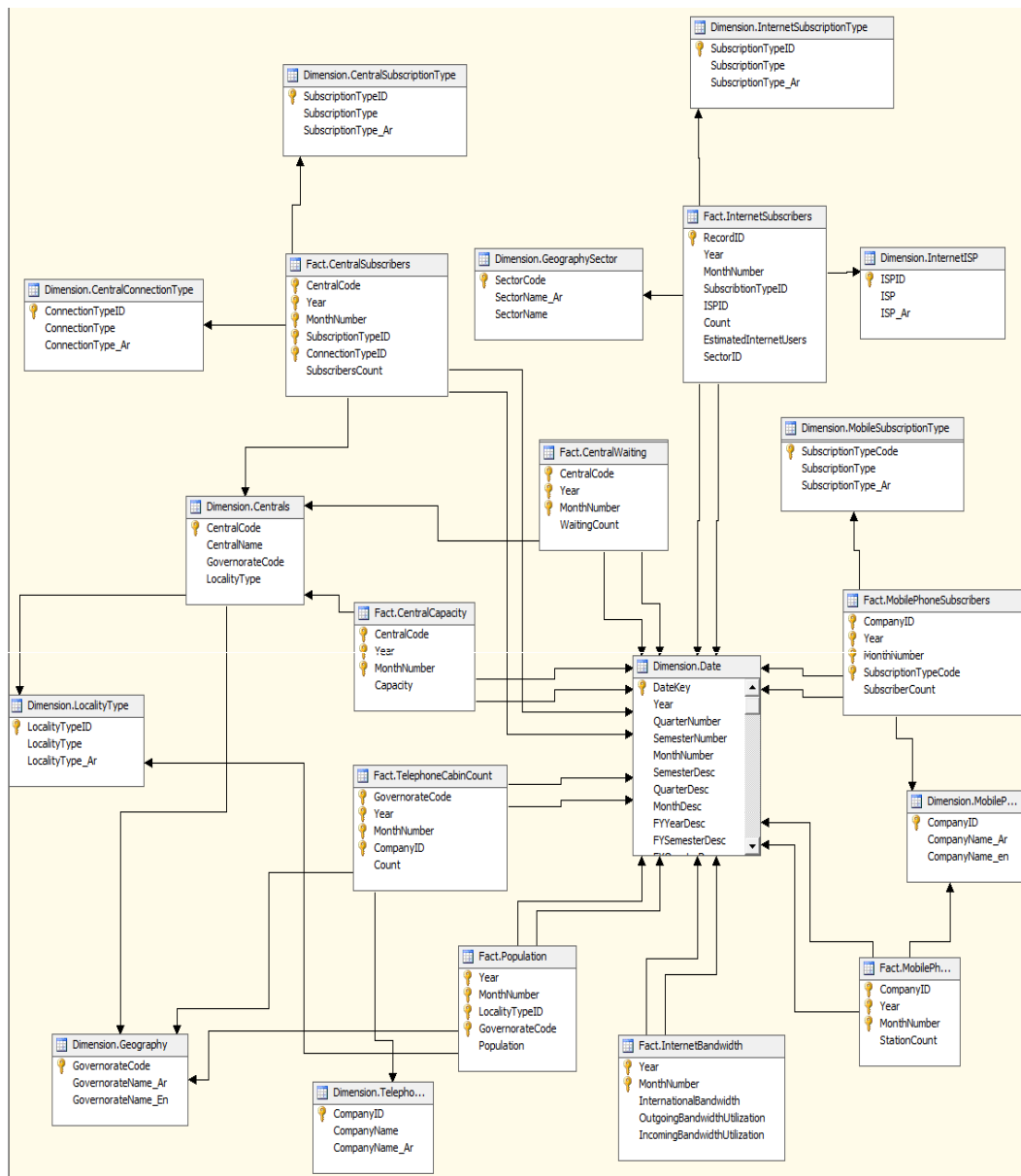
**Figure 2 – The MCIT data warehouse consolidated ERD**

**OLAP Layer:** On-Line Analytical Processing (OLAP) is a different kind of database technology designed specifically for BI. Instead of organizing information into tables with rows and columns like a relational database, an OLAP database stores data in a multidimensional format. Rather than trying to get a relational database to meet all the performance and usability needs by the MCIT executive and managerial level, we build an OLAP database that the MCIT users can query for the analytical proposes.

An OLAP cube consists of data from one or more fact tables and presents information to the users in the form of measures and dimensions. In addition to the measures, we implement complex calculations and analytical logic to the cube to meet the analysis requires of the users. Moreover, a careful aggregation design was carried out to improve the querying efficiency. For the infrastructure capacity planning domain, we implemented three subjective OLAP cubes; each is responsible representing a specific analytical theme in the domain, namely Fixed Lines, Mobile Phones, and Internet Usage. Each analytical theme has a set of measure groups, where each has a set of measures and calculations. Figure 3 shows the object browser of the MCIT_BI OLAP database, which includes the three aforementioned cubes.
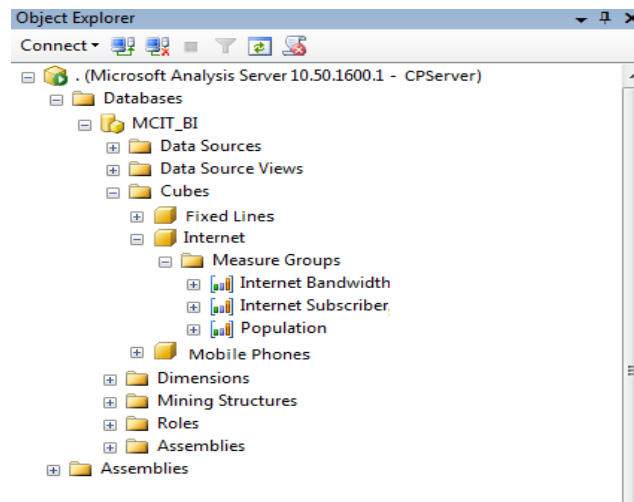


**Figure 3 - MCIT_BI SSAS OLAP Cubes**

**Web-based Dashboard and Visualization Layer:** This layer provides the MCIT executive user with tools and capabilities to easily query and the data of it domain of concern. This layer should provide applications such as OLAP charting and reporting, performance monitoring gauges, trend analysis, and specialized profilers. This layer is the focus of our current work and is discussed in detail in the following sections.

## 4. MCIT BI Visualization Components Architecture

In the MCIT BI solution, the web-based dashboard is a rich and easy-to-use, user interface, showing a graphical presentation of the current status and historical trends of the key performance indicators in each domain of concern, which enables instantaneous and informed decisions to be made at a glance. The dashboard visualize the multi-dimensional information stored in the well-crafted OLAP cubes and provide the user with tools for graphically monitoring the high-level processes and then drill down to explore the low-level data. Moreover, flexible and advanced techniques are provided to facilitate analyzing the data with multiple perspectives and observing the patterns and trends from different point of views. Benefits of using our proposed MCIT BI dashboard include:

- Ability to make more informed decisions based on OLAP cubes.
- Flexible querying and informative visualization.

- Ability to identify and correct negative trends.
- Geographical-based visualization analytics and analytics
- Ability to create, customize and manipulate multi-dimensional reports.
- Saves time compared to running multiple reports.
- Gain total visibility of domainbehavior.
- Quick identification of data outliers and correlations.

For that, we develop several visualization applications, namely OLAP Reporting, Intelligent Maps, and Trend analysis, to give the user the maximum insight in his business domains, where key concerns are the flexibility and the richness of analysis. We used Dundas Charts for OLAP (version 7) and we designed the unified data querying and visualization architecture that applies on the three different visualization applications in the dashboard. Figure 4 illustrate the main components in the unified visualization architecture, followed by a description of each component of the visualization components.
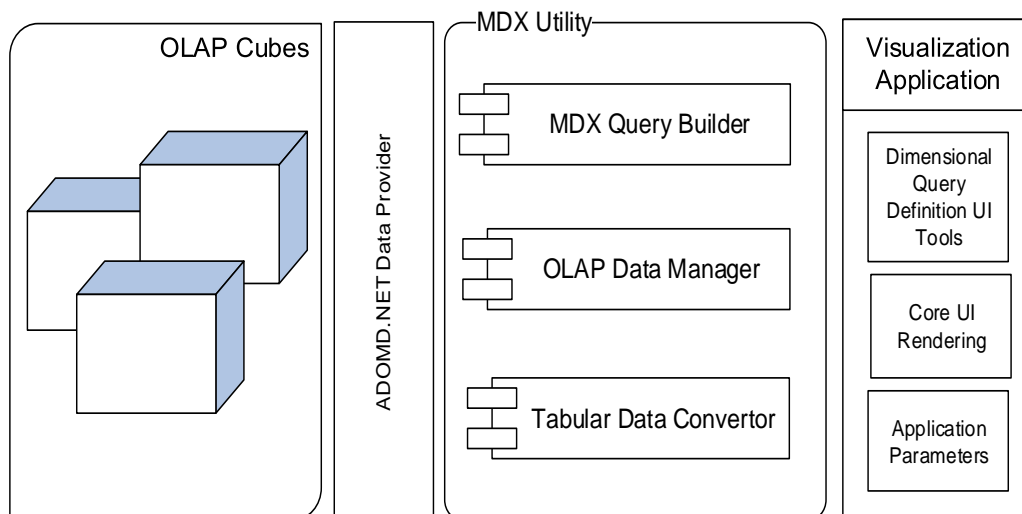


**Figure 4 - MCIT_BI Visualization Components Architecture**

- **Dimensional Query Definition UI Tools:**This set of components is UI-based controls that browse the structure of the OLAP objects. More precisely, the Dimensional Query Definition UI Tools contains two main types of controls: 1) Cube Browser and 2) Axis Descriptor. The Cube Browser control list the available measures and dimension in a selected cube, while the Axis Descriptor control is used to browse (a) specific dimension(s) and select a set of members (or levels) to be used for the current query. An Axis Descriptor can have three types:
    - The firs type is **Slicer**, of which the selected dimension members are used to filter the measure values of the query (similar to the WHERE condition in SQL).
    - The second type is**Categorical**, of which the selected dimension members are used to categories (dice) the measure values of the query.
    - The third type is **Series**, of which the measures of the query are defines.

The user use Dimensional Query Definition UI Tools to dynamically define the measures and dimensions (slicer, categorical, and series) of the OLAP query desired in a flexible and interactive way, where selected measures and dimensions' members are then use programmatically to invoke the query. Note that these controls are used in all of our visualization application as the main multi-dimensional analytical tools. The way by which the multi-dimensional data is visualized differs from an application to another, according to the next component.

- **Core UI Rendering:** This component represents the core rendering technique in each of our proposed visualization application. In other words, each application has its own technique to render and visualize the information retrieved using the OLAP query. In the OLAP Reporting application, we visualize the data using Dundas OLAP Charts and Grid controls, where a multi-dimensional data object (the OLAP Report object that it is constructed from the query results) can be rendered and manipulated directly. In the Intelligent Maps, the Core UI rendering is a Dundas Map control. In the Trend Analysis, the multi-dimensional data is visualized in a regular chart, after the data is flattened using the Tabular Data Converter component (discussed later in the section). Therefore, the main Core UI Rendering controls used in our applications are:

  o DundasOLAP Charts
  o DundasOLAP Grids
  o DundasMaps
  o DundasCharts

- **Application Parameters:**These are application-specific controls by which the user can customize the current analytical view and enrich the analytical experience. For example, in the OLAP Reporting application, the user can change the Chart Type parameter from Bars to Pie chart. On the other hand, in the Intelligent Map application, the user can change the zoom level parameter and the Map analytical type. More details about each specific application are shown in the next sections.

- **MDX Query Builder:**In order to retrieve information from an OLAP cube a specific query script should be defines. MDX [15] (Multi-Dimensional eXpressions) is the query language used for retrieving multi-dimensional data from the OLAP Cubes. The role of the MDX Query Builder control is to take the query definitions as parameters from the Dimensional Query Definition UI Tools, build an MDX query and execute the query to get back the results. The typical structure of the MDX query that is used in our various applications is as following:

```
SELECT
{<<dimension members>>}ON ROWS,
{<<measuers>>}ON COLUMNS,
FROM
[<<cube>>]
WHERE
{<< dimension members>>}
```

Basically, four types of parameters should be defined in such and MDX query. First, the cube name [<<cube>>] from which the data is retrieved. A menu of the available domains

(cubes and perspectives) is shown on each visualization application web-page, where the user can select the specific desired domain of concern for analysis. The selection of a specific domain in the menu is reflected as the cube parameter in the MDX query. Second, the measure(s) we query for is(are) defined in the {`<<measuers>>`}parameter. Such a parameter is set using the select measure from the Series Axis Descriptor Control, as defined in the Dimensional Query Definition UI Tools. Third, the set of dimension members by which the data is filtered, which are represented in the {`<< dimension members>>`}parameter after the (`WHERE)`  key word. The dimension members in the filter parameters are set from the Slicer Axis Descriptor Control. Fourth, the set of dimension members by which the data is categorized, which are represented in the {`<< dimension members>>`}parameter before the (`ON ROWS)`key word. The dimension members in the category parameters are set from the Categorical Axis Descriptor Control.

- ▪ **OLAP Data Manager:** This component the object model of the multi-dimensional data retrieved from an OLAP cube. The main object in this component is the OLAPReport. The content of the current OLAPReport reflects on both the Core Rendering UI visualization components, as well as the Dimensional Query Definition UI controls. Likewise, manipulating the Dimensional Query Definitions issues a new MDX query which updates the current OLAPReport object.

- ▪ **Tabular Data Convertor:** This component is responsible for converting the data retrieved from an OLAP cube via an MDX query into one of two forms: The convertor may convert the multi-dimensional data data intoand OLAPReport object, which can be used directly with the Dundas OLAP Charts and Grids in the OLAP Reporting visualization application. As for the Intelligent Map and Tend Analysis applications, the convertor converts the data into a normalized DataSet object, which can be rendered in the normal Chart and Map controls.

- ▪ **ADOMD.NET Data Provider:** This component is provides a set of APIs by which we interconnectprogrammatically with the OLAP cubes. ADOMD.NET is a Microsoft .NET Framework data provider that is designed to communicate with Microsoft SQL Server Analysis Services. ADOMD.NET uses the XML for Analysis protocol to communicate with analytical data sources by using either TCP/IP or HTTP connections to transmit and receive SOAP requests and responses that are compliant with the XML for Analysis specification. Commands can be sent in MDX to receive results.Moreover, ADOMD.NET data provider component allow working with metadata and retrieving the object definitions (i.e. cubes, measures and dimensions) besides executing MDX queries to retrieve results.

The diagram in Figure 5 illustrates a typical sequence of user-dashboard interaction and the collaboration between the previously discussed multi-dimensional visualization components, as follows:

1. In any visualization application, the user selects the [Cube] (business domain) from the Domains Menu in which he\she desires to perform queries and analysis.

2. Using the Dimensional Query Definition UI Tools, the user specifies a [Measure] from the Axis Descriptor Series, a set dimension members as [Filer] from the Axis Descriptor Slicer control, and a set of dimension members as [Categories] from the Axis Descriptor Categorical.

3. The specified [Cube], [Measure], [Filter], and [Categories] parameters are then passed to the MDX Query Builder component.

4. The MDX Query Builder component then constructs, validates, and executes the MDX query via communicates with the ADOMD.NET Data Provider.

5. The ADOMD.NET Data Provider returns the multi-dimensional data in a CellSet object.

6. The CellSet Object is used to build an OLAPReport object if the calling application is the OLAP Reporting. In which case the OLAReport is directly rendered in the Core UI Rendering component, which can be either OLAP Chart or OLAP Grid.

7. For other visualization applications, the CellSet object is converted into a normalized DataSet object.

8. The DataSet object is the returned to the application to be rendered in the Core UI Rendering component, which can be a Map or a Chart.

9. The user can use the application parameters to further customize and manipulate the current data view.
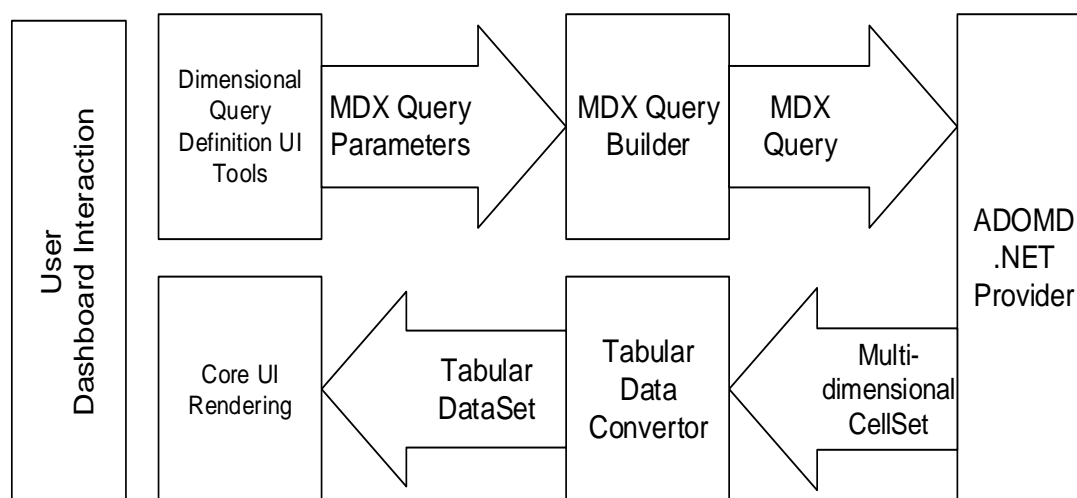


**Figure 5 - Visualization Components Sequence Interaction**

## 5. OLAP Reporting

The first visualization application we propose is the OLAP reporting, which is the main analytical tool in our MCIT dashboard. The OLAP Reporting application allow the executive user to build his own report on-the-fly in an easy and flexible manner, utilizing the data in the multi-dimensional OLAP cubes design to model the business domains. Using the OLAP Reporting application, the user would be able to investigate about any measures in his business

domain and view using the various business dimensions. Dimensions can be used to either filter (slice) the retrieved measures or to categorize (dice) this measure into separate values, one for each dimension members. Useful roll-up and drill-down operations can be applied to view the measures in different levels of granularity. More rich and complex multi-dimensional reports can be constructed using combinations of different dimensions in various axis of the OLAP report. The OLAP report can be rendered either in a graphical chart or a numerical grid. Figure 6 a screenshot of a report constructed in the OLAP Reporting application.
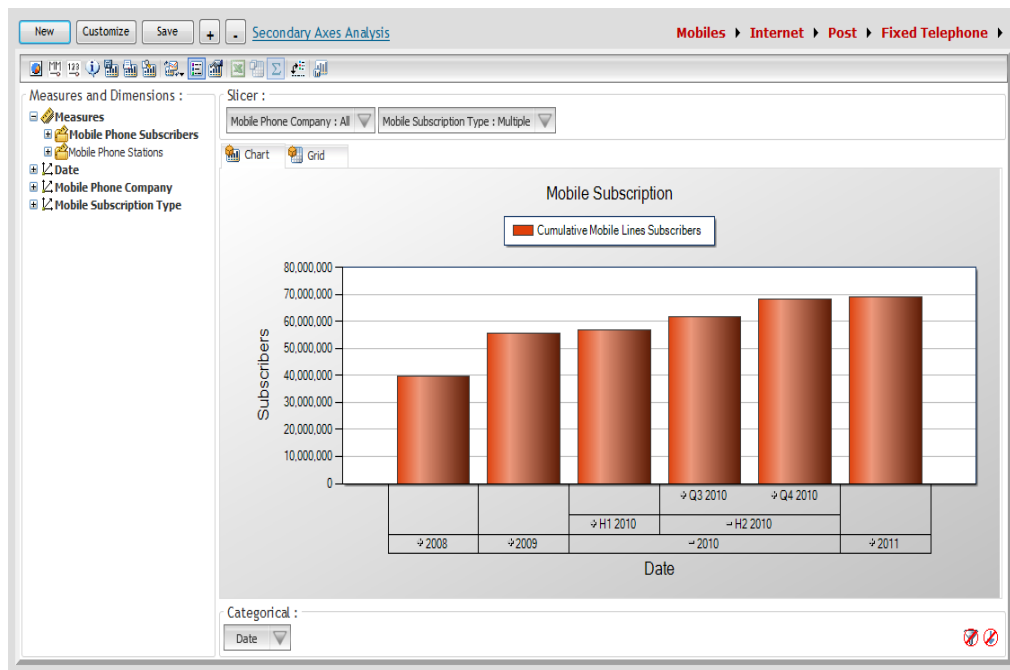


**Figure 6–Multi-dimensional Report - OLAP Reporting Visualization Application**

As shown in the Figure 6, the OLAP reporting application has several components. First, the Business Domain menu, shown in the top right, represents the OLAP cubes available in the MCIT BI solution. Each menu item has a list of previously created reports saved due it is frequent usage. Second, the Dimensional Query Definition UI tools, which consist of Cube Browser (Measure and Dimensions) vertical panel on the right, the Slicer Axis Descriptor on the top, and the Categorical Axis Descriptor on the bottom. The Core UI Rendering control is either an OLAP Chart (as seen in the Figure 6) or an OLAP Grid (which can be viewed by pressing the Grid tab). The user constructs an OLAP report according to the following steps:

1. From the Business Domains menu, select an OLAP cube, The Cube Browser will load the measures and dimensions available in the selected cube.

2. Press the new bottom to start a blank report.

3. Select the measure(s) wanted to be analyzed and reported from the Cube Browser panel by dragging and dropping the measures from the panel to the OLAP Chart\Grid.

4. Select the dimension(s) you which to filter the measure with by dragging and dropping the dimension(s) from the Cube Browser panel to the Slicer Axis Descriptor.

5. Browse the selection dimensions in the Slicer Axis Descriptor to select the specific member(s) by which the data need to be filtered (as shown in Figure 7).

6. Select the dimension(s) you which to categorize the measure with by dragging and dropping the dimension(s) from the Cube Browser panel to the Categorical Axis Descriptor.

7. Browse the selection dimensions in the Categorical Axis Descriptor to select the specific member(s) by which the data need to view.

8. Select the chart type from the tool bar.

9. Press on the + and – symbols on the bars in the chart (as shown in Figure 6) to roll-up and drill-down.
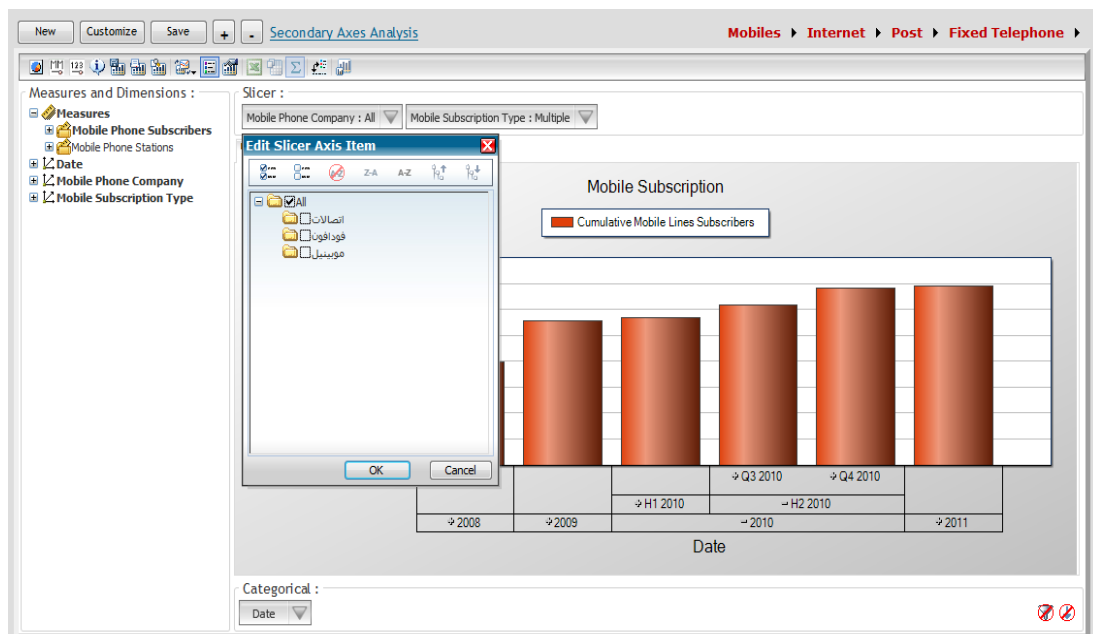


**Figure 7–Selecting the Filter's Dimension members - OLAP Reporting Visualization Application**

The following are the other operations and parameters of the OLAP Reporting visualization application:

- Create new report.
- Save a created report.
- Customize an existing report.
- Change chart type (Figure 8 shows an example of a pie chart report).
- Show\hide the maximum and the minimum values.
- Show\hide the numerical labels on the chart elements.
- Show\hide the meta-data of the selected measures.
- Switch the chart mode from 2D to 3D.
- Save the chart image.
- Change the chart properties (font, legend, title, etc.)
- Change the report view from Chart to Grid.
- Switch to the secondary Axis view (as shown in Figure 10).
- In the secondary Axis analysis, a test correlation can perform between two measures (as shown in Figure 10).
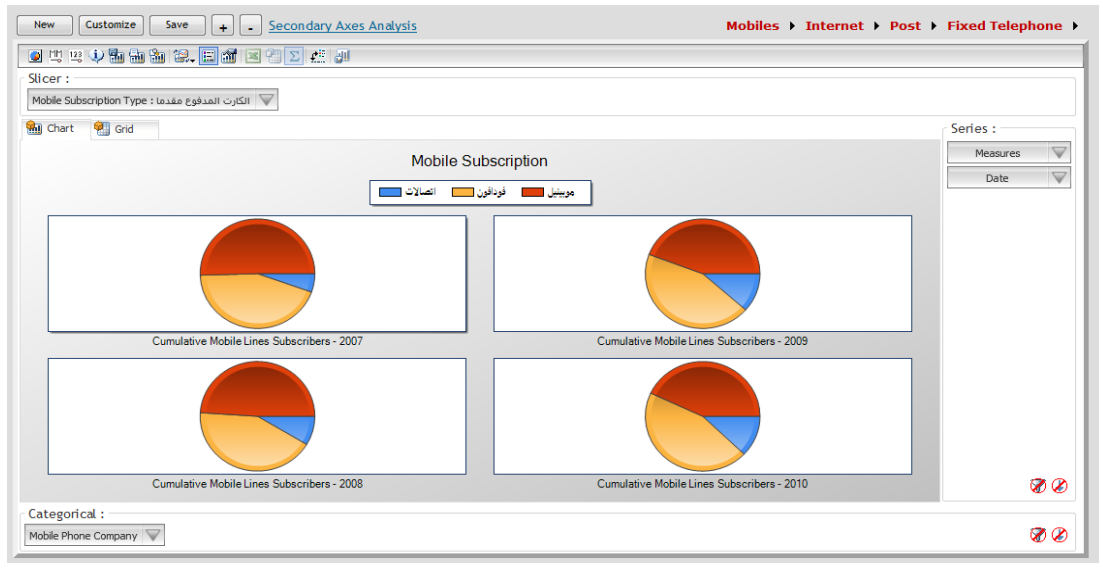
**Figure 8–Pie Chart Report - OLAP Reporting Visualization Application**
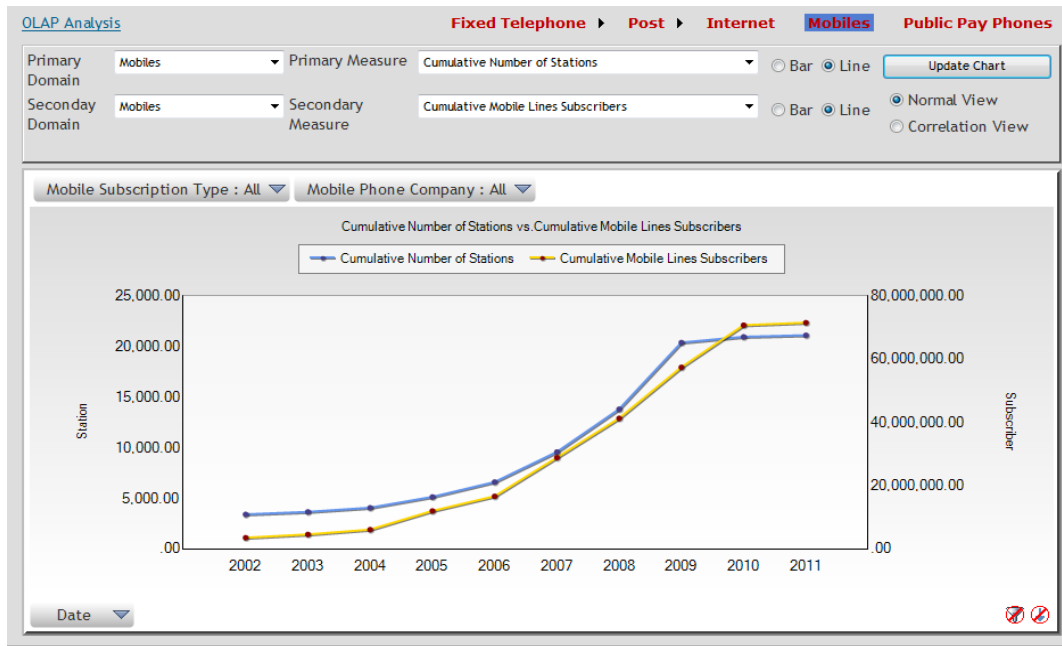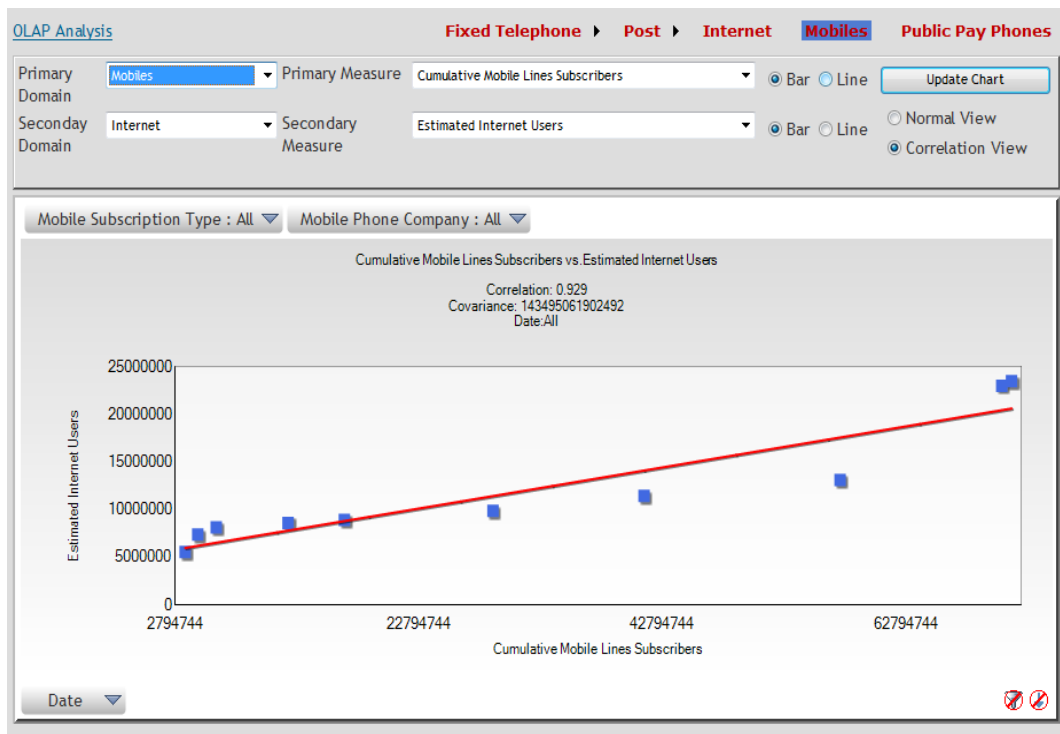


**Figure 9–Secondary Axis Analysis - OLAP Reporting Visualization Application**

**Figure 10–Secondary Axis Analysis with the correlation view. The correlation is tested between two measures: the primary measure and the secondary measure. Statistics resulted from the correlation test are shown on the top of the graph.**

## 6.  Intelligent Map

The second visualization application proposed in current work for the MCIT_BI dashboard is the Intelligent Map. The Intelligent Map application allow the user to view the Business Domain measures from the geographical aspects, and enable him to notice efficiencies and deficiencies in the different geographical spots using smart map coloring and interactive analytical features. Using the intelligent Map, the executive user in the MCIT can have an overview on the performance of all the governorates in the country in specific domains.  In addition, several tools are available for the user to refine his geographical-based query to get more details about a certain measure given a certain business dimension in a specific governorate, and how this measure changes overtime. Figure 11 shows a screenshot of the Intelligent Map visualization application.
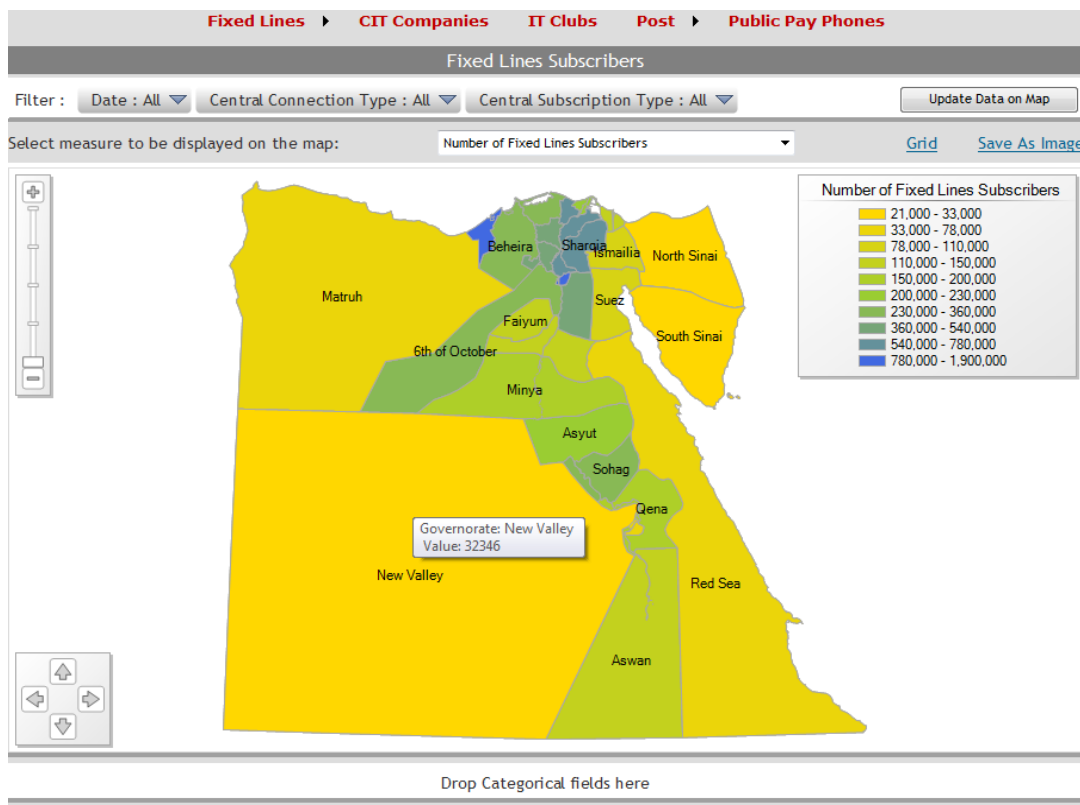
**Figure 11–The Number of Fixed line Subscribers across Egypt - Intelligent Visualization Application**

As shown in the Figure 11, the intelligent Map application has several components. First, the Business Domain menu, shown in the top, represents the OLAP cubes available in the MCIT BI solution. Second, the Dimensional Query Definition UI tools, which consist of the Slicer Axis Descriptor on the top, and the Categorical Axis Descriptor on the bottom. Note that in the initial load of the application, all the available dimensions in a selected cube is loaded on the Slicer Axis Descriptor (without having any specific member(s) selected) and the measures are loaded in the drop down list on the top of the map. Therefore, Cube Browser panel (in the OLAP Reporting application) is no longer needed, as requested by the user. The Core UI Rendering control is the Map of Egypt. For a selected measure, the map renders the measure as follows. Each governorate is colored with the color which corresponds to the measure value (interval) as shown in the legend. The color of the governorate, as well as its intensity, reflects the density of this measure on the governorate. The user manipulates the Intelligent Map according to the following steps:

1. Select the OLAP cube from the menu on the top
2. The measures of this cube are loaded in the drop down list, and the available dimensions are dropped on the Slicer Axis Descriptor.
3. Select the desired measure from the drop down list.
4. Select the dimension member(s) by which the data needs to be filtered.
5. Press the Update Data on Map bottom the render the map according to the configuration settings.

The following are the other operations and parameters of the Intelligent Map visualization application:

- View the data in a Grid (as shown in Figure 12).
- Save the Map as an image.
- Zoom in and out the map.
- Navigate in the map.
- Hover over the governorate to show a tool tip with the governorate's exact value of the select measure (as shown in Figure 11).
- If a dimension is dragged-and-dropped from the Slicer to the Categorical Axis Descriptor, this will change the displayed tool tip on hovering over a governorate[18]. In which case, a small pie chart is displayed, rather than a simple tool tip, to categorize in selected member for the current governorate according to the members of the dimension used in the Categorical Axis Descriptor (as shown in Figure 13).
- When Clicking on a specific governorate, a full profiler is displayed about this governorate. The profiler is divided into several parts, on for each Business domain. For each part, all the measure in the business domains are plotted in graphs[19] over the time dimension to observe the performance of this governorate in over the time in various business domains (as shown in Figure 14).

| Governorate | Cumulative Local Exchanges Capacity |
|---|---|
| All | 6809629 |
| 6th of October | 249060 |
| Alexandria | 1323838 |
| Aswan | 11184 |
| Asyut | 130725 |
| Beheira | 97907 |
| Beni Suef | 74222 |
| Cairo | 2318962 |
| Dakahlia | 42730 |
| Damietta | 43900 |
| Faiyum | 2000 |
| Gharbia | 18400 |
| Giza | 632980 |
| Helwan | 640858 |
| Ismailia | 9008 |
| Kafr el-Sheikh | 51926 |
| Luxor | 74188 |
| Matruh | 9890 |
| Minya | 52892 |
| Monufia | 0 |
| New Valley | 0 |
| North Sinai | 7200 |
| Port Said | 203029 |
| Qalyubia | 328198 |

**Figure 12–Grid view of the Cumulative Local Exchanges Capacityacross Egypt - Intelligent Visualization Application**
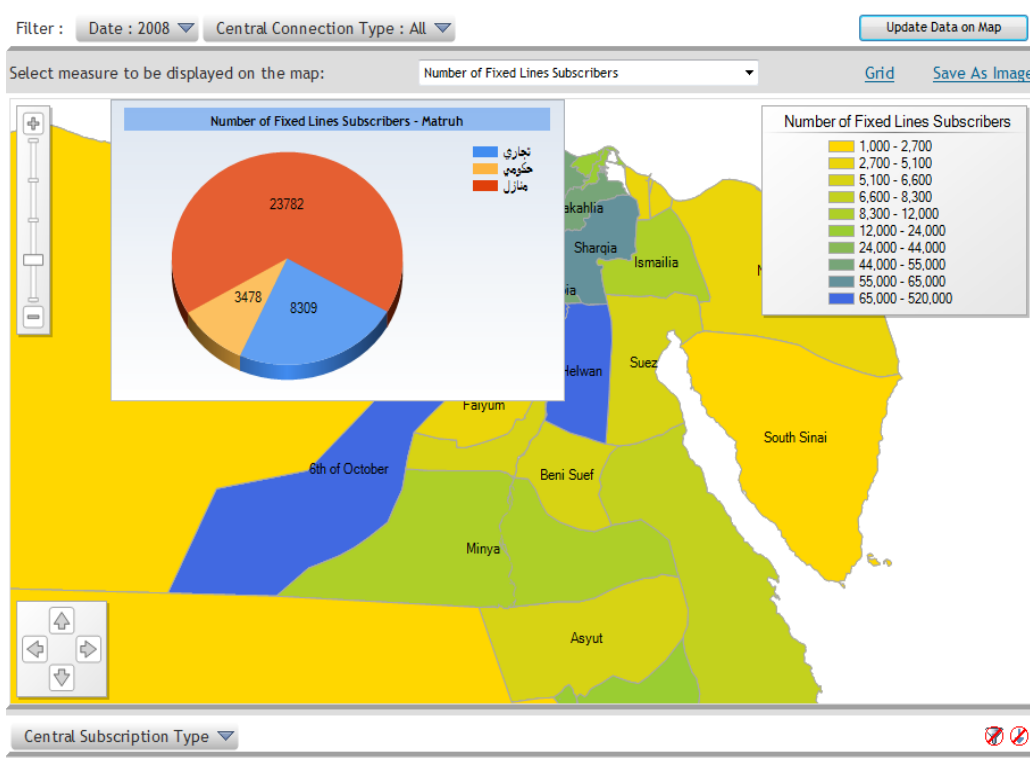
**Figure 13– A Pie Chart is display to categorize the Number of Fixed Line Subscribers' measure by the Subscription Type dimension for Matruh governorate - Intelligent Visualization Application**
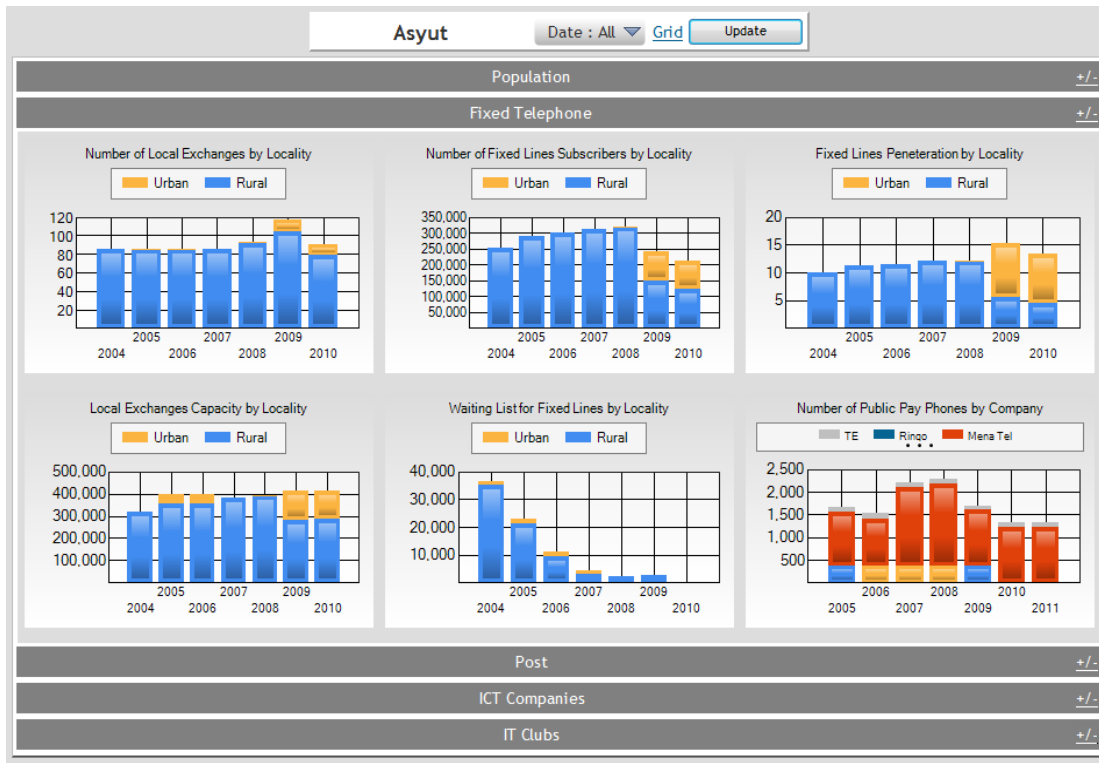


**Figure 14–Asyut governorate profiler of the various measures of each business domain over the time - Intelligent Visualization Application**
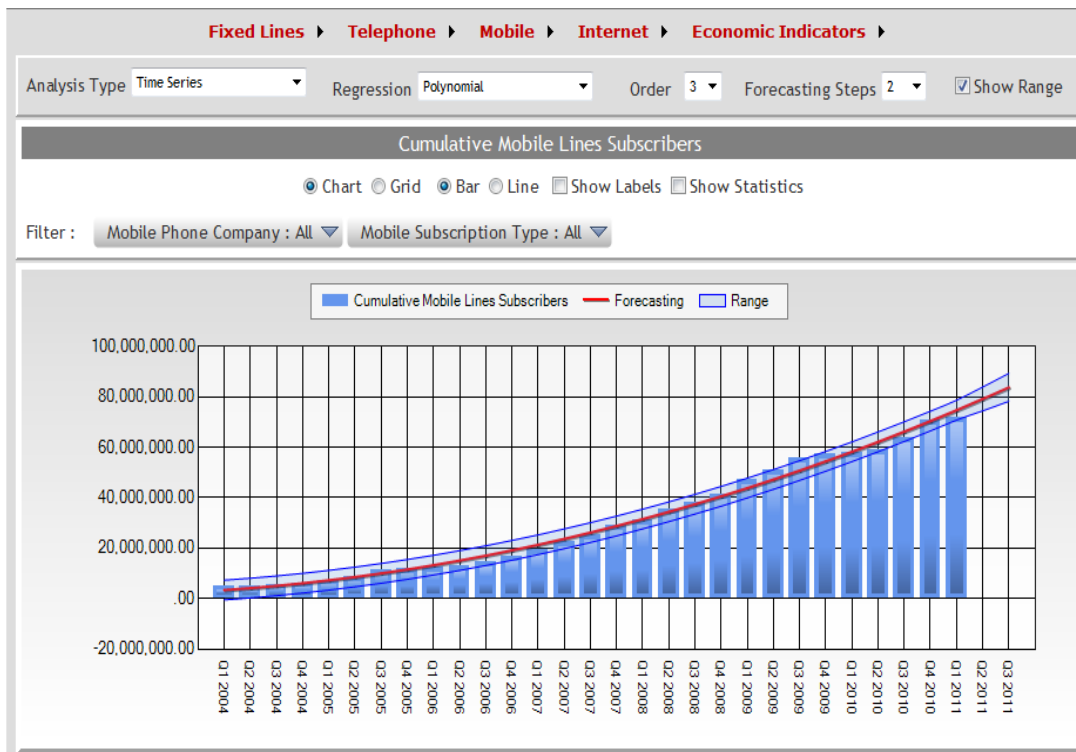
## 7. Trend Analysis

The third proposed visualization application for the MCIT BI solution's dashboard the Trend Analysis. The chronological aspect is of the data is always a very important dimension in any business domains, which allow the user to see how the performance of a specific measure changes over time and allow him\her to detect temporal patterns and trends. In MCIT business domains, capacity planning involves analyzing the behavior of the specific performance indicator and forecast its trend in the future so that appropriate planning can be carried out. In our proposed application, we use two of the most useful temporal trend analysis methods: time series analysis and moving average.

A time series is a sequence of data points [17] , measured typically at successive points in time spaced at uniform time intervals. Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model to predict future values based on previously observed values. In our application, various regression methods are employed in to evaluate the hypothesis about the trend of the temporal data.

On the other hand, a moving average, also known as running mean, is a type of filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set. A moving average is commonly used to give a general overview on temporal data trend by smoothing out short-term fluctuations and highlighting longer-term trends or cycles. The threshold between short-term and long-term depends on the application, and the parameters of the moving average will be set accordingly.
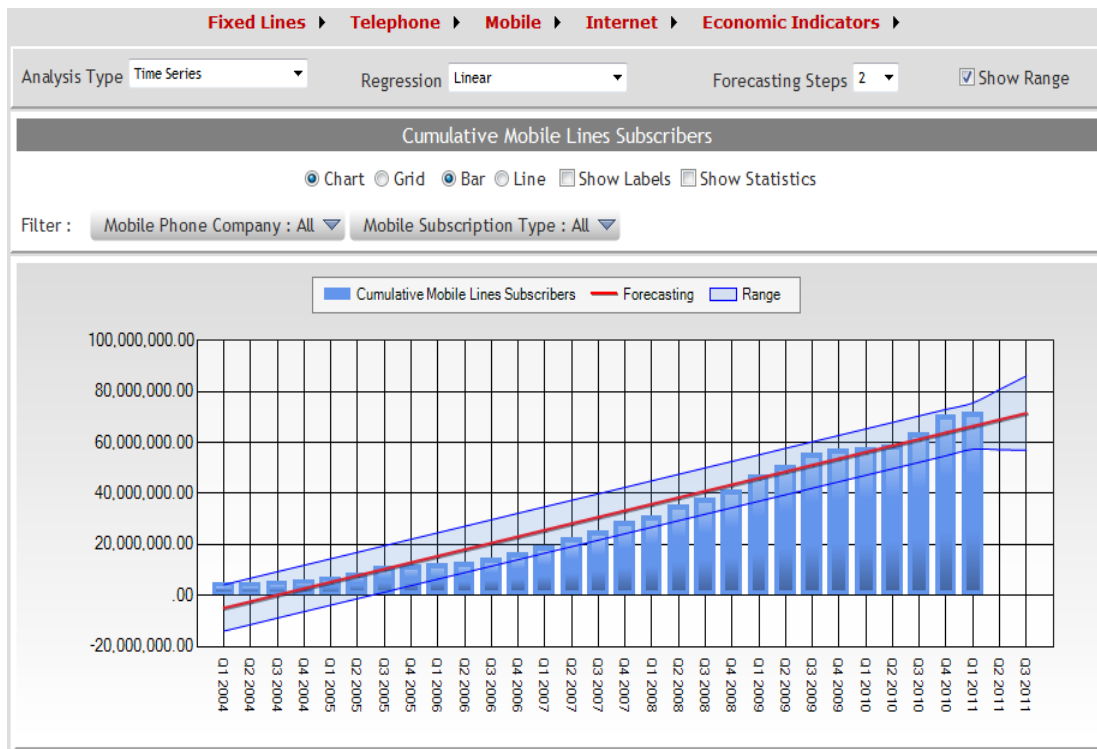
As shown in Figure 16, the Trend Analysis visualization application [15] consists of the following components. On the top is the Domains Menu from which the user selects the desired OLAP cube. Each menu items contains menu sub-items that represent the available measures in a certain cube. The selected measure's name is shown on the title graph. The Slicer Axis Descriptor, shown above the graph, contains the dimensions of the selected OLAP cube and can be used to filter the data for analysis. Note that the Categorical Axis Descriptor has always the time dimension in order to perform the chronological-based analysis. For time series analysis, the regression line is shown in red, while the error range is shown in around the regression in light blue. As shown Figure 15, the polynomial regression a quadratic order of 3 better fits the data than the linear regression, as shown in Figure 16. This is can be notices from the error range produced by each regression type.

**Figure 15—Time Series Analysis using Polynomial Regression for the Cumulative Mobile Line Subscribers - Intelligent Visualization Application**

The user manipulates the Trend Analysis application according to the following steps:

1. Select an OLAP cube from the Domains Menu.
2. Select the required measure to be analyzed from sub-items of the selected OLAP cube menu item.
3. Select the dimension's members by which the data need to be filtered.
4. Selected the analysis type, either Trend Analysis or Moving Average.
5. For trend Analysis, select the regression type.
6. Define the time range (from toe) and the level (Year, Half, Quarter, Month).
7. Define the Forecasting steps.

**Figure 16–Time Series Analysis using Liner Regression for the Cumulative Mobile Line Subscribers - Intelligent Visualization Application**

The following are the other operations and parameters of the Trend Analysis visualization application:

- Show Error Range.
- Change graph type from chart to grid.
- Change the Chart type
- Show\hide data labels
- Show detailed statistics (parameters) of the regression model.
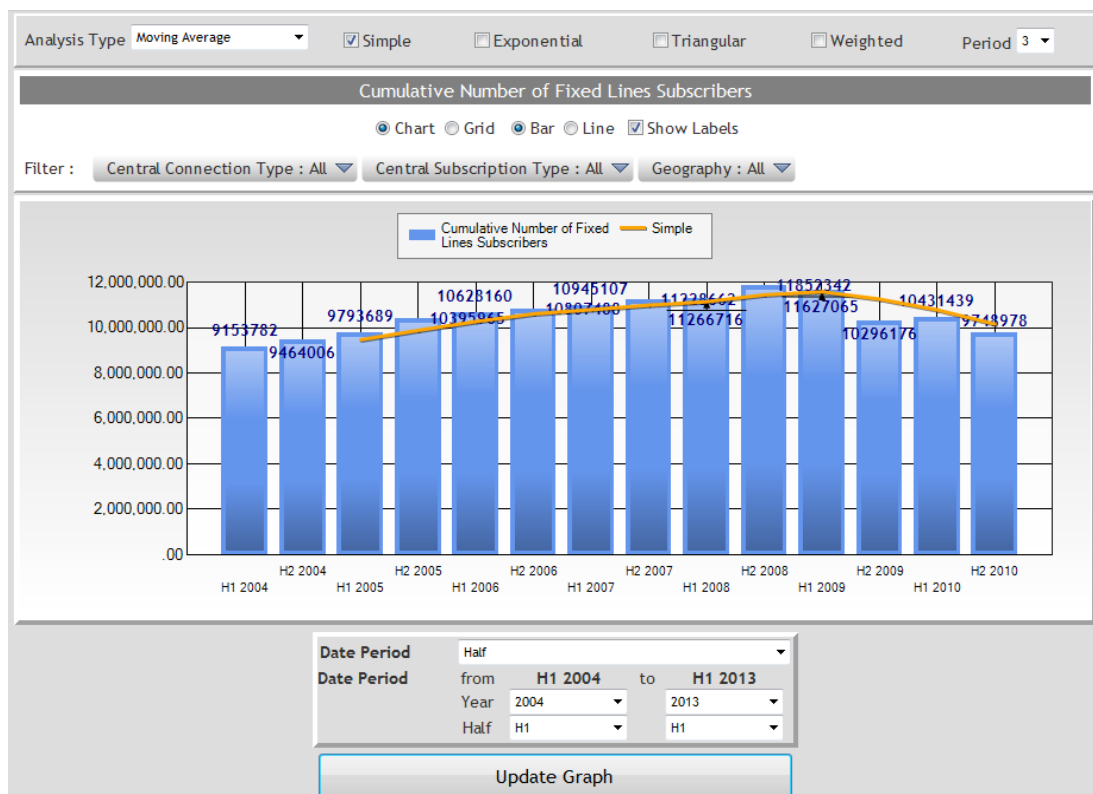- Select the Moving Average Type and period (as shown in Figure 17).

**Figure 17–Simple Moving Average Analysis for the Cumulative Number of Fixed Line Subscribers - Intelligent Visualization Application**

## 8. Conclusion

In this paper we have proposed several advanced visualization application to the MCIT BI solution. The MCIT dashboard is a web-based solution which provides there main visualization applications, namely OLAP Reporting, Intelligent maps and trend analysis. The three aforementioned visualization applications provide the user with which and flexible tools to perform multi-dimensional analysis with various techniques. OLAP Reporting enables the user to create, customize and manipulate multi-dimensional charts. The intelligent map renders the multi-dimensional information of the OLAP cubes in a user-friendly map. The trend analysis application provides the user with useful and powerful forecasting mechanism. The key concerns in designing and implementing the visualization dashboard are flexibility and richness, with which the user can see his same version of truth with multiple visions.

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