

Designing And Implementing An Online WebGIS-Based Decision Support System

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Abstract: This paper focuses on providing a market analysis solution through designing and implementing an online decision-support system (DSS) for businesses decision makers in Tobacco industry in China. The procedure makes use of data, information and software from Web based Geographical Information Systems (GIS) to generate online analysis, mapping and visualisation systems. These procedures are integrated and synchronised with market analysis techniques and customer relationship management (CRM) systems.

By integrating these two techniques, a webGIS-based tobacco market information system is presented to demonstrate the significance of WebGIS in market analysis field. Specifically, to meet the needs of market practitioners (retailer, distributor and industry authority) in understanding the current market and sales performance, the system is designed and mainly consisted of four functional components: Communication and administration, Current market analysis, CRM (Client Relationship Management) and Sales/customer analysis, and Operational issues. From the system design and system usage perspectives, the illustration on the system architecture and the process of marketing information transmission reveals the benefits raised from this E-commerce tool to both the system users and service provider in marketing analysis. Based on this, the fusion of technology enhancement and marketing strategy in business process are called for and discussed.

Keywords: Decision Support & Group Systems, WebGIS, Market Analysis.

I. Background and Current Development of WebGIS In E-commerce

I.1 E-commerce Role in Business and Marketing

So far, Internet is becoming a global common platform where organizations and business people communicate with each other to carry out various commercial actives and to provide vale-added services [4].

With the variety applications of e-commerce in business, Feeny [3] summarizes the role of e-commerce into three perspectives: E-operations, E-marketing and E-service (see Table 1). As he says, "For traditional bricks and- mortar companies, components of e-operations and e-marketing are likely to represent immediate opportunities with real economic benefits. The e-service strategy creates a strategic

intent that will influence the evolution of the other two strategies". He predicts that e-services will be the focus of firms' business strategies in the future and the source of great potential profit; according to him, "E-services represent the ultimate aspiration of the Information Age, with their electronic orchestration of offerings that span the breadth and lifespan of a customer/client's needs within a chosen and defined market space".

Table 1. The Role of E-commerce

| E-opportunity | Component |
|---------------|---|
| E-Operations | <ul style="list-style-type: none"> • Automation of administration processes • Supply chain reconfiguration and integration • Re-engineering of primary infrastructure • Intensified competitive procurement • Increased parenting value |
| E-Marketing | <ul style="list-style-type: none"> • Enhanced selling process • Enhanced customer/client usage experience • Enhanced customer/client buying experience |
| E-Services | <ul style="list-style-type: none"> • Understanding of customer/client needs • Provision of customer/client service • Knowledge of all relevant providers • Negotiation of customer/client requirements • Construction of customer/client options |

(Source: Feeny, 2001)[3]

Today, e-commerce provides ready access to a vast array of information resources and facilitates the gathering of valuable knowledge and competitive intelligence. As the network of Internet users expands, marketers are increasingly turning to the Web for market research information needed for decision making [2, 13], for example, market surveys, "virtual shopping" experiments for testing new product concepts, customer satisfaction measurements, etc.

Based on internet technology, more and more techniques from the other disciplined have been integrated for e-commerce activities, for example, data-mining techniques

have been applied to Web sites for providing timely trend analysis and customer/client profiling information that is valuable in making effective marketing- mix decisions [7]. Applying GIS technology in e-commerce is another example of providing market intelligence by focusing on spatial context.

I. 2 WebGIS-based E-commerce Application

A Geographical Information System (GIS) is a digital mapping and spatial analysis system capable of assembling, storing, manipulating and displaying geographically referenced information. It helps users understand spatial relationships, enhances decision-making and solves problems more quickly [5, 10]. A Web GIS platform provides a powerful online data process and display system. The swift development Marketing Information System (MIS) or Decision Support System (DSS) enables it now becoming an important part of business life [12]. The power of a WebGIS in business decision support areas could be its ability to manage spatial data from a number of sources, to display spatial data online dynamically, and provide spatial analysis modelling and decision support scenarios.

Specifically, GIS is capable of integrating retailers' internally-generated databases (eg. CRMs) with database produced by 'external' sources using spatial proximity, GIS helps to analyse and visualise these data effectively, therefore, enhance communication and provide knowledge to decision makers for their decision making. The use of WebGIS technology to enable or facilitate the delivery of information services online has the potential to benefit both the system users and service providers alike. These benefits could be seen from the above three perspectives in Table 1. Although the significance of GIS in business world has been identified by more and more researchers and practitioners in marketing [1, 6, 14], there is not enough attention has been drawn on the application of WebGIS on marketing research, especially, from both academic and managerial perspective to explore the significance of WebGIS application in marketing analysis perspective.

Based on this, the purpose of this paper is to explore the designing and implementing the hierarchical structures and the analytical process of this WebGIS based tobacco marketing analysis system, and then further elaborate benefits of such WebGIS based E-commerce system can be made to the business world. Considering the information needs from different users, firstly and broadly, the structure design of this WebGIS-based system is illustrated in Section 2. Then, the process of information transmission in using this online MIS is explored in Section 3. Specifically, the detailed information on the functionality of the system is demonstrated in Section 4. This leads to the discussion of the benefits fetched by this system and the consideration of the future research in Section 5.

II. The Architecture and Structure of WebGIS-Based Market Analysis System

II. 1 Tobacco Industry in China & Information Need

In China, over the last decade, tobacco has perennially been the largest contributor to China's tax coffers by industry [8]. In 2003 alone, tobacco taxes nationwide totaled approximately US \$29 billion [15]. The production, marketing, and distribution of tobacco have remained under the watchful control of China's State Tobacco Monopoly Bureau [8], by considering the tobacco risk-reduction to the public health (for instance the license control in each geographical area and different type of retailers/clients). Specifically, in this information era, the role of government authority in tobacco industry has been gradually transferred to a service provider in the industry to enhance the tobacco-control and improve the efficiency of tobacco distribution and marketing.

Considering the government authority as the service provider for this market analysis system, the key users will include the Tobacco industry clients (i.e. tobacco retailers, and distributors) and industry authority itself. As the system involves the users in different geographical areas, and different levels in the administration system, thus different information are needed by different system users, which is shown in Table 2.

Table 2. Information Needed by the Different Users

| System user | Information needed |
|--------------------|--|
| Retailer | <ul style="list-style-type: none"> • Current sales of tobaccos • Spatial distribution of sales within the local area • Market share • Brand sales • Sub-category sales • Sales change • Customer (group) behaviour • Market potential in each area |
| Distributor | <ul style="list-style-type: none"> • As the above • The performance of covered retailer • The change of performance of covered retailer • The network of local retailers distribution • The efficient way to keep inventory and deliver tobacco to the retailers. |
| Industry authority | <ul style="list-style-type: none"> • As above information within industry in the context of country/regional wide • The cost and efficiency of running tobacco business • The cost and efficiency of doing market analysis |

As shown in table 2, this market analysis system should

be designed not only to help the clients of industry authority (retailers/distributor) understand the geographical distribution and the behaviour of customer (i.e. the individual end-user/consumer of tobacco), but also help industry authority auditing the sales, marketing and behaviour of its clients. Consequently the system will help to improve both industry economic efficiency and public health awareness, and protect the industry from international/national threats of smoking restrictions and supporting the industry position [11].

II. 2 The Structure Design of WebGIS-based Market Analysis System

The WebGIS-based market analysis system developed provides both users and decision-makers with a flexible, problem-solving online environment with a geographic foundation. From the perspectives of the industry authority/information provider and the clients, the accurate updated data is a common fundamental issue. In order to track the market trend and collect sales-related data on a regularly (daily) base, the whole system is designed into three interrelated layers: user layer, application layer, and service layer, which is shown in Figure 1.

In computing network design, user layer is described as a client, and the other two layers within the network, which are used to store the comprehensive databases and ran more complicated applications, are described as servers.

User layer

As it is shown in Figure 1, the main tasks of the system users (retail outlets or decision makers in different level) include:

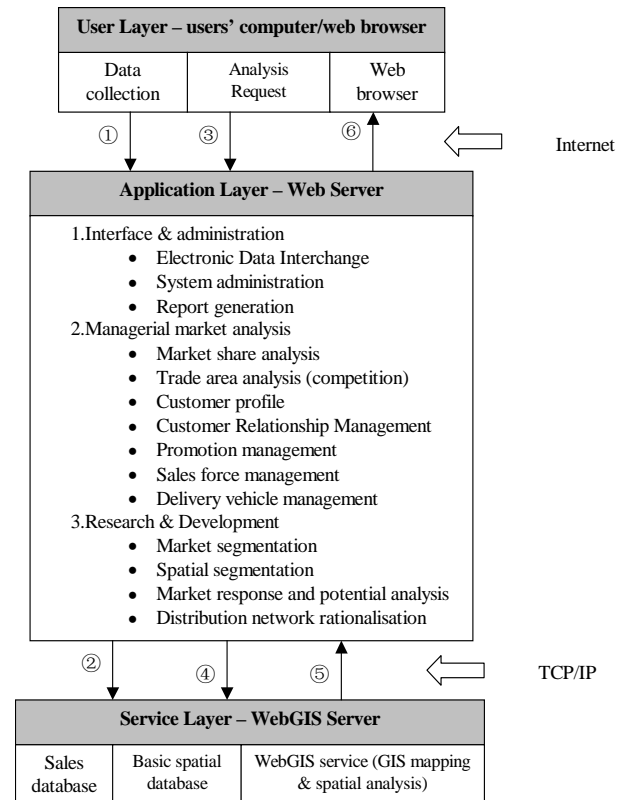
- 1) Data collection - to update their sales related data on a regular base.
- 2) Request sending - send the requests to the server about various market analyses for examining the current market performance, evaluating the market potential of a certain customer group or a target area.
- 3) Web browser - to receive and display the result of analysis from the server.

Considering the main duties of users are to provide the detail sales information, send request for the market analysis and receive the analysis results to/from a stand-alone server rather than running a comprehensive and sophisticated marketing analysis in a single computer. As the main duties at user level are simplified to the basic level, the requirements are minimised in terms of the hardware computing power and technical skill required to a user in data collection, marketing analysis and computer usage.

Application layer

To meet the variety needs from the different users, application layer is designed to provide a comprehensive marketing managerial and research analysis module.

Figure 1. The Structure of WebGIS-based Market Analysis System



(After: Lembo, 2004)

Internet is the connection link between the requests from client-side (user layer) and the result analysis provided from service-side (this application layer). The web interface & system administration tool links system user to various analytical and managerial analyses. This standardized interface and system administration tool facilitates the automation of administration processes, reduces the cost on learning and training the use of the system, and minimise expenses on maintaining and providing technical support of using the system.

As the major analysis and administration functions are pushed back, the requirement to the computing hardware, system design is quite high, since this is application-running station of interface & administration, managerial market analysis and research & development.

Service layer

The service layer consists of two key components: relational database system and WebGIS module. This relational database system stores and provides geo-referenced datasets requested by the applications in the application layer. The requested spatial analysis and geographical mapping tasks will be fulfilled by GIS module.

Specifically, relational database includes CRM (sales database) and the basic spatial database. Sales database will be updated on a regular base by the users of the system. And

basic spatial database is a pre-build database set, which contains all the relevant information about the whole study areas.

Within this relational database system, not only the comprehensive geo-referenced datasets are kept, but also, the spatial relationships among these geo-referenced datasets are stored and structured, therefore, geo-referenced information could be retrieved, aggregated, calculated based on the request from the users.

As this market analysis system is set on a spatial base, thus spatial analysis and geographical mapping will be requested by almost all the analysis. And the results of each analysis can be reported by geographical mapping. In addition, as GIS and spatial database need to work together closely, thus, this relational database system and GIS module are developed together. TCP/IP, a special language, is used to link this layer with the other (i.e. application layer)

III. The Information Process in WebGIS-Based Tobacco Market Analysis System

The above structure design provides efficient information flow, and generates useful market analysis knowledge and intelligence to be used by various users and decision makers.

Step ①: Data collecting, data entry, and data coding (E-operation)

Currently, aided by bar-code reader, the sales data on daily base could be captured and stored easily. For instance, roughly, there is 16 million sales of tobacco in Hainan province, i.e. 50 thousand sales in daily based records, which is shown in the sales scanner data records. Based on this imported scanner data, the system will automatically sort the data into pre-set standardized format for the next step analysis.

On a regular base, the users of the system within broad geographical areas update their sales data from their own computer. This update information is passed through Internet to the Web server. The electronic data interface (EDI) structures the updated information from the users in a broad geographical area in an identical format. This standardized and atomised E-operation in data entry and coding method will improve the efficiency of data collection, entry, and coding within whole industry/system.

Step ②: Sales data updating (E-operation)

Then this structured sales information is passed on to the central sales database via TCP/IP automatically.

Step ③: Analysis request sending (E-operation, E-service and E-marketing)

Based on different purposes, the analysis request is sent out from user to the web server (computer(s) in belonging to application layer). For instance, as a member of user group, user can request to update the user profile via *system administration* module.

The general marketing analysis tools can be requested by the users. As there are series inter-related analyses within web server, users can customize their request for their specific purpose and just pay for the use of their customized analysis. Consequently, reduce the cost of users and improve the efficiency of the system performance, since only the requested analyses are run on the system.

Based on result from general marketing analysis tools, the more sophisticated and specific researches can be conducted via the interactive communication between system user and this marketing analysis system. This research and strategy development module includes market and spatial segmentation, market response, retail network rationalisation and budget optimisation.

Within this application layer, it is noted the *CRM* and *delivery vehicle management* module are incorporated, thus, based on the result of customer profile, the target market will be revealed and determined. And the spatial differentiation in terms of demand can be identified. Accordingly, the promotion management can directly send out promotion letters/advertisement to the target market. And the *delivery vehicle management* can automatically coordinate the distribution schedule based on the principle of minimizing the total distribution cost by considering both the travel path distance, traffic flow and the labour cost etc. Thus, in this layer, all the functions of E-commerce, which are listed in Table 1, could be found in this system, i.e. E-operation, E-marketing and E-services.

Step ④ data communicating and result generation request

Because, the sales database and relevant spatial database are requested and incorporated during these analysis and exploration processes, the data communication occurs all the time. And at the end of analysis and exploration, the result generation request is always sent out to WebGIS server for a more vivid analytical output.

Step ⑤ GIS mapping & output exporting

Within this WebGIS server, firstly, sales database is updated and geocoded as a routine updating process. Then, the sales database will be incorporated into the Basic spatial database for spatial analysis and mapping. The detailed trading area market analysis could be found in Appendix A. The significant features of GIS module could be found not only in market share analysis, spatial segmentation, but also in distribution network rationalisation. At the end of these analyses, geographical maps will be created *within* WebGIS server. Then these maps (only the image itself) will be exported application layer, i.e. Web server.

Step ⑥ result browsing

The output image exported from WebGIS server will be packaged into a customized format in Application Layer according to the request from user and *System*

administration tools. Eventually, this formulated output will be displayed by the Internet browser in user's side.

IV. The Functional Components of the WebGIS-Based Marketing Analysis System

To meet the requirement of different users in understanding current market performance, customer behaviour, and working out the solution for daily business practice (e.g. tobacco delivery). This WebGIS-based marketing analysis system is consisted of four major functional components (shown in Table 3): A) Communication and administration, B) Current market analysis, C) CRM and Sales/customer analysis, D) Operation & Decision Support Issues.

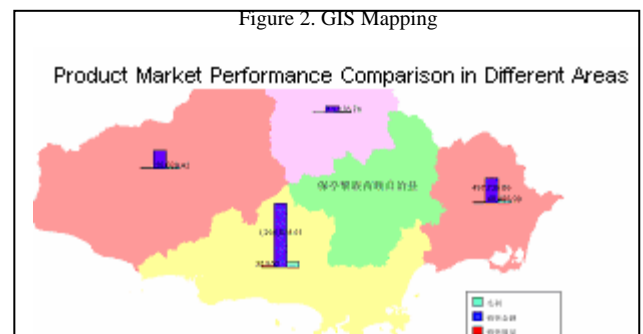
A. Communication & administration

In this module, administration means the market information is periodically collected from the retail outlets, and provides system management mechanism as well. For example, as the users of system, they are authorised to logon the system to acquire the marketing information they need. However, by categorizing the user into different groups and allowing them to access information they want at different content levels, Thus, not only this mechanism can reduce the cost of system user, but also improve the speed of whole system operation. 'Information user group management' function can easily match customer identity with the customized information will be offered.

With this WebGIS-based system, not only the system could incorporate and integrate the data from different sources by GIS Database functions, but also geographical mapping improve the communication efficiency and effectiveness by putting the intensive marketing information into easy to understand map format. With maps, the enormous and complicated marketing analysis and spatial modelling results can be vividly presented, the presentation can help system users and/or decision-makers easily link or integrate their considerable influencing factors (eg, experiences, consciousness) and the complicated analysis results together. Thus, maps have the potential to integrate the human intelligence with the Internet-based powerful computing capacity to achieve the communication and analysis efficiency and effectiveness. For instance, in Figure 2, while the colour base map shows the level of total sales in each area, the three bar chart figure in each area indicated the level of detail sales performance, i.e. sales profit, total quantity sales, total sales amount. This map output can help users/decision makers to understand sales performance in different regions by simply glancing.

Table 3. Functional component of the WebGIS-based MIS

| Functional module | Function -classification |
|--|---|
| A. Administration & Communication | <ul style="list-style-type: none"> • System administration • System tool • Information user group management • Information management • Information collection and assortment • Internal management |
| B. Current market analysis | <ul style="list-style-type: none"> • Total sales • By the class of quality • By sub-category • By produce origin • By functional specification • By brand • Sales spatial distribution pattern |
| C. CRM & Sales/customer analysis | <ul style="list-style-type: none"> • CRM • Performance analysis • Customer value evaluation • Customer audit system |
| D. Operational / Decision support issues | <ul style="list-style-type: none"> • Logistic management • Area-based optimisation • retail outlet rationalization |



B. Current market analysis

As the intensive marketing information is organised in GIS-based relational database, thus, a variety combination of marketing analysis can be offered by the system to meet the needs of different users under the different conditions, which is shown in Table 3.

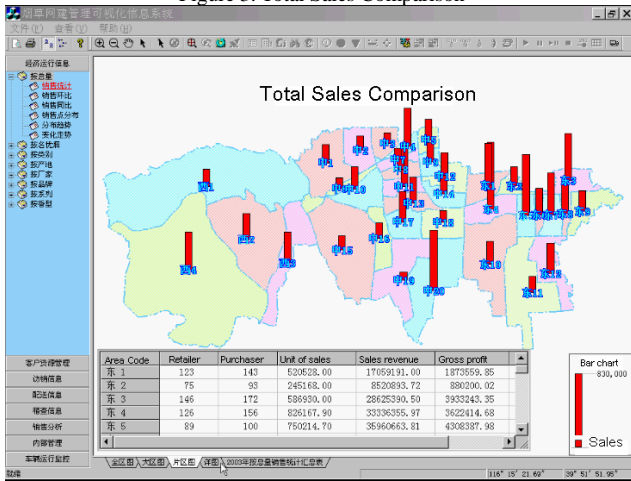
By compacting and integrating the various market analysis and knowledge discovery module on customer study, market segmentation, spatial segmentation, 'if-then' multi-criteria scenario exercise, and optimisation/operation research into the analytical system, it could provide the chance of mass-customisation, i.e. the user can select and pay for the analysis based on their needs and preference. Also, it is noted, this standardized managerial market analysis and research & development module not only can provide the valuable information on current sales pattern, demand distribution, market pattern in a standard format within various time and spatial context, but also it could

improve the comparability of sales and market in different places and time frames. In addition, this standardized analytical module makes it easier and cheaper to update the entire analytical system and functions without big changes in user-side. Consequently, reduce the overall cost of market analysis within the whole user group or industry.

C. CRM & Sales/customer analysis

This GIS-based CRM system can go beyond the functionality provided by general CRM system, i.e. the performance, value and preference of each customer. In addition, the CRM system links customer with geography. Thus, the system user could get additional information of the spatial distribution and spatial location of the high value/potential areas/clients and the comparison of the market performance could be revealed, which is shown in Figure 3.

Figure 3. Total Sales Comparison



Not only the sales statistics across a broad geographical area could be displayed in a single map, but also the performance of each individual retail outlet could be linked and examined, which is shown in Figure 4. This can facilitate the target market planning in the organization.

Figure 4. Link to Individual Retail Outlet

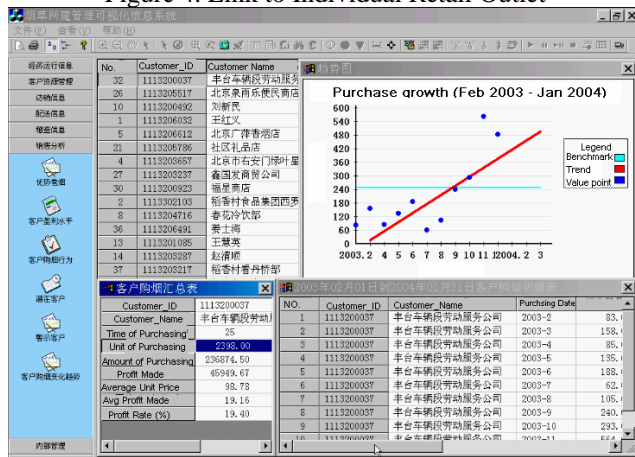
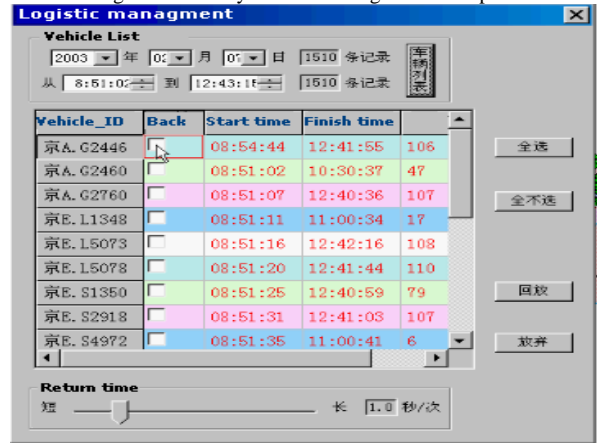


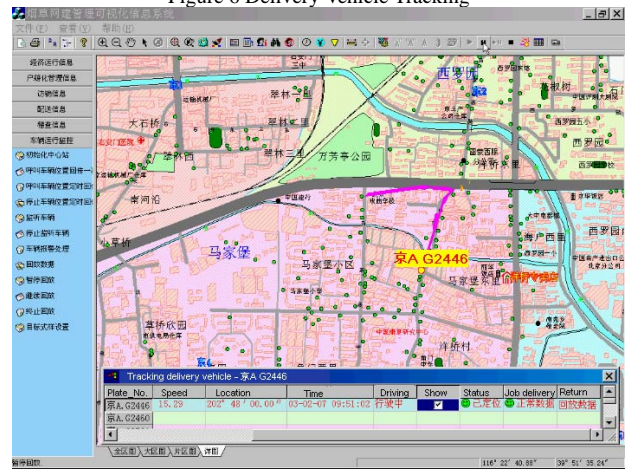
Figure 5 Delivery Vehicle Management Component



D. Operation and Decision Support Issues

Different from the general MIS, this GIS-based DSS provide a special facility in spatial analysis. Thus, it enables the decision-makers conduct the operational planning on *delivery vehicle management, area-based optimisation, and retail outlet rationalization*. For example, based on spatial analysis results, that is shown in Figure 5, the real-time delivery vehicle tracking function provides decision makers a practical tool to coordinate the members in the distribution channel, accordingly, improve the delivery efficiency by incorporating the local traffic information, which is shown in Figure 6.

Figure 6 Delivery Vehicle Tracking



As it is mentioned above, to meet the needs of the system users in different levels, the Internet-based technology provides significant advantages. These advantages could be perceived clearly by examining on the architectures of this WebGIS-based DSS.

V. Discussion

V. 1 Benefits Raised from WebGIS-Based System Design

By fulfilling the role of E-commerce (E-operating, E-marketing and E-service), which is shown in the above illustration, it is shown that this WebGIS-based tobacco market analysis system can help in improving the market analysis functionality, reducing the cost, enhancing the operational efficiency, and increasing the adaptability of the system:

1) *Improving the functionality*, as it is shown above, by developing the applications into a few different modules, more functionalities are provided, thus it could match the different demand of marketing analysis. Within this open system (to every user in a broad geography areas, and decision-makers in different levels and departments), the horizontal and vertical integration of available datasets make the prediction accuracy improved. Thus, the marketing analysis and exploration will be conducted based on longitudinal data rather than cross-section data, and a spatial continuous area rather than limited spatial points. In addition, not only the sales-related dataset is incorporated, but also, the geo-referenced data is intensively used. Accordingly, the information provided by this system represents the spatial-temporal dynamics, i.e. close to the spatial reality, which lead to more accurate result for market analysis. More importantly, the system is available online and maintains an open and fair market place to member in this industry. In addition, as the GIS-based exploratory researching modules are incorporated, the multi-criteria based 'if-then' scenario exercise will help the users simulate the spatial reality. These will contribute the improvement on the quality of marketing analysis and prediction.

2) *Reducing the cost*, by modelling the process and analytical modules into a hierarchy structure, linking the computers and analysis together via Internet, this system reduces the workload on each single computer. This structured design reduces the technical and skill requirements on user side and it makes the marketing practitioners feel easier with market spatial analysis. Also, as the users only pay for the customized services (analysis) and need not to run it on their machines, thus it reduces the cost for the users. In addition, the standardised and automated process of data collection, transaction and analysis extremely reduce the cost and effort put in by comparing the conventional approaches. From the users' perspective, the customized functions and analyses provide the chance to minimum their budget on the service.

3) *Enhancing the operational efficiency*: The analytical system interoperation and working efficiency for administrating and communicating are improved by a series of standardized and automated process and approaches. By organising the marketing analysis into different modules, it facilitates the users to choose and customized the modules they want and the order to do the analysis. Thus, in one hand this flexibility will lead to the budget saving, on the other hand, this flexibility could increase the customer participation and remove the customer resistance to adopt the service. By pushing the analysis layer and database layer backwards, it standardises the content format and database

manipulation process and market analysis. Thus, this structure makes it easier to transform the whole system into the new operating system, database management system and networking structure, i.e. improving the compatibility.

4) *Improving relationship* between the system users (decision-makers in different levels) and *the adaptability*, by working under online open environment, the sales-related figures and analyses could be updated automatically in the same format and/or under the request of the users, this will reduce and remove the suspicion and misunderstanding, increase trust. As the analytical module is removed from user layer, it reduced the knowledge and skill requirement level of using the specific software and makes the marketing analysis job easier. And the visualization of GIS increase the level of interesting and reduce the complexity.

V. 2 Future – the fusion of marketing practice and technology transformation

1) *Technology* → *service*: *WebGIS, Customer-based decision support system & service*

WebGIS can help integrate the spatial information and bridge human analytical skills with their machine-processability. As it is shown above, the architecture of WebGIS-based DSS provides the possibility to solve the technique-oriented problems, i.e. the appropriate GIS services (both spatial information and analysis) could be requested from and delivered to the users who have different GIS skills to match their needs.

Currently, Internet accelerates the integration of information in both horizontal (spatial) and vertical (temporal) dimensions. The extensive information extends decision-makers' scope in one hand, in the other hand the overload and under-utilized data confuse and frustrate decision-makers' motivation and interest. However, the mechanism of WebGIS provides customized decision support system based the client-server structure, 'if-then' scenario spatial analysis and vividly computer mapping. Thus, it (WebGIS) turns this desktop-based software or system (i.e. GIS) into a Web-based service. During this process, the emerging/new role of marketing could be seen. Therefore, in this field (WebGIS in marketing), the critical thing goes beyond the functionality of WebGIS could provide. Also, when, what and how to provide these information/solution to the decision-makers in different level become the other important thing. And this directly relates to the marketing strategy on subscription of system usage.

2) *Service* → *technology*: *The role of service provider and its marketing strategy*

When market analysis is taken as a service, the standardization of spatial data used, the system tool for spatial analysis in an open GIS environment is requested. As the standardization can significantly improve the inter-operationality, it will improve the efficiency from the whole system perspective. As WebGIS is turning this market analysis system into a service, then the concept of

coordination in terms of the relationship within client-server and the net of computers will become a critical issue. Then from a technology perspective, if the client-side strategy should be adopted or the server-side strategy should be adopted will become the other issue in this field. With client-side strategy, the enhancement in client-side infrastructure will be improvement, thus it can speed up data manipulation and the interaction between user and system. However, the requirement of the users' computing/GIS skill will be very high. On the other side, if the server-side strategy is adopted, the requirement of users' skill will be reduced, while the requirement of the server-side will be highlighted.

In sum, the swift development of information technology (e.g. Internet) has bought the revolution in marketing; on the contrary, the shift of marketing's role in the new technology environment accelerates the evolution of information technology. From both technology and marketing perspective, how can we utilize the available techniques, resource and marketing strategies to improve the business practice is becoming a hot topic in both academic and practice field.

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