

CROSS-MEDIA USER INTERFACES FOR CONTROLLING THE ENTERPRISE

The EAGLE Integrated System

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Abstract: Current Business Intelligence (BI) tools are aimed at providing managers with a way to control and measure their businesses. However, and despite much research and many commercial and academic prototypes, the user acceptability of these systems remains challenging. We describe an innovative approach to enhancing the ease of use and the visualization, control and decision-making of small-to-medium enterprises. Our approach to the design of BI tools is novel because (a) it combines user-centered design techniques with recent advances in quantitative information visualization, and (b) it employs several media (webcams, telephones, interactive maps and *sparklines*) to provide the user with a more powerful way of business control. We present a tool called Eagle which was designed using this approach and was developed in an industrial, real-world setting. We also describe some principles which were outlined along this case study.

1 INTRODUCTION

Business Intelligence (BI) is defined as the result of “acquisition, interpretation, collation, assessment, and exploitation of information” (Davies, 2002, p. 313) in the business domain.

There is currently a trend towards satisfying new customer needs relating *visual* business intelligence. Existing business analysis systems are difficult to use and visually complicated. There is clearly a need for user-friendly software applications as well as a need to control multi-placed business sites, offices or stores anytime, anywhere.

Our premise is that the key to obtaining more usable and useful executive information systems implies providing the executive with the right business tools, coupled with the right visualizations, using an interface designed to support the decision tasks efficiently.

In this paper, we describe the approach we took in the design of the Eagle system, a new BI tool that

integrates several media (live streaming webcams, conventional, fixed telephones, interactive maps). Our approach is novel because current BI tools suffer from a lack of appropriate user-centered design methods: instead of focusing on features, we focused on the relevant business decision-making tasks. We also combined user-centered design techniques with recent advances in quantitative information visualization to design the Eagle system.

The remaining of this paper is organized as follows: Section 2 describes some background foundations of our work, namely the need for better BI tools, sparklines for visualizing intense, quantitative data, and the usage-centered design process. Section 3 describes related tools and approaches. Section 4 presents both the architecture and the user interface of the Eagle system which we developed as a proof of concept for our cross-media, usage-centered approach to the design of BI tools. Section 5 gathers some principles we found useful, and that could guide the effective design of BI tools. Finally, Sec-

tion 6 draws some conclusions and outlines possible future work.

2 BACKGROUND

Business Intelligence tools have been the target of much research since the beginning of the 90s (Lundeberg and Sundgren, 1996). The purpose of this class of systems is to provide managers and executives with a way to control, measure and obtain information for decision-making regarding their businesses. However, the number of companies and executives actually using these systems remains relatively small (Lundeberg and Sundgren, 1996).

According to a recent BI survey (Information-Week, 2006), a majority of companies report a limited number of their employees as having access to BI tools. Only 8% of the surveyed companies report that half or more of their employees access BI tools.

More importantly, it is expected that BI tools will be accessed by more than half of the companies' employees within two years (38% of responses), and nine out of ten companies report BI spending to be growing or remaining the same as last year. This suggests that usability will be a major concern in the design of the next generation of BI tools.

The design of these systems faces many challenges: the ability to display large amounts of enterprise-wide data, as well as to provide easy-to-use mechanisms for visualizing and exploring that data are some of the most difficult ones to tackle (Keim et al., 2006).

Simplicity, flexibility, accurate representation of the data (and high-quality, reliable, data) have been referred to as particularly important factors for the actual design and development of Executive Information Systems (EIS) (Lundeberg and Sundgren, 1996).

This review, along with a more extensive BI tools literature review reveals the following gaps:

- existing business intelligence tools suffer from a lack of *visualization* and *analysis* capabilities (Chung et al., 2005);
- none of the existing tools allow the user to *act*, e.g. call the employee at one of the stores, watch two stores through a live video stream,
- none of the existing tools provide the user with a *cross-media, integrated* environment for actually controlling their businesses.

The solution we propose (the Eagle system) aims at addressing gap (a) by being based on novel visualization techniques particularly effective for business data. It addresses gap (b) by using VoIP and

live webcams technology. And finally, it addresses gap (c) by providing an integrated environment that allows the user to visualize data, see live images from desired stores, talk to and hear the employees, customers, and the overall business environment along with the traditional information which is displayed in conventional BI tools. The Eagle system we describe in this paper was designed through a user-centered approach and is being tested in real-world small-to-medium businesses.

2.1 Sparklines

Sparklines (Tufte, 2006) are "simple, intense, word-sized graphics". Figure 1 shows an example of a sparkline that displays a large set of data in a very small space. The most recent value of net sales is linked to the 6.2 number through the use of the red color. Some context is provided by showing the normal range of net sales as a grey band.



Figure 1: Sparkline showing intense data in a small space: the grey band shows normal range of values.

The application of sparklines to financial data is quite appealing. The essential task of BI tools' users is to make decisions, and making decisions implies making comparisons. Since sparklines are small, high-resolution data lines (usually embedded in a wider context comprised of words, diagrams and images), stacking several of these sparklines together helps the BI user to quickly detect patterns and perform fast parallel comparisons. Figure 2 shows a simple example of sparklines stacked together.



Figure 2: Sparklines can be stacked together to facilitate fast comparisons between several business metrics.

In terms of BI tools, sparklines are particularly useful "for tracking and comparing changes over time, by showing overall trend along with local detail" (Tufte, 2006). In the system we present in this paper, we added more detail by displaying the extreme values (high-low, least/most recent values). These values should be displayed directly over the sparkline, like Figure 3 shows.



Figure 3: Sparkline showing local values of interest (high/low least/most recent values).

By providing an upfront, contextualized look at intense data, sparklines can be particularly effective in BI tools. In the recent words of Edward Tufte, upon which most of this research was based, “sparkline graphics give us some chance to be approximately right rather than exactly wrong” (Tufte, 2006).

2.2 Usage-Centered Design

Usage-Centered Design (Constantine and Lockwood, 1999) is a model-driven engineering process essentially based on three simple models: a user model, a task model, and an interface model.

Usage-Centered Design employs abstract models that have been finely tuned through experience and practical, real-world cases to capture and clarify the essence of users, tasks, and interfaces in the most expeditious and efficient manner. Regarding users, the interest lies uniquely in the roles they play in relation to a system, and the designer tries to capture the salient and significant aspects of these relationships in the form of an abstract user role model. For a task model, task cases are employed: these are use cases defined by “abstract, generalized, technology-free descriptions” (Constantine and Lockwood, 1999; 2001). For the interface itself, the designer begins with simple models of interface contents and maps of navigation paths or other forms of abstract prototypes (Constantine, 1999) to help achieve the structure and organization right before becoming buried in the details of the real user interface.

The analysis and design process we followed, skipped the interface model and was focused on gathering information about user needs as well as a thorough task analysis. In the context of the task analysis we performed, these were the tasks classified with the best combination of importance (business importance) and frequency (of usage):

- Compare business metrics;
- Compare business metrics between business sites;
- Compare business metrics against time;
- See and hear business sites (possibly more than one simultaneously);
- Talk to business sites (possibly more than one simultaneously);

In addition to the visualization techniques like sparklines and the usage-centered design process, we also followed a design philosophy aimed at supporting workstyle transitions (Self-Reference). We adapted our workstyle model to the business executive needs, and followed a cross-media approach to the design of BI tools, aimed at supporting the workstyles of BI tools’ users.

3 RELATED WORK

The Business Intelligence Explorer (Chung et al., 2005) is a visualization system for browsing a large number of results related to business Web sites. Its design was based on a visual framework for knowledge discovery on the Web, which provides an approach to reducing information overload.

A similar tool called INSYDER (Reiterer et al., 2000) aims at providing an information assistant for finding and analysis business information from the Internet. INSYDER is a system that uses different agents for crawling the Web, evaluating and visualizing the results.

The idea of combining vision and hearing capabilities to the development of financial information visualization tools is explored by Nesbitt and Barrass (2004). They propose a combined visual and auditory design for helping traders detect patterns and predict stock market direction. Their basic motivation for designing a multi-sensory display was to widen the computer-human bandwidth, which is slightly different than our approach: we aim at providing more control capabilities to managers and executives.

Integrating business intelligence with knowledge management has also been the target of some researchers. Cody et al. (2002) present their concept of BIKM, systems that blend BI with Knowledge Management capabilities and describe two tools that we have developed to explore their approach – eClassifier, which performs text analysis, and Sapien, which integrates data and text through an OLAP-style interaction model.

Attesting the importance of providing managers with a real-time environment for monitoring and controlling the enterprise, Sayal and colleagues (2002) present the Business Process Cockpit (BPC), a tool that supports real-time monitoring, analysis, and management of business processes. The BPC was developed after the analysis of requirements for this class of tools. Sayal et al. (2002) identified that it is essential that users can quickly and easily analyze business-level indicators. Enabling a way for

business users to easily define and extract business-level metrics from execution data, however, meant only “without writing any code”. In the user-centered Eagle approach, we do not aim at providing means to let the user determine the best reports or the desired visualizations without having to write code, but instead to provide a tool with proven visualization techniques

Finally, advocating how the usability issues should be considered in the design of Data Mining tools, Berzal (2003) proposes to integrate diverse tools into a framework which should be kept coherent and simple from the user's point of view. The focus “is usually on complex algorithmic techniques whose influence is minor when it comes to users’ acceptance of the systems we build” (Berzal, 2003).

4 THE EAGLE SYSTEM

In this section, we will describe both the architecture and the user interface of the Eagle system.

4.1 Architecture

The main framework structure is composed by three main components:

- the multiple control sites on the top of Fig. 2,
- the main server structure on the middle of Fig. 2,
- and the client interfaces on the bottom of Fig. 2 (including possible interactive shop windows).

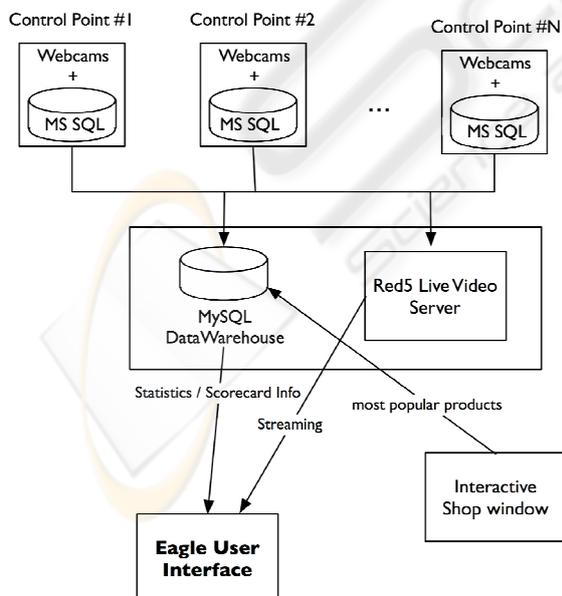


Figure 4: The Eagle system architecture.

Control Points. The multiple control points can be defined as workstations, points of sales (POS) or business sites. Each of these places is a piece of a network that is aggregated and controlled by Eagle as one. Each site incorporates a set of IP Network Cameras and a database with information about the control point. This information is usually created and maintained by a local operational system (like stock management systems or POS). The databases used in these sites can have different structure and brand (although MS SQL is very common, small-to-medium enterprises often recur to less sophisticated solutions, like MS Access databases or even Excel files which are stored locally).

Main Server Structure. The main server structure includes a minimum of two servers: a MySQL 5.0 database server and an OSFlash Red5 server (OSFlash Red5, 2006) using the Real-Time Messaging Protocol (RTMP). The MySQL server gathers data from the control sites and compiles them into statistical information for the graphical client interface. The gathering of this information is triggered by the Eagle/Fox clients. The Red5 server awaits broadcast connections from the control points and transmits video/voice streaming data to the clients upon request.

Eagle Client. The Eagle client communicates with the MySQL server for online data information and the Red5 server for the media streaming data. The clients are responsible for managing the online and offline control points, requesting information directly to the control point on a minimal basis.

It is assumed that the control points have a dynamic IP configuration, so the clients only now the current IP of the control site after it has logged on to the Red5 server.

Figure 4 also shows an aspect not yet implemented, but which seems promising: coupling an interactive shop window (or a touch-screen inside the shop) to the system could provide the business user with detailed information about the most popular products, e.g. the ones most browsed, and during what times of the day. Regardless of that extra aspect, the system is very flexible regarding hardware requirements: one can use low resolution, USB webcams or high resolution wireless IP cams. Any business manager with an Internet connection can use Eagle both as a data visualization tool and as a surveillance system.

4.2 Eagle’s User Interface

The main interface framework is shown in Figure 5 and can be divided in four distinct displays: (1) the

main screen on the left, (2) the right top screen, (3) the right middle screen, (4) and the right lower screen. The main framework was developed on Adobe Flex (Adobe, 2006a) technology. It allowed us to rapidly develop sparkline charts using the Chart components, which are usable and easily extended. It also allowed us to integrate the Red5 live stream server technology. Also, and because it's based on the Flash Player (Adobe, 2006b), resizing and reuse are simplified, since Flash is vector-based.

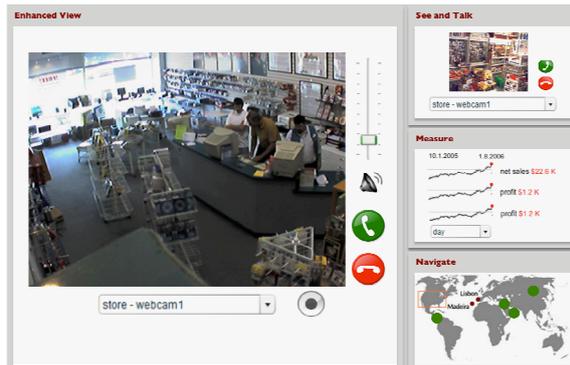


Figure 5: A screenshot from the Eagle system.

Main Screen. The main screen enhances the functionality of one of the three screens on the right upon selection. If the user selects one of these right screens, the selected screen is enlarged on the left main screen with extra functionality options. In Figure 5, the selected screen is the top right screen, enlarged in the left main screen. This is a way of supporting smooth workstyle transitions: the user may be interested in visualizing live video from one or more business sites, then rapidly check the sparklines to obtain information about net sales or gross profit from those sites. And if he/she wishes to go further in detail, then by clicking at the sparklines, the enhanced view shows in-detail, highly interactive charts.

Right Top Screen. This is the media screen which incorporates the video and voice functionalities. The business site camera view can be selected in the dropdown box and then shown to the user. Volume control is also accessible plus an option to directly call the fixed network telephone line of the control site.

Right Middle Screen. The statistics screen shows online data of the selected business site. The selected business site is the same as the one selected in the media screen (right top screen). The shown statistics can include net sales, gross margin, gross profit, etc. The temporal interval can be selected by the user through a drop down box in this screen.

This temporal navigation is also aimed at supporting workstyle transitions (in this case, going smoothly back and forth in the time dimension).

Right Lower Screen. The control map screen is used to visualize all the business sites in the network and to highlight the selected one. Online and offline sites are presented with differentiated colors. This screen can be used to select another control point.

The interface functionality can be described by three main views: (1) the Site Map view, (2) the Cam View and the (3) Metrics View.

The Cam View. This view is shown to the user when the right top screen is selected (the media screen), enhancing with a slide effect to the main screen (as Figure 5 shows). The main screen incorporates the same options as in the right top media screen, plus a recording functionality.

The Metrics View. This view includes metric comparing functionalities in time and space – between sites and across different seasonal time sets. The Metric view is enable when the right middle screen is selected, enhancing to the main screen (with a sliding effect) the statistics from the currently selected business site. The main purpose for this view is to generate intelligent information to make decisions.

The Site Map View. This view is the default view when launching the Eagle application. It shows in the main screen an enhanced and more detailed map with the business sites in a particular area. If a particular area is selected in the right lower screen, then that area is enhanced in detail in the main screen.

4.3 Stock Management Systems Synchronization

The MySQL Data Warehouse (DW) retains all updated information about all business sites in a uniform matter. So the data warehouse is synchronized with the databases in the control points following a data synchronization strategy which is outside the scope of this paper.

As it is, the information update is triggered by the client application (Eagle) retrieving daily information from the main data warehouse. Then, if an information updated is needed in the DW, the control points data servers shall be contacted first to request the needed information and then stored in a uniform way in the main MySQL data warehouse server. To display this information, the application clients should access directly the main server.

The main data warehouse keeps track of the last update dates in order to automatically decide when

to request an update from the control points. The time frame between updates is a configurable variable.

Since the control points have a dynamic IP configuration, each client should retrieve the online data servers IP addresses from the Red5 server on which they are all connected.

4.4 VoIP Connection to the Local Phone Network

For the local phone network connection, a partnership with an existing global VoIP service company can be enabled – (example companies like Skype or Voipbuster). An interface component was created to facilitate the Eagle client interface with the partner company system communication protocol.

The Eagle user is able to use the interface as easily as the partner company's original application client.

Any information about the user logins and passwords relating the VoIP service is hidden from the user in the Eagle application. Such configurations should only be made on an administrator level.

5 PRINCIPLES FOR BI TOOLS

“Everyone spoke of an information overload, but what there was in fact was a non-information overload.”

Richard Saul Wurman, *What-If, Could-Be* (Philadelphia, 1976), quoted by E. Tufte.

Following the inspiration of Tufte's principles (Tufte, 2006), and after the design of the Eagle system, we reflected upon the approach and gathered a set of principles that should help guide the design of new BI tools.

Maximize the data-clicks ratio. Also maximize the data-pixels ratio, within reason. Current BI tools suffer from usability problems since the number of mouse-clicks required to achieve a desired visualization is too large. Thus tools should be designed in an essential way that doesn't penalize the user for exploring or visualizing the maximum amount of data as possible.

Erase non-enterprise data user interface components. All the information needed to accomplish the business decision and control tasks should be available in a WYGIWYN manner (What You Get Is What You Need). As one can see through the screenshot of Figure 5, only the relevant interface

elements are shown, e.g. the controls for configuration of the control points' network like phone numbers, metrics from the company's scorecard, database parameters, all of these are hidden from the business executive user. Of course the system is fully customizable and adaptable to any small-to-medium organization, but the details for that customization only appear in the relevant screens.

Integrate enterprise data from several sources and from several media. Tufte's principle for the display of quantitative data, which preaches the integration of evidence from multiple sources, of multiple nature (e.g. tables, diagrams integrated with images, etc.) should also be applied to the design of interfaces for visualization of business information, like modern BI tools. One way to achieve this is proposed in the Eagle system: information about the most browsed (the most visualized) products in the interactive shop window is sent to the tool, and the business executive can see a sparkline or table about the products which were most seen by shoppers. This doesn't have to be implemented in a sophisticated large interactive shop window. A simple touch-screen or conventional LCD (with a mouse attached) placed inside the store can invite potential clients and gather important marketing information.

Show multivariate, multimedia data. This principle is also based on Tufte's. BI tools should combine live video/audio streams from the relevant business sites with charts, tables and maps of the company or organization at stake. Providing the user with a full, high-quality picture of the business is essential to increase the level of acceptance of BI tools.

In the Eagle system, financial information like net sales, gross profit or the top 5 products is shown alongside with live images of the selected stores. Geographical information is also shown in the map view. The aim is not only to integrate information from various sources, but also *to show* the integrated data, whether it's a video stream, a table of numeric data, or a set of sparkline graphics.

Provide cross-media ways to control the enterprise at stake. Knowledge is useless without a means of action according to the knowledge. Eagle's button for calling up someone through the local phone network allows the user not only to control the business but also to act (e.g. ask why there's so many clients observing a product, ask to change the location of a given product or set of products). BI

tools should be designed not only to show business information but also to provide means of action.

6 CONCLUSIONS

In this paper, we have shown some design and programming details about a new tool called Eagle. We also presented some design ideas that we applied in the design of this system. Our research goal is not to create a sound theory, but instead to provide a proof-of-concept tool that illustrates some useful ideas aimed at BI tools' development. Industrial designers need practical guidance, not canned solutions: providing them with adequate design ideas and examples is therefore an important research objective.

The implementation of the tool is in touch with the definition of a BI tool, since it is easily coupled with a web-based interface that is currently being extended to support data-mining issues, balanced scorecards and similar tools. A thorough evaluation of Eagle is being planned, using collaborative usability inspections (Constantine and Lockwood, 1999) as well as formal, quantitative methods. This will probably shed more light into how business managers actually use a tool like Eagle.

One of the limitations of our approach is that it was designed specifically for small-to-medium enterprises. However, this class of companies constitutes the vast majority of Portugal's business organizations, and some of the principles we advocate here are essentially general design principles. Future work could include a study on the scalability of our tool and design ideas.

Future work also includes gathering information from interactive shop windows into the Eagle application. This could allow the visualization and comparison of net sales data with the most browsed products. Another interesting line of research is related to empirical studies of this kind of BI tools. With the predictable increase in the dissemination and usage of this class of systems, effort should be devoted to usability studies that could shed light into how they are actually used, and that could bring new insight into the development of modern BI tools.

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