Mobile Business Intelligence for Small and Medium Sized Mobile Enterprises

[1]Sudeep Talati, [1]Graeme McRobbie, [2]Kenneth Watt
[1]*School of Computing, University of the West of Scotland*
[2]*UK Whitegoods Ltd*

Abstract

Business intelligence has a key part in every business. It gives information to support the business decisions. All businesses go through lots of data and information exchange every day. There is a wealth of valuable information in this data. This information can be needed at different places and time, depending upon type of business. Some businesses works from local site while some from remote site. Some businesses even run from the mobile vans. Thus, in this dynamic business model, it is hard to manage the information. The existing legacy systems and their architecture lacks the potential to support these functionalities. Moreover, they are complex and expensive which makes it out of reach for Small and Medium Sized Enterprises (SME). By using the power of current mobile technology and open source software API (Application Program Interface), the SMEs can be served with the power of business intelligence at cheap cost.

1. Introduction

Business intelligence or BI is a very broad term commonly associated with business information. It is knowledge gained from the daily activities of business (data) that supports in decision-making. This knowledge is derived when the data is processed through some logics and algorithms, which produces information to support the business decisions. The data generated from daily activities is in statistical or raw format. These data exhibit some patterns in them, which can be periodic, non-periodic or completely unique. Business intelligence tools identify and analyses these patterns that are further processed to make some meaningful results. The need of business intelligence evolved when entrepreneurs started analyzing the business data to better understand the situation and make decisions. Business Intelligence systems are something similar to monitoring system, which gets data from each activity, analyzes it and produces summary information of that activity [HYPERLINK "" \l "Vas97" **1**].

The existence of this intelligence in business is from a very long time. Business owners are already using these intelligence logics in daily practices. For instance, a shop owner clearly knows when to put the stock of which item. He can undoubtedly differentiate between his seasonal and regular running items. For example, there is no point in keeping the summer collections in the autumn. This intelligence is generated from the experience of number of years as sale of some items might have risen at a particular event or period of time. Thus, shop owner can identify some generic patterns in his stock like seasonal items, active or inactive items that help him to make business decisions. However, in this case the size of data set is small, so calculations can be easily done in mind. Also this intelligence generates only from the individual experience and is hard to transfer completely to someone else.

Thus if daily activities are recorded in a system, it can also act in a similar manner and can generate the results or pattern from the activities over a period of time. These results can be further processed to extract more valuable information. Furthermore the results can be made in simple and standard format, which could be easily understood by everyone.

The developments on Business Intelligence tools have started since a long time. Several tools have been already developed, implemented and deployed in large enterprises. The common scenario is that all big enterprises have some systems to manage their work. Small and Medium Sized Enterprises (SMEs) who are associated with these big enterprises are either forced to use some version of these systems or they are out of game. The problem gets worse if SMEs are working with multiple different companies together, as they have to follow different systems and protocols of all different companies. Little efforts have also been put in the developing BI tools for the SMEs, but they are not very successful due to their design, features, cost and several other drawbacks.

In this paper, the first part covered a brief introduction of what BI tools are. The second part is about analysis of existing business intelligence systems and their drawbacks, third part is on power of mobile technology, fourth part is on the system architecture for this model and fifth part is methods

to integrate all these together followed by conclusion.

2. Current Business Intelligence systems and drawbacks

There are several tools in the market for the business intelligence as well as for real time business intelligence (RTBI). These tools have been developed to suit different business scenarios. However the major section of this development is centered for large enterprises only. This is because the efforts, budget and the resources required in developing and maintaining these tools can be afforded by big enterprises only. Since the small enterprises lack huge budget and resources for business intelligence, therefore nothing major excel have been developed for them.**2**] The BI tools are usually designed to serve the following purposes:

- Reporting
- Visualization
- Trend analysis (historic and emerging)
- Customer behavior analysis
- Predictive modeling
- Predicting future scenarios

The BI tools available in the market can be classified in two categories:

2.1. Tools for Large Enterprises

These kinds of tools are especially designed around requirements of the particular enterprises and are usually developed in-house or outsourced. Several features are embedded in the tools like data mining, visualization techniques, competitive intelligence or OLAP (Online Analytical Processing) to perform various functions like data gathering, data storage knowledge management, etc. These features sometimes make systems cumbersome and need special hardware requirements to run it as shown in figure 1. For instance, business intelligence process largely depends on data warehouse. The size of the data can grow rapidly if not handled properly. Usually, subsets of data is extracted and refined (also called data marts) from data warehouse for processing and analyzing the data [HYPERLINK "" \l "Sol08" **3**]. Thus, firstly there is need of data warehouse, which can store the huge data. Secondly, a program is required for creating data marts, which will be either on the server or on local machine. Furthermore handling data marts can sometimes put requirement of another hardware device.

Another matter with these tools is special skills and/or separate team of analytics is required to operate these systems. This is because the information is not in the format that could be easily understood by the end user. Some of these softwares produce raw data only, which needs to be processed by another software to get the desired output. The information is further filtered using techniques like text-data mining, forecasting, econometrics, statistics, optimization, etc. This helps to present information, aligned with the strategic and tactical objectives of the organization. Therefore, business intelligence is also called as data driven decision support system.

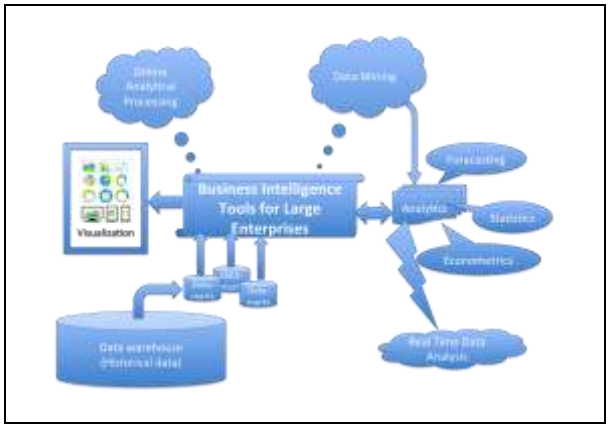

Figure 1. The complexity of the BI tools for large enterprises

The BI tool is a software suite consisting of several tools embedded into it to perform multiple tasks like data warehouse, visualization, Data Mining, Analytics, etc. Some tasks like analytics further require fragmentation into smaller tasks to get the end result.

The complexity increases even more when data needs to be analyzed in real time. Real time data is data at the current point of time with zero latency. Real time business intelligence is possible, when the tools have direct access to the current business data. Historic data does not give indications of the current situation. Thus, the business intelligence tools should have the direct and real time data analysis to generate the more accurate information. Real time business intelligence (RTBI) allows business intelligence systems to directly access operational systems enabling data virtualization, 1, enterprise information integration (EII), enterprise application integration (EAI) and service-oriented architectures (SOA).

In short, small or medium enterprise cannot afford to use these systems due to:

- High cost of installation, maintenance & operation
- Rigid and complex process
- Irrelevant extraneous features that do not fit in SME business model.

2.2 Light Version Tools

The other kind of business intelligence tools is light version tools with some generic features and functions. These tools are small, mini or condensed version of large enterprises business intelligence tools that fits very rarely in small enterprises business models. This is because they still carry the complexity and rigidness of their parent business tools (from where they are inherited).

Spreadsheets managing software like Microsoft excel or open office are the most commonly used tool for the reporting and data analysis by several SMEs. It can perform all major functions for data analysis like data integration, light transformation, high-speed memory based lookup, predictive analytics, low cost dashboards, etc. Spreadsheets have been considered as most standardized way for data analysis at local level and almost all major BI tools have features to export their reports in spreadsheets or excel files format. Using macros and other advance features in spreadsheets allow designing of very creative and informative systems. Some spreadsheets managing software like excel or open office allow pulling data from all leading database platforms [HYPERLINK "" \l "BRa11" **4**]. The drawback is different users have different way of handling and managing data. This creates diversity in data sets and makes it hard to collaborate the work from different sources. Also, it is hard to manage large data set of millions of rows manually.

Some BI solutions are also available through web and cloud services. Web-based approach eliminates several issues related to software installation, maintenance and backups. Furthermore, it helps to build a customized solution as per needs of the user. Most importantly it eradicates the dependency on operating system and information can be accessed from any web browser running device. Web browsers are lightweight and running a web browser on a system is not huge resource intensive process. All resource intensive tasks and complex logics are already performed on the server. However a major drawback of the web-based approach is dependency on Internet. There is a vital need of Internet with good speed & bandwidth to access the information and resources. According to survey of broadband speed in UK, the average Internet speed on 8/10Mbit/s DSL services was 3.3Mbit/s. However, more than 50% users said that their download speed was even below average as the speed varies in peak and off-peak hours**5]}**. Thus there is not very good availability of Internet Speed and bandwidth everywhere. The user also does not have the physical hold of data and has to rely on third party systems. If something fails on those systems, there is risk of bringing business to hold. Also there is data theft and integrity issues associated with cloud and web based services. Furthermore, SMEs staff often lacks the adequate knowledge of IT and SME owners often feel that Internet is not the safe place to keep their official data.

Mobile technology can bring several benefits to the business like:

- Increase in service level
- Improved communication between all stakeholders
- Increase in productivity and profitability
- Decrease of cost and minimizing loss

Few years before in mobile phones, memory was limited and the processors were not very powerful. These limitations restrained mobile phones to run the business utility application with its full potential in stable mode. Furthermore, it also posed a limit on the data transfer speed and use of Internet. The popular operating systems for mobile phones that time were Symbian OS and Binary Runtime Environment of Wireless (BREW). The applications additionally needed J2ME (Java 2 Micro Edition) and MIDP1.0 (Mobile Information Device Profile) to run on these operating systems. However, these applications could not hit the market as due to following main reasons:

- J2ME is not ideally suited to the mobile platform & operating systems
- J2ME applications had the size limit of few kilobytes, else the performance gets low
- The only way to share data between two apps is through a common data record
- J2ME had no direct access to some native features of phones like bluetooth, camera, phone dialing, phone book, etc.
- J2ME does not supports the concept of "One Size for All", therefore, different apps for different phones

Other drawbacks were the mobile features, which brought the user experience to lower level were:

- Small keypad for input which makes the use limited and time consuming
- Small screen size and low screen resolution, which were not optimal for visualizing the results in graphs, figures and other format
- Hard navigation buttons to switch within and outside the application
- Also data and information transfer was usually through SMS (Short Message

Service) where customer was charged per SMS, which was not a cheap option.

This calls for the new revised architecture of mobile phones, which is now available in smartphones. Now a smartphone have the applications that can replace some of desktop-based applications and tasks. This covers from email, word documents, excel sheets, pdfs, etc. There are also applications that cover the wide business aspects of ERP (Enterprise Resource Planning), CRM (Customer Relationship Management) & Business Intelligence (BI). This is an indication that these phones can actually do much more than expected. This is similar to case when symbian operating system in earlier phones used C++ machine code compiled applications; it provides inspiration for today's smart phone applications [HYPERLINK "" \l "ORa" **8**].

The smartphones applications have redefined the use Internet on mobile phones. These applications have made the user experience very quick and easy. The tablet devices have further enhanced the mobile experience to greater level of screen resolutions as well as have also overcome some limitations of mobile devices.

Some organizations have tried to adapt the mobile technology and drive their business through it. The devices like iPad and other tablet devices have tried to eliminate the need of laptop while travelling or even when working from remote site. The systems can be enabled to use mobile technology is by changing their data access pattern or process. It is hard to change the data access patterns in some legacy systems due to their intact and rigid architecture. Enabling data access from mobile devices will allow them to send and retrieve the information from the system. However this poses some risk on data theft and security due to which mobile technology in business is not very successful. Work on mobile technology is still continuing and several products, software and mobile operating systems are already released. Thus the ideal system to fully support the business process is not too far.

Figure 2. The potential of mobile technology and the benefits it can bring to business

The new mobile devices equipped new features like greater screen resolution, GPS or camera have opened ways to enhance the productivity.

Mobile technology in business intelligence can be an added benefit for the SMEs as shown in figure 2. The requirements of the SMEs are not too large & complex and business processes are fairly simple and straight as compared to large organizations. Thus, enabling the mobile technology in the business process of SMEs can be easy and hugely productive. The mobile devices now supports various features and services like weather information, live transport information, route planning, property finding, navigation, product information, service manuals and much more. However, information is valuable only if it available right at the time needed.

Consider a SME of service industry, where service man has a schedule to repair the machines at different locations. Firstly smartphones could eliminate the use of navigation device. There are several smartphone applications that could provide the accurate directions. The GPS (Global Positioning System) would also help in locating the current position of the person. This could help to increase the service level to a very large extent. It could give the information how far is the serviceman from his destination and how long will he take to reach there. Again, almost all smartphones are shipped with the GPS functionality, so this feature can be easily used in the mobile phone. Furthermore if service man is having problem in finding the property, image of the property can be sent using multimedia support. Services like Google map also give street view features, which could further ease this task. Information like traffic updates or weather information is easily available on the web. If this information is available while route planning, an optimized planning can be done, which could save time as well as fuel. Moreover, if this information is sent across to the customer, it could bring a big leap in the service level.

Currently, all these activities are performed by different applications and it creates lots of hassle of closing one application and opening another. If user could get this information easily in just few clicks, it could greatly save time and reduce cost. Amalgamating all these features can help to deliver the technology to its full potential. However, putting all these features in one application can be risky. Creating an application with the feature overload is another major cause of failure for systems adaptability. The application should be modular enough to adapt requirements of the business.

Another major requirement in mobile technology is the coverage of data network. Still in some remote parts of the world the mobile and data coverage is

not good. Thus the application must be designed in a way so that it works in online as well as offline mode.

4. System Architecture

The processes and requirements in the business are never static. It keeps on changing with time. The primary reason of systems downfall is their rigidness and resistance to change. In management terms, it is said that the continuous development is the utmost criteria for organization's growth and development. Different organizations run different programs and spend money on the continuous development of their employees. But the systems of the organizations are not considered for the same. Systems are also part of the organization and they needs to be changed along with the change in the organization. Continuing with the legacy system that could not cope with the new requirements can result in loss of productivity. However always changing the system can be expensive and organization takes time to get accustom to the new system. Thus the system architecture should be always modular and flexible enough to adapt the change in the organization or with the technology.

Next important feature in the system architecture of business intelligence to be considered is data warehousing. Again data warehouse and data structure should not be rigid as seen in the legacy system. Data warehouses too should be adaptive with flexibility of alteration. It is preferred if data warehouse is not inbuilt in system and is completely managed by a different system or unit. This eases the task of data extraction in the desired format and patterns. New channels can be made for data extraction without actually disturbing the systems stability. Also if one channel or module is broken, it won't bring the complete system to hold. Some data warehouse architecture models has been projected for business intelligence like the XML data warehouse, relational data warehouse, documented data warehouse, etc. The more efficiently the data handled, the easier it becomes to extract the information out of it [HYPERLINK "" \l "HJW07" **9**]. For example, we have two sources of data, one from the flat file systems like the pdf, word documents or text files and other source is from the relational database like spreadsheet or SQL database. From both defined sources it is easier to extract the information from relational database as information is already structured in it. To extract the information from raw document or other text file, data mining techniques have to be applied, which may still have some impurities in data. There have been several techniques used for data warehousing, i.e. how data is stored:

4.1.XML Document Warehouse

There has been vast bulk of data available in unstructured format. It includes the data in the form of raw text, multimedia, documents, etc. It is very hard to extract the data out of these sources. Using XML document warehouse, the data can be converted to semi-structured format and can be used for analysis10**]**. The XML document serves as a data dictionary or metadata, referring to these documents. Usually keywords are extracted from the data to create metadata. Sometimes data mining tools are also used to extract the data out of the sources. This raw data is processed then populated in the XML files. However these XML documents lack the complete information and only main document hold the complete details.

4.2.XML Data Warehouse

XML data warehouse holds data in structured format. Sometimes to extract the information, XML data is also converted into relational database schema. Data in structured format helps in generating valuable information more easily. Several techniques have been developed to handle the data in this way like Xyleme [HYPERLINK "" \l "Luc01" **11**], which is a dynamic warehouse of XML data. Another example is DAWAX - Data Warehouse for XML systems **12**] where XML document is used to refer the existing XML data sources. This is similar to data dictionary or metadata or table of contents of the XML document.

4.3. Relational Databases

Most of the software solutions uses relational database to manage their data. The data is stored and retrieved through a separate database engine. In the early times between 1990s and 2000, FoxPro was the prominent in all software solutions. However FoxPro could not be categorized in Relational Database as it lacked transactional processing. Most popular database servers today are SQL and MySQL used for desktop and web based solutions respectively. The data is very well structured and stored in such databases. The only limitation of these storage engines is database has to be defined well before adding data to it. Furthermore, if some changes are to be made in the database, there is a threat to system stability. However using good design and coding practice, these threats can be overcome to some extent.

4.4 Spreadsheets and other text documents

This is the most widely used method of storing and transferring the data. All big and small

enterprises using computer systems store their data in spreadsheet and text documents. With the rapid and increasing use of spreadsheets, several software products available that could analyze the data straight from spreadsheet and present the information. Software products like Microsoft Excel or Open office allows user to add custom programs and logic on the top of the data.

Storage location of data basically depends on its task and usability. For Example in a small business with all operations from one local system, data is stored locally. Conversely, in an enterprise with multiple systems for operations, data is stored on the local server or shared space and all systems have access to that server. A recent result from field survey of SME export companies in Costa Rican suggested in about 40% companies, more than half of their employees use computers**13]}**. Thus, there is need of sharing of data. Cloud computing is another popular solution, which is further extension of local server. In cloud computing, the data is on web server and the data is accessed via Internet. Data can be easily presented on web browsers using different techniques and this also liberates SMEs from hassle of hardware and software maintenance. However the limitations of cloud computing is that the user does not have the physical hold of the data and it also raises data theft and security issues. Also retrieval of data is completely depended on the Internet connection and cloud service provider, which is another limitation of cloud service.

However these models needs modification to suit the SME needs. An ideal model for SME is one, which sits on the local system for instant access and also has access from anywhere. This ideal model solves many problems of the SME. For instance, in sole trading business, person might be at different places for a business activity. At some point, if they need to get their data from their local system, this model allows them to get it instantly. Also in scenario of no Internet connection, the system still works locally. Thus the main data center is always on their local system, and other devices are feed through local data center only online as well as offline. All operations of data integration, data analysis will be performed on the local system only.

If the data size is getting too big to fit on local computer, then the data could be transported to local data center and operations on data will be performed from the local system. In case multiple users or systems are involved, then the operations task can also be assigned to separate server machine. The local computer will be only client computer to communicate with server and server will communicate with data center.

The business intelligence tools architecture is quite similar to model-view-controller (MVC) architecture as shown in figure 3. Like in the MVC architecture, model has data processes; business intelligence tools have the data source or warehouse. These data warehouses contain all logics for communication with the data sources, integrating the data from different sources and storing it. The controllers in MVC have the operations & logics; business intelligence tools also need some logics to process the data. All operations on data like analysis and logics on how to integrate the data are performed in the controllers. Lastly, view is for visualizing the processed data in easy, clear and understandable manner. The data when processed is presented in the desired format of the user. There could be number of devices that could be used to visualize the data in variety of formats.

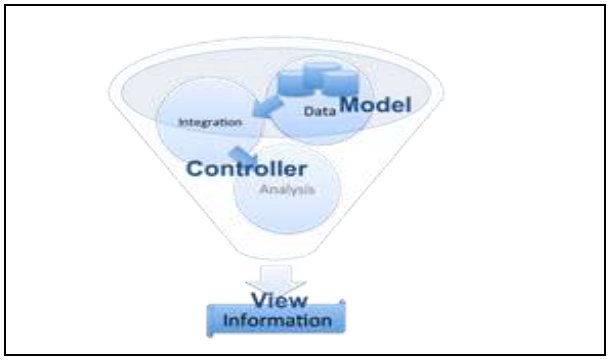

Figure 3. Similarities of the Business Intelligence architecture and Model-View-controller (MVC) architecture

The Figure 3 also shows how the components of business intelligence resemble the components of MVC architecture. The data warehouse resembles to model, integration and analysis logics resemble to controller and view resembles to presentation. However, to get the real time information this architecture needs some modification. The models and controllers need to be working very closely for real time information. Models and controllers can even overlap the task and behavior of each other depending upon the scenarios. If the data source is internal within the system the tasks can be easily distributed between the models and controllers. However, if the data source is external, the logics to fetch the data are contained in the controller. This data is processed directly to generate the real time information without sending it to model (data warehouse).

Other features to be considered in the system architecture design are that the system should be platform independence, could work with as well as without Internet, highly flexible & modular and could easily adapt the changes without affecting the complete system stability. The system should also allow secured two-way communication with the outside word, so that even system features could be inherited in developing new systems.

5. How to integrate these technologies?

The real challenge comes when different technologies are tried to bind and work together. Since, all technologies works on their designed protocols, therefore it is hard to change their protocols as it could make the complete system instable. An efficient communication channel needs to be developed, so that the two technologies can talk with each other and exchange the data and information.

Some methods have been projected earlier for integrating the business systems with the mobile and other technologies. However, they failed due to complex usability and limitations of legacy mobile systems. With the requirements of the SMEs and current technology, there can be two methods for integrating these systems.

One method is through online web server. The system is installed on the webserver and all communications are done through it. The data, logic and all calculations are performed on the server and any machine with the web browser can act as client machine. The raw data could be also accessed through ftp (File Transfer Protocol) or cloud service. This gives the flexibility to access the system from any corner of the world with the Internet connection. The different web service can also be integrated which could create ocean of valuable information, right at the time needed. This could also ease the implementation of real time business intelligence as system could be always fed with the live data. But, this poses a major & vital requirement of Internet connectivity to access the system. Also, if the server is down, it can bring all the related processes to hold. The data has to keep on third party machines and user does not have the physical hold of its data. Also the system needs to be secure enough, to prevent the system & data from any attack of hacker or virus.

Other option is by installing the system on the local machine or local server. Selection of local machine or server will depend upon the size of data and the processes. The only way to access and locate the system is by calling to its local IP (Internet Protocol).

The IP of the machine should be make static, to allow easy and effective connection & communication among all connected devices. The system will be fast and secure as it is only talking to systems connected in same network and not outside world. The data can be easily managed either in the local data center or in the same machine, depending upon size. However it is safe to keep the data in separate data center machine as it allows data to keep safe and any problem in system won't affect the data. However the only problem is that the system and the data is only limited in local intranet network and cannot be accessed from outside world. This poses a limitation to access the systems from remote locations.

There can also be a third approach, which will be hybrid approach (shown in figure 4) of above two. The only downfall of this approach is that it will put an extra cost on the system. There are services available in the market that allows connection from remote locations (outside the local network) to IP featured devices like webcam, digital video recorder or desktop. These services can be installed on the local server or desktops and thus any device and communicate with the local server via these services. This is a better option as the services is only used when needed. This also eliminates the limitation of Internet connection as the data is always on the local system. Furthermore, all the required features of webserver can be used on local server. However services used to expose the system to outside world should be highly secure. Some of these low cost services require changes in the firewall settings. This could put a high risk of the virus and hacks not only on the system but also to the complete network.

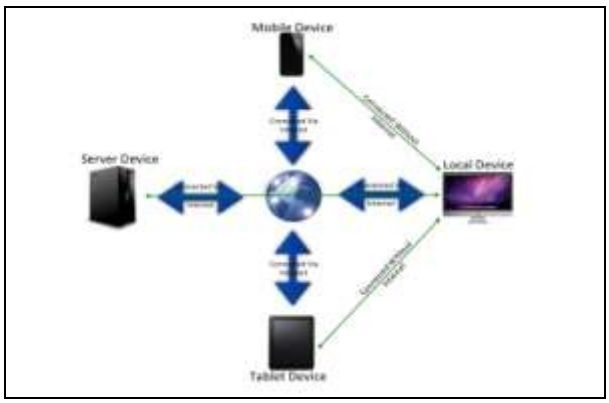

Figure 4. Communication of information between different devices

The main data center is on the local device and all other devices talk to that local device online as well as offline. The online communication is via Internet and offline communication is in closed network).

API (application program interface) can be helpful in implementing this architecture for systems to work in online as well as offline modes. API is the most flexible, simple and efficient way to enable communications between different devices. The add-on advantage of API is that it open the possibility of integrating several other features and services within the system, as well as could also allow system to become part of other services. All mobile applications as well as other devices can communicate easily within Internet as well as Intranet network with API. Thus, the limitations of Internet can be easily solved in the Intranet network. There are already some smartphone applications like

air- play, mobile mouse, multiplayer gaming or wireless transfer, which are using this feature of closed connection or Intranet to talk between system and devices. This approach can be easily implemented using the client server architecture. The client machines locate the host machine and make the requests for connection. Once the host authenticates the client device, it could facilitate synchronized communication between client and host. Furthermore, using the API feature, most of the complex logics and calculations are performed on the server. Client devices will be only sending a query URL to the server. The server will do the calculations on it and will fires back the results in raw data format. The devices can easily fetch the data from raw format and can present the user-friendly results. Thus, the power of mobile devices will be used in presenting the data in more understandable manner, rather than doing calculations. This will also take less memory of the device and will produce more productive output. It could be similar to scenario where the device has outsourced the calculation part to the server and the device serving the task of visualization.

Consider the scenario, where we are trying to get the stock usage patterns over a year on mobile. The mobile application will send a query to server with the item name and duration. The local system will first search the item with item name, and will then generate the data over its usage. The system will fire back the statistical data for each month over a year. This data can be interpreted by the mobile application, which will produce a graph on items usage. The mobile device only has to perform operations to draw the graph for which the server provides filtered data. Thus the server performs all logics and calculations and results are presented on the device. This is the benefit of client server (system) architecture, where client see the output, and the server handles all complexity as illustrated in Figure 5.

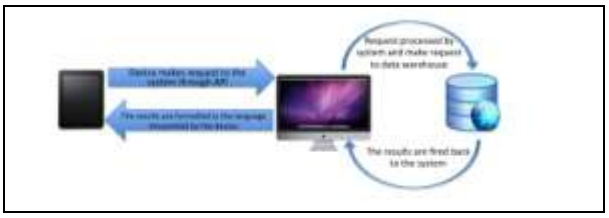

Figure 5. Insert the title of the Figure 5

The Figure 5 shows the request from a device to a system and the response returned from the system to the device.

Data transfer between the nodes (devices) can be done by several methods. Earlier XML (Extensible Markup Language) was the most standard way for data communication. But as JSON (JavaScript Object Notation) is light, fast and use less CPU resources, JSON is being preferred over XML now. JSON file format is hierarchical data structure in the array format, which makes it easy to extract data in any platform and environment.

6. Conclusion

This paper presents the model and the system architecture for the business intelligence tools for SMEs. The core idea and information behind this architecture is to design a generic system that is flexible enough to suit to different requirement of the business. The system should also be open so that it can easily communicate to all other different devices irrespective of their platform and environment. The new mobile architecture & design could support to make information readily available anytime and anywhere. These systems could define a working standard for the SMEs. Furthermore, this could help SMEs to get the similar kind of information as getting used by the large enterprises. It can help SMEs to manage their work style to match with the standards of large enterprises. There are several developments opportunities associated with these systems. The system will be constantly evolving, as system will be modified on different requirement of the business. Furthermore, since the SMEs too will have the business intelligence data, this data merged with the business intelligence data of large enterprises can help to generate a very powerful knowledgebase.

7. Acknowledgment

This work was funded by KTP (Knowledge Transfer Partnership) involving Scottish Executives, University of the West of Scotland and UK Whitegoods Limited.

8. References

[1] Roger Stein Vasant Dhar, "Intelligence Density : A measure of Organizational Intelligence and Productivity," in *Seven Methods of Transforming Corporate Data into Business Inteligence*. New Jersey: Prentice Hall, 1997, pp. 9-14.

[2] Jerome Darmont, Jean-Hugues Chauchat, Iryna Zolotaryova Oksana Grabova, "Business Intelligence for Small and Middle-Sized Entreprises," vol. 39, no. 2, June 2010.

[3] Paul Gray Solomon Negash, "Business Intelligence," in *Handbook on Decision Support Systems 2*, Clyde W. Holsapple Frada Burstein, Ed.: Springer, 2008, pp. 175-193.

[4] B. Ralston, *PowerPivot for Business Intelligence*

Using Excel and SharePoint. Berkley, US: aPress, 2011.

[5] Ofcom, "UK Broadband Speeds, May 2010," Research 2010.

[6] Viktor Kaufman, Albina Shapiro Yuri Natchetoi, Service-Oriented Architecture for Mobile Applications, 2008.

[8] R. Thompson, P. Coulton, R. Edwards O. Rashid, "A comparative study of mobile application development in Symbian and J2ME using example of a live football results service operating over GPRS," in *IEEE International Symposium on Consumer Electronics*, Reading, pp. 203-207.

[7] Chen-Wei Huang and Yi-Hsuan Yeh Ting-Peng Liang, "Adoption of mobile technology in business: a fit-viability model," *Industrial Management & Data Systems* , vol. 107, no. 8, pp. 1154-1169, 2007.

[9] BH Wixom HJ Watson, "The Current State of Business Intelligence," vol. 40, no. 9, Spet 2007.

[10] R. Rajugan , Tharam S. Dillon , and Wenny Rahayu Vicky Nassis, "Conceptual Design of XML Document Warehouses," *Proceedings of the 6th International on data Warehouse and Knowledge Discovery*, pp. 1-14, 2004.

[11] Lucie Xyleme, "A dynamic warehouse for XML data of the Web," *Bulletin of the IEEE Computer Society Technical Committee on Data Engineering*, 2001.

[12] Zohra Bellahsène Xavier Baril, "Designing and Managing an XML Warehouse," in *XML Data Management: Native XML and XML-Enabled Database Systems*.: Addison-Wesley Professional, 2003, pp. 455-473.

[13] Ariella Quesada Francisco J. Mata, "E-Marketing in Costa Rican Export Companies," , London, 2012.

