User Adaptive Web Engine:

A Marketing Application in E-Commerce

by

Shirley S. Fung

S.B., C.S. M.I.T., 2007

Submitted to the Department of Electrical Engineering and Computer Science

in Partial Fulfillment of the Requirements for the Degree of

Master of Engineering in Electrical Engineering and Computer Science

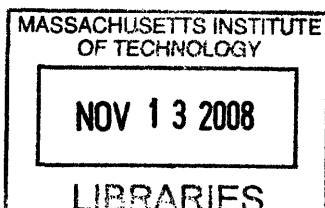at the Massachusetts Institute of Technology

May 23, 2008

Author_____
Department of Electrical Engineering and Computer Science
May 17, 2007

Certified by_____
Professor Glen Urban
David Austin Professor of Marketing
Chairman, Center for Digital Business at MIT
Thesis Supervisor

Accepted by_____
Arthur C. Smith
Professor of Electrical Engineering
Chairman, Department Committee on Graduate Theses

User Adaptive Web Engine:

A Marketing Application in E-Commerce

by
Shirley S. Fung
S.B., C.S. M.I.T., 2007

Submitted to the
Department of Electrical Engineering and Computer Science

May 23, 2008

In Partial Fulfillment of the Requirements for the Degree of
Master of Engineering in Electrical Engineering and Computer Science

ABSTRACT

In order to improve the effectiveness of communications in marketing, companies must now find ways to target their marketing campaigns to the right people, and present content in a way that the end user is most comfortable with. Contrary to classical market segmentation, the user adaptive Web engine in this paper segments users based on cognitive and cultural dimensions. To build a Web site that changes based on what the user has clicked on, the system must be capable of figuring out what version to serve, and be able to morph between different versions of the Web site. The engine to achieve this goal has two main components: the presentation engine, and the math engine. I am responsible for building the presentation engine, and to ensure that it interfaces well with the math engine. First, I designed the entire system to make sure that it follows the main principle of software engineering—modularity. Then, I implemented the presentation engine. As part of the research group, I helped create working prototypes for two industry partners. Lastly, 501 participants in a study conducted in Japan evaluated the prototype Web site. Results showed significant positive effects of morphing in terms of user experience, and probability of purchase.

This research has made contributions to how morphing Web sites should be built. The highlight of the system design is the novel rules component that allows non-technical users to update the behavior of the Web site.

Thesis Supervisor: Glen L. Urban
Title: David Austin Professor of Marketing

Acknowledgements

I thank...

Professor Urban for being a wonderful advisor and mentor, teaching me skills that I will continue to use throughout my career and my life.

British Telecom, Suruga Bank, and General Motors for making the project financially possible.

Shelley Lau, for having the vision of a building an enterprise-grade system and for guiding me to create a well-designed Web engine.

Clarence Lee, Jimmy Li, Ele Ocholi, and Kevin Wang for being so fun work with and for their great contributions to the success of the morphing project.

Yoshio Tokoro for being the ultimate colleague from Japan, in creating the wonderful content used for the Suruga Bank Web site.

Cinda Amyx, Antonio Lorenzon, and Fabio Colacchio for their marketing research in making the British Telecom Web site.

To my "family", I thank...

mom, dad, and sister for their unconditional love and support.

Andrew for his love, for his patience, for his ways to keep me sane all these years.

My two cute furry kitties for being so loving throughout my MIT years.

Contents

List of Figures

CHAPTER 1

INTRODUCTION

The Internet has become one of the dominate forms of communication for the modern society. Companies are exploring ways to improve the efficiency of delivering marketing messages online. Better Web sites and advertisements can in turn increase customer satisfaction and generate more sales. I propose to design, build, and test a user adaptive Web engine that can achieve this goal. The user adaptive Web engine is designed to allow companies to track user activities on a Web site, make inferences about the characteristics of an individual consumer, and create Web pages that match the characteristics of the user. Moreover, the Web engine can learn from all the users visiting the Web site over time to determine which of the strategies performs best. In this paper, the model of changing the Web site dynamically to tailor to different users is termed "*morphing*". The different versions of the Web pages are called "*morphs*".

In the field of Internet marketing, researchers are working to develop new strategies to increase sales for businesses. When making a Web site for the global audience, the marketing team for a company should be aware that visitors to the Web site have a large spectrum of varying preferences and needs. This becomes an important issue when visitors leave a Web site because they were frustrated, or because they did not like the way how

content was presented to them. For instance, a tech savvy visitor looking to purchase broadband services would like to see more technical details about the quality of the service; whereas a visitor who may not have as much technical expertise may only wish to see the qualitative difference between each broadband plan. As a result, visitors may leave because of poor user experience, leading to the loss of potential sales.

A way to tailor the Web site content presentation to various kinds of users is to employ a user adaptive system (Hauser, Urban, & Liberali, 2008). The system would provide a solution where the Web engine can intelligently adapt to different user profiles. Using information about what the user has clicked on, the system can infer the user profile using artificial intelligence machine learning methods. Given the best guess on the user profile, the Web engine can tailor the content presentation, where Web pages would *"morph"* to adapt to different user styles. By using this system, a better suited Web site can be delivered without annoying questionnaires. User adaptive interfaces can improve customer experience on a Web site and can help accrue higher sales.

1.1 OBJECTIVES AND GOALS: ENGINE DESIGN AND FUNCTIONAL REQUIREMENTS

The desired morphing Web engine must have the following components:

- Web page content generation and management
- Interface with Artificial Intelligence (AI) component

In order to dynamically tailor a Web site to the user, the user adaptive Web engine must be able to generate Web pages on the fly based on each click. The system must also be flexible and scalable. I implemented a content generation component so that the engine can dynamically generate Web pages based on a set of rules defined in an external rules component.

The AI component requires information about (1) clicks, and also (2) the characteristics of the clicks. To collect user data, a clickstream (time-series database of click information) tracker is integrated with the Web engine. Clickstreams in conjunction with the respective weights are then provided to the math engine to find out which morph the engine should serve next. Bayesian statistics were used to calculate the group that a consumer most likely falls into. The system uses the Gittins' Index to collects information about the probability of purchase over time over many users to optimize for the best morph to serve to the user.

1.2 DESIGN IMPLICATIONS

The Web engine system is designed with the principle of modularity, and as a consequence, the system is extensible, scalable, reusability, and flexible.

In the usual business setting, the development of this Web engine would generally involve content writers, Web designers, and Web programmers. All these players, both technical and non-technical, should be able to collaborate and contribute to the design of the final Web application using the architecture. Having a system composed of different modules, the architecture would preserve the separation of concerns between different roles on the project. Modularity enables the system to be an open-system architecture, where each

component can be swapped with other application-specific modules. The ability to swap components for different business applications makes the system extensible. Finally, the system will need to be scalable to accommodate for larger and more complex Web applications. By following software engineering principles, the result from the design process of this system will be a Web engine suitable for many kinds of applications with varying complexity.

1.3 STEPS AND CONTRIBUTIONS TO THE MORPHING PROJECT

The user adaptive Web engine project is a team effort, led by Professor Glen Urban, with the following members and roles:

- Antonio Lorenzon, Fabio Colacchio, Cinda Amyx, Yoshio Tokoro, marketing research assistants, created morphing Web site content for the prototypes.
- Shelley Lau and Shirley Fung, research assistants, worked together to propose a design for the system
- Shirley Fung implemented the barebone system design and infrastructure of the user adaptive Web engine.
- Clarence Lee, a technical research assistant created the Artificial Intelligence engine.
- Jimmy Li and Clarence Lee, Shirley Fung, technical research assistants, worked to populate content of the prototypes.

Here are the specific steps I have taken to achieve the goals of the project:

1. Working closely with Shelley Lau, we proposed a system design of the user adaptive Web engine.

2. I implemented a working prototype as a proof of concept of the user adaptive Web engine.

3. I worked closely with industry partners to create a repository of content for the Web pages.

4. I implemented the content generation and management system. Clarence Lee, another technical research assistant was responsible for implementing the AI component within the user adaptive Web engine.

5. The morphing engine team built a working prototype for British Telecom for broadband plans as a proof of concept.

6. The morphing engine team built another prototype for Suruga Bank for card loans to test the system design, and determine the effectiveness of the system as a marketing tool in a field study. The study was conducted in Tokyo with 501 people through a survey and a Web site experience. The results from the study showed that morphing increases customer satisfaction.

Chapter 2 will provide the background information about targeted marketing and morphing. Also, I will discuss the old system (a previous morphing project) and its short comings, presenting the motivation for the new user adaptive Web engine.

Chapter 3 will give an overview of the final system design, and enumerate design decisions.

Chapter 4 will go into details about the architecture and implementation of the system. The details will include information and control flows of the system, and also code samples of the rules language.

Chapter 5 will describe the methods and procedures taken to evaluate the Web site. Methods included panel studies and surveys. I will also present preliminary results from the priming study.

Chapter 6 will discuss in depth what the current system design challenges are. In addition, I will mention some current work done by Jimmy Li and Kevin Wang on a variation of the morphing engine. Finally, I'll propose some motivating examples of future work.

Chapter 7 will summarize the contributions of the research for in both the engineering community, and also the marketing community.

CHAPTER 2

BACKGROUND

2.1 MARKETING TRENDS ON THE INTERNET

Communications on the Internet have evolved from simple Web pages to elaborate Web sites about products and services. We often use the Internet to search for information when we are looking to buy a car, or search for advice on mortgages. When Internet is so rich with information, the ability to deliver the message effectively through the medium is key to making the right connection with the consumer. If a consumer finds information presented exactly the way the consumer wanted, or if a consumer finds the information that resonates with them, the consumer will be more likely to buy a product or service.

With the ability to track users as they visit a Web site, companies now have information to be able to take a guess at what the user is like, and change the format of the Web site content to adapt to the user, or push an advertisement that would most likely influence the consumer. Sources of information about the user can range from the geographic data associated with an IP address, to the history of search terms. Advertisers have coined the

term, "E-Customization"[1] for advertising campaigns that changes from visitor to visitor

based on the individual visitor's behavior on the Web site.

2.2 "MORPHING" ON COGNITIVE AND CULTURAL STYLES

Leading companies such as DoubleClick, Amazon, MySpace and Facebook, began recently to

use the behavioral data to guess what the consumers are interested in, and also use the

data to create market segments to better focus their marketing campaigns. For instance, a

company may need different marketing strategies for a 17-year old, male, adventure

seeking, skateboarder, and a 29-year old woman who recently gave birth to her first

daughter. The strategy to separate groups of consumers by demographics is classical

market segmentation.

Instead of using classical market segmentation, the user adaptive Web engine segments by

the *cognitive and cultural styles* of a consumer, which can shape how companies should

communicate with consumers, and how consumers make purchasing decisions. The

morphing engine uses this new kind of market segmentation, and dynamically changes the

Web site to tailor the content to different kinds of consumers.

In this study, cognitive and cultural styles were chosen to characterize how users process

information and make purchasing decisions. User dimensions include the following:

---

[1] Refer to Asim Ansari and Carl Mela's December 2000 paper titled "E-Customization" about ways to leverage the Internet to customize marketing messages at the individual level.

- Cognitive dimensions:
  - Reading versus Listening
  - Analytic versus Holistic
  - Deliberative versus Impulsive

- Cultural dimensions

  - Individualistic versus Collectivistic[2]

  - Hierarchical versus Egalitarian[3]

  - Emotional versus Neutral[4]

These dimensions are extracted by Antonio Lorenzon from psychology and sociology literature on the role of national culture in international marketing, and are used as the basis for categorizing users into various groups.

2.3 PREVIOUS SYSTEM DESIGN CONCERNS FOR USER ADAPTIVE WEB SITES

Creating a User Adaptive Web site requires extensive work on creating a large library of content. In addition, the Web site must be able to make decisions on how the Web site should look like for different users.

2.3.1 SHORTCOMINGS OF AN OLDER SYSTEM FROM A PREVIOUS MORPHING PROJECT

A previous morphing project at the Center for Digital Business had a closed architecture where a single programmer developed the entire application-specific Web engine. The result of the older system was hard to reuse, and lacked modularity. When the marketing researchers need to change the content and behavior of the Web site, the new modifications are always relayed to the programmer to make changes. Often, the

---

[2] Adapted from the Geert Hofsted Framework
[3] Adapted from the Shalom H. Schwartz' Framework
[4] Adapted from the Shalom H. Schwartz' Framework

modifications prolonged the production cycle. Moreover, when a new application was needed, the programmer would have to start from scratch again because the code could not be reused easily due to the lack of well defined interfaces within the system. As the Web applications become larger, the new system will need to streamline the work within a multidisciplinary team, where even non-technical users can edit the content, or change the behavior or the Web site without having to ask the programmer to do so. The new architecture design aims to solve these problems by following modern software engineering principles.

For n binary dimensions, 2^n versions (morphs) were needed to cover all the possible combinations. An older morphing system built for British Telecom worked with three binary cognitive dimensions, and had 8 different versions of every single Web page in the site. The Web pages morphed according to three dimensions: (1) impulsive vs. deliberative, (2) visual vs. verbal, and (3) analytic vs. holistic.

This old system design has the following issues:

- **Scalability:** The total number of morphs of a morphing Web site is 2^n, where n is the number of binary user dimensions. The number of morphs explodes exponentially as n increases. In the old system, each morph is a set of static HTML pages. Each time a dimension is added, the number of morphs required doubles. Businesses already have limited resources to create and maintain one version of a Web site, let alone an exponential number of pages per dimension. The new engine must avoid the problem of having to create 2^n individual sets of pages for each

morph. If the dimensions become more than just binary variables, the growth of morphs would be even larger.

- **Flexibility:** If business rules change, the Web site may need to morph differently for a dimension. For instance, if I would like to change the tone of voice used in pages designed for impulsive users, I would have to change 4 out of the 8 pages that carried the impulsive dimension, modifying each of the Web pages individually. The process of updating the morphs can be very inefficient.

- **Extensibility:** The closed-architecture system was built specifically for British Telecom, with hard coded rules built into how the pages should change for each individual user. If a similar system were to be built for a different domain, or for a different company, it would be difficult to reuse the code due to the lack of well defined modules within the system.

- **Modularity:** The lack of modules not only makes it harder to reuse code from the past, it also makes it harder for multiple team members to work on the system at the same time. In general, a team with various specialties would be responsible for building a Web site. This team probably would include players like: graphic designers, content writers, managers who decide on how the Web site should morph. If the system can be designed to have workable interfaces for various team members, it would decrease the load of having to communicate all changes to the programmer. If the databank of content and rules was externalized modules, modifications to the content and behavior can be done without affecting the rest of the system, or consult the programmer to make changes. Updates can be made to

the system and it would be instantly reflected in the system. Modularity also

provides the benefit that bugs can be tracked down easily to individual components.

2.4 IMPROVEMENTS ON CONTENT GENERATION: MODEL-VIEW-CONTROLLER PARADIGM WITH EXTERNALIZED RULES COMPONENT

In order to facilitate the work done by a team, a modular system is needed so that each

player can work on the system independently. Also, a framework forces the programmer to

separate the main functions of a system. A common framework used is the Model-View-

Controller (MVC) paradigm, where data is stored in the Model, templates are stored in the

View, and the business logic (including the AI component) is stored in the Controller. This

framework is adopted in a popular Web development framework, Ruby on Rails, famed for

its ability to quickly prototype Web sites.

2.5 AI COMPONENT: BAYESIAN STATISTICS FOR INFERENCE

A user visiting the Web site can be categorized into groups. Figuring out which group a user

falls into is a form of a classification problem. In order to infer which group a user falls into,

we use the information on the click and formulate an inference using a naïve Bayes-

inspired probabilistic model. To illustrate the idea, see the following example of the

inference model (this is a simplified description of the system):

1. The user has clicked on a link L, on a Web page

2. Using the naïve Bayes formula, the system calculates the probability that a user

   belongs in a particular group given a click on link L.

3. By finding the group, G, that maximizes this probability (maximum likelihood
    decision rule), the system can infer that the user is likely to fall in group G.

The actual system is more complicated than this example, and is described by Clarence Lee
in his thesis (Lee, 2008).

2.5 AI COMPONENT: GITTINS' INDEX FOR LEARNING

The system uses a simple reward system to optimize for the best Web site to serve by
collecting data on the success of the Web site. For instance, if a Web site were to sell
broadband plans, the metric for measuring the success would be the purchase of a
broadband plan through the Web site. Using a table to store measures of success and
failures, the AI engine can place preferences on which group to assign a user to. However,
the AI engine must make a tradeoff between the desire to provide a Web site that "sells"
(exploitation) versus the opportunity to learn how users react to other versions of the Web
site (exploration). The model used for making this tradeoff is called the Gittins' Index. The
learning mechanism of exploration and exploitation of Web site visitors allows the Web
engine to find the optimal Web site.

CHAPTER 3

OVERVIEW OF SYSTEM DESIGN

The design strategy was to build upon a framework, and create a user adaptive Web engine. Using the Model-View-Controller (MVC) controller paradigm, I chose the CakePHP framework for the project. CakePHP framework follows the MVC model, and allows users to quickly prototype Web applications using PHP and MySQL. The libraries in CakePHP offer a large collection of built-in functions for interfacing between the MVC modules. The framework also allows programmers to build smaller modules within the MVC modules. Strict naming conventions are required for proper functioning of the system, however, the benefits of the framework outweighs this minor inconvenience.

3.1 SOLUTION TO BUSINESS NEEDS AND ENGINEERING CONSIDERATIONS

The final design of the system solves each of the issues posed by the old system designed for British Telecom. The new system uses the Model-View-Controller paradigm, with smaller sub modules within each of the main components of MVC. To solve the issues identified and listed in section 2.3.1, the new system is designed to be scalable, flexible, extensible, and modular. Moreover, the new design has an added benefit: human-readability.

- **Scalability:** The system can be scaled to a more complex user adaptive Web engine that morphs on more dimensions by having a rules engine that can easily be used for a system with an arbitrary number of dimensions.

- **Flexibility:** The new system design is flexible to changes in business rules and content changes. By externalizing the rules that govern the Web site behavior, the rules component can be updated without affecting the rest of the system. Also, by creating a defined interface between the rules engine and the controller, the content designer can change the behavior of the Web site just by manipulating the rules file. The well-defined interface can provide the content designer with a rich library of morphing behaviors. Moreover, the entire process can be done without extending the development cycle.

- **Extensibility:** The new system design is also extensible, so that prototypes in different domains can be built quickly by reusing the modules in the current system.

- **Modularity:** The new system design is modular, and can take advantage of reusability, the ability to preserve the separation of concerns for the various modules, and the ability to isolate bugs and errors quickly.

- **Human Readability:** Lastly, the rules engine is built with XML (Extensible Markup Language), to improve human readability, so that the system can be modified by someone with limited technical background.

CHAPTER 4

ARCHITECTURE AND IMPLEMENTATION

To illustrate how the morphing system works, this chapter describes an overview of the entire system, which includes the content generation and management engine, and the AI engine. However, only the implementation of the content generation and management engine is elaborated in this chapter.

4.1 LOGICAL MODEL OF USER STATE

The model of the user is concerned with the binary values for cognitive and cultural dimensions of user characteristics. At each click, the user adaptive Web site takes the click information and makes an inference about the individual user based on a set of statistical priors and the characteristics of the link. This information is sent to the AI component, and a new user state is calculated. The new user state is then updated in the model. The content generation engine uses the new user state to put together a Web page tailored to the individual user. The logical representation of the user state update routine is shown in Figure 1 The flow control diagram of this updating process is shown in Figure 2.
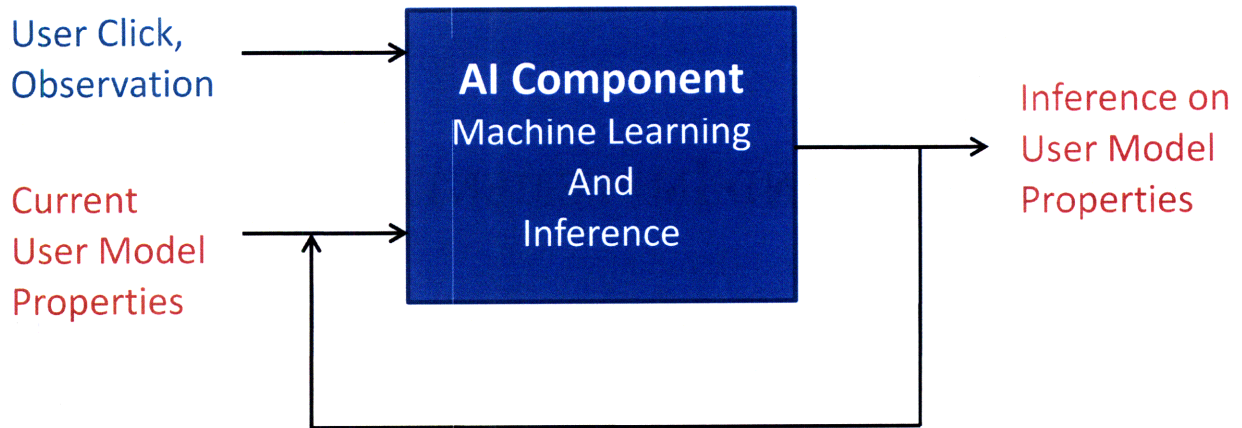
Figure 1 Logical representation of the user state update routine in the user adaptive Web engine
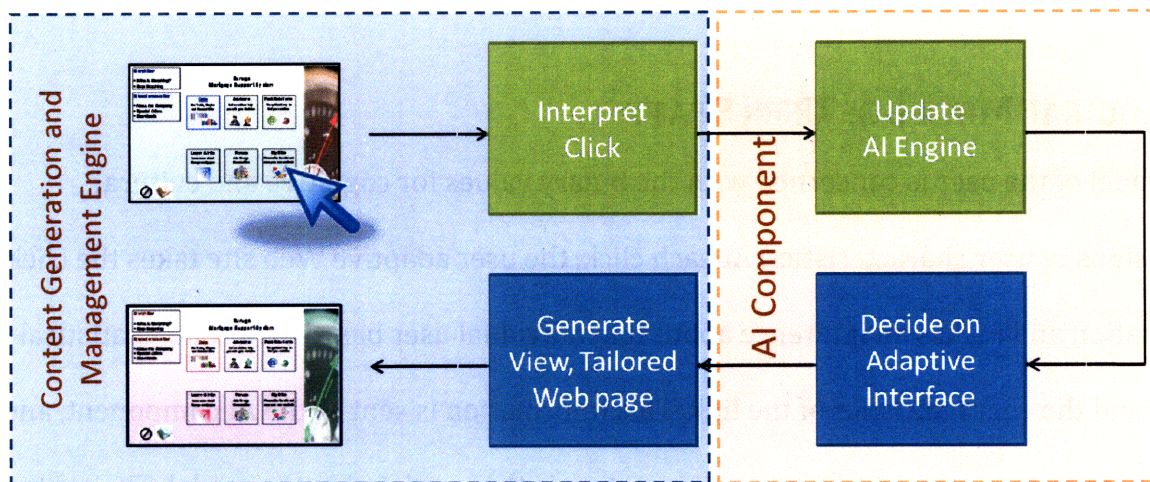
Figure 2 Flow control diagram of the user model updating process

The user state is a vector of binary values for each dimension. This user state is used for both the math engine, and also the rules engine. The math engine uses the current user state and also the past user states to calculate for the new user state. The rules engine uses the current state to determine how the Web page should put together.

4.2 LAYERS

The system has a layered architecture that can separate components of the core engine (infrastructure layer), and components that can be swapped for other application-specific features (application layer). See Figure 3 for the layered architecture diagram. By changing the application layer, the system can be used for a variety of applications.
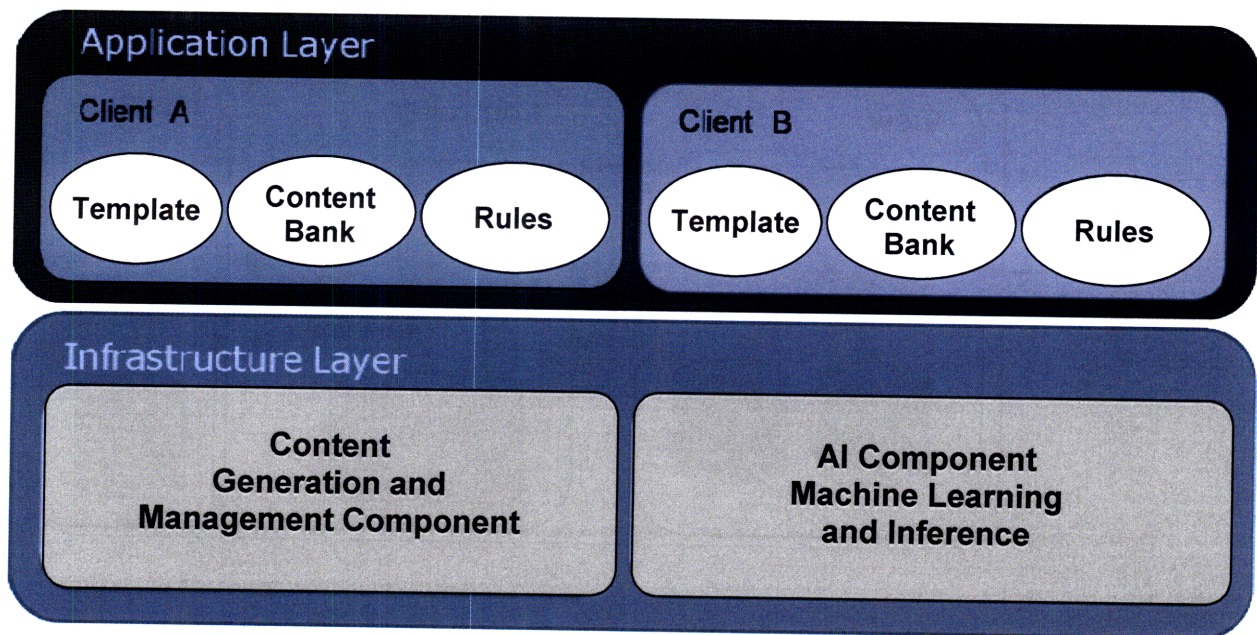
Figure 3 Layered architecture of the user adaptive Web engine

Lying within the infrastructure layer is the AI component that performs the machine learning routines, and also the rules engine that allows for the parameterization of Web site behavior. Components that may change depending on the application are the view templates, content databank, and rules. The view templates are application-specific layouts of the Web pages and Web site tree; the content databank is consisted of all the different versions of the textual passages and images on a Web page; the rules are XML files that defines the parameters of the Web site behavior.

4.3 MODEL-VIEW-CONTROLLER

The modules of the Web engine fits well within the main modules of the Model-View-Controller module. The interaction and sub-modules of the MVC model is illustrated in the system view in Figure 4.
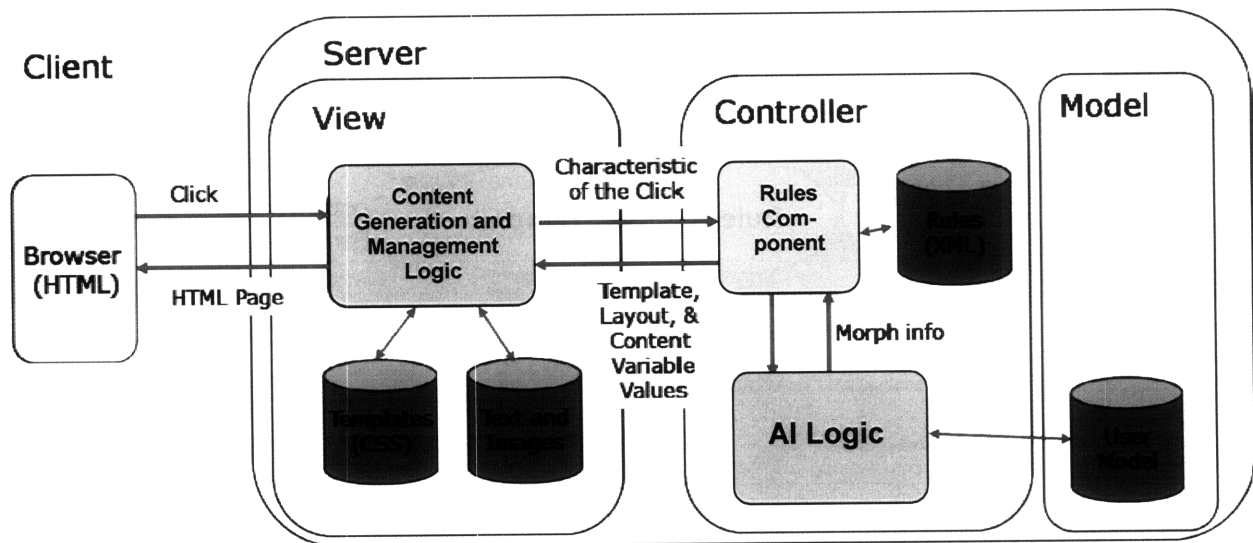
Figure 4 Model-View-Controller (MVC) architecture of the user adaptive Web engine

The Model contains user model, which consists of the user state, click history. The user state stores the current and past states of the user. A click stream model stores a history of all the clicks on the Web site for later data analysis and parameters estimation.

The View contains HTML templates and PHP presentation logic along with a databank of images and text used to generate pages for the Web site.

The Controller contains the business logic that controls each view depending on the current state of the model (rules engine). Also, it contains the business logic that changes the state of the model depending on user clicks (math engine).

4.4 RULES COMPONENT

The rules component resides in the controller and is consisted of two XML files that allows a non-programmer to change parameters in the rules engine. The two XML files controls: (1) display parameters for morphing the look-and-feel, (2) databank filename selectors for morphing images and textual content.

Display parameters can be specified to change the look-and-feel of the Web site for each morph styles and each level of the Web site. For each morph style, parameters can be specified for each level. At each level, a Web page can be broken down to various sections (i.e. top region, left bar, etc.). Each section of a Web page can then carry a list of parameters in the form of a string.

4.1.1 EXAMPLE RULES USED IN THE WEB ENGINE

By way of illustration, see the following tree that specifies parameters for a morph style:

- Morph dimension: *deliberative*
  - o Level 1:
    - Top Area:
      - Display Ticker: **YES**
    - Left Area:
      - Width: **MEDIUM**
    - Center Area:
      - Width: **WIDE**
  - o Level 2:
    - Top Area:
      - Display Ticker: **YES**
    - Left Area:
      - Show Popup Tips: **YES**
      - Width: **WIDE**
    - Right Area:
      - Show Paper Clip Helper: **YES**
    - Center Area:
      - Width: **NARROW**
      - Display related topics: **YES**
      - Number of choices: **MANY**

The corresponding XML code excerpt would look like the following:

```
<rules>
     <rule dimension="reading">
          <layout level="1">
               <Top>
                    <Display_Ticker>YES</Display_Ticker>
               </Top>
               <Left>
                    <Width>MEDIUM</Width>
               </Left>
               <Center>
                    <Width>WIDE</Width>
               </Center>
          </layout>
          <layout level="2">
               <Top>
                    <Display_Ticker>YES</Display_Ticker>
               </Top>
```

```
                <Left>
                        <Show_Popup_Tips>YES</Show_Popup_Tips>
                        <Width>WIDE</Width>
                </Left>
                <Right>
                        <Show_Paper_Clip_Helper>YES</Show_Paper_Clip_Helper>
                </Right>
                <Center>
                        <Width>NARROW</Width>
                        <Display_Related_Topics>YES</Display_Related_Topics>
                        <Number_Of_Choices>MANY</Number_Of_Choices>
                </Center>
        </layout>
    </rule>
</rules>
```

The PHP code in the presentation engine is equipped to import the XML data and translate it into an associative array. The templates would check for pre-defined vocabulary of behaviors and use that information to dynamically generate Web pages.

The goal of the rules engine is to allow a non-technical user to be able to modify the behavior of the system without requiring the work of a programmer to change the internal code. For the rules engine to work, a set of primitives must be pre-defined in the code. Note that if the desired behavior has not been defined, changing the system to have the desired behavior will require programmers to change the internal controller and view components. However, the non-technical user can modify the rules by changing the parameters to another pre-defined value. Because the Web site is dynamically generated using the rules, changes to the rules are reflected to the Web site immediately.

The databank filename selectors module is the other part of the rules engine that

specializes in controlling how images and textual content should change on a Web site.

When building the Web site, the content designer would specify particular images and text

to morph according to the user morph. First, the content designer will create a set of

different versions of an image or text. Then, the content designer must decide on which one

to display depending on the morph of the user. In general, morphing content is only

conditional to a subset of all the morph dimensions. For instance, a graph may only change

according to the dimension of ANALYTIC versus HOLISTIC. In order to specify this

behavior, the content must follow the following convention in the rules file:

Pseudocode:

Start Rule for <LEVEL> on <PAGE> in <REGION> with <FILE EXTENSION>

    Consider Reading <YES/NO> Analytic <YES/NO> Deliberative <YES/NO> ...

End Rule

An example of the XML code is shown below:

```
<rule level="1" page="home" region="pics" file=".jpg">
        <consider reading="no" analytic="yes" deliberative="no" … />
</rule>
```

After defining the rule, the content designer must follow a filename convention to make

sure that the appropriate file is selected. For dimensions that are not considered (a value of

NO in the rule), "x" is used. For other dimensions that are considered, a "0" or a "1" is used

to represent the binary value of the morph dimension. For a system that has n dimensions, each filename must be n letters long, with possible values of "x", "0" and "1". Depending on the current morph state of the user (binary values for each dimension as a vector), the appropriate string can be created so that the image file or a text file can be selected to be included in the Web page. A file with the name x01x1x.jpg represents a JPEG file to be shown to those with matching binary values for dimensions 2, 3, and 5.

The system allows the content designer to flexibly change the rules for displaying pictures and text on a Web page, without having to change the internal code of the Web site. By changing the rules and creating a set of files with the appropriate naming conventions, a content designer can specify how the image or text changes depending on the morph. An excellent application can be used for banner advertisements. Banner advertisement images can change frequently due to current promotions. A content designer can easily put together a set of images for the banner ad that adapts to different user dimensions, specify the correct rule, and the Web site would immediate reflect the change. Pushing changes to an official corporate Web site can take a few months to a year to get implemented and tested. This system can significantly cut down the time it takes to update various content on a Web site, allowing the Web to quickly change with the fast-paced business world.

4.5 DETERMINING LINK CHARACTERISTICS AND INTERFACING WITH THE AI ENGINE

To calculate the next user state, the AI engine is interested in the information that describes a click. In particular, the information in a click must describe the information

about the choice the user had made subconsciously when the user chose a particular link to click on out of all the other links on a Web page. The content designers must put in links and actions on the Web site that are informative and useful for the inference engine. Content designers must reasonably expect these links to help classify users. For instance, the content designer can create a section called "Tables and Graphs" to attract analytic users. This assumption allows us to infer on the dimensions of the user given a particular click the system has seen.

In order to verify that the assumptions were correct, a panel study was conducted with 6 participants who were asked to rate each link on the Web site by his or her expectation on the page that the link would lead to. Each participant was asked to look at the screenshot of one Web page at a time. For a prototype built for Suruga Bank of Japan, 35 links for a total of 11 Web pages were rated with over a set of 8 questions for each link. See the Appendix for a sample score sheet. One of the questions is: "Do you expect the page pointed by this link to have graphs?" The panelist is then asked to put down a score according to the following rubric:

Rate "3" if:	This link indicated a page with graphs
Rate "2" if:	Probably a page with graphs
Rate "1" if:	Probably a page with no graphs
Rate "0" if:	The link indicated a page with no graphs
Rate "NA" if:	I cannot judge

Each participant is asked to provide a score for all the links on a Web page before moving on to the next question. This ensures that the each link is rated relatively to other links on a page for a particular question. The final scores were checked for panelist agreement for reliability (Rust & Cooil, 1994), by calculating the portion of inter-judge agreement over all questions (proportion on inter-judge agreement = 0.401, with a reliability score of 0.84)[5]. The proportion of agreement is significant for the number of choices given for each question.

The ratings for each link serves as the characteristics of a link. The score for a particular question provides us with the information to make an inference with the user's choice to click on a link. A vector of values (averaged scores from the panel study) are used represent link characteristics. This vector is used as an input to the math engine for classifying users. A database is used to store all the vectors and a unique identifier is used to query for the correct vector.

---

[5] Rust and Cooil suggests that the reliability score for exploratory studies should meet a minimum standard of 0.70. Thanks to Jimmy Li for computing the reliability score.

CHAPTER 5

TESTING AND EVALUATION

After the implementation of the user adaptive Web engine, the system is tested with real

users to determine whether this system can (1) improve user experience, and (2) increase

sales.

5.1 FIXED-MORPHS SITE VISIT STUDY

In order to evaluate the effect of morphing, a priming study was conducted by randomizing

the version of the Web site shown to a user. This study was conducted with a total of 501

people who had finished the entire study. The Web site was built for a Japanese banking

product—card loans—which are similar to American credit cards. The content of the Web

site promotes consumer advocacy, and was created in many different versions for

morphing purposes. The Web site was focused on providing educational and unbiased

information about card loan products offered by various banks in Tokyo. The morphing

Web site content tailors to the following dimensions: (1) Analytic vs. Holistic, (2)

Deliberative vs. Impulsive, (3) Collectivistic vs. Individualistic, and (4) Hierarchical vs.

Egalitarian. With 4 binary dimensions, the Web site has a total of $2^4 = 16$ morphs for 16

user groups. An example user group is: Holistic-Impulsive-Collectivistic-Egalitarian.

The content was designed to have contrasting characteristics for different versions (see the

following table for a list of characteristics with their corresponding user cognitive or

cultural dimension). These differences are meant to suit those with one dimension over another. For instance, a person who is analytic may wish to see more detailed graphs with technical content, whereas, a holistic individual may wish to see less graphs and more general content.

Characteristic	Represents...	Opposite Characteristic	Represents...
Many graphs	Analytic	Few graphs	Holistic
More detailed, technical content	Analytic	More general, non-technical content	Holistic
More textual content	Deliberative	Less textual content	Impulsive
More options and alternatives available	Deliberative	Less options and alternatives available	Impulsive
More content regarding popular trends	Collectivistic	Less content regarding popular trends	Individualistic
More content directly addressed to you	Individualistic	Less content directly addressed to you	Collectivistic
More formal language	Hierarchical	More informal language	Egalitarian
More hierarchical images	Hierarchical	Less hierarchical images	Egalitarian

Key Web pages for consumer advocacy provides card loan advisors, payment and interest calculators for card loans, and data tables with analyses over a majority of card loans. Other Web pages include community forums, quick solutions for the impulsive type, and a learning center that educates the consumer about card loans and other general banking topics. Each of the key sections are meant to target different kinds of users, so that when a

user makes a choice to click to view a particular area of the Web site, we can use that information to make an inference on the user dimensions.

Figure 5 Six main sections designed for the Card loans Web site: (from left to right, and top to bottom) Data, Advisors, Fast Solutions, Learning Center, Community Forums, Your Web site; a pop up is shown when the user mouse over any of the 6 options
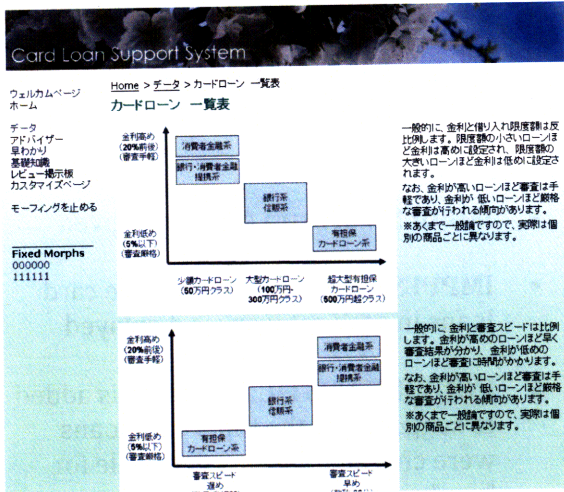

5.1.1 SCREENSHOTS FROM MORPHING WEB SITE USED IN FIXED-MORPHS STUDY
To illustrate the changes in the Web site, the following are screenshots from the Web site used in the study. One of the sections that has many morphs is the card loans data and tables section. The data section is designed to display information about card loans, such as interest rates, and borrowing limits. An overview of card loans in the market is shown to the user, and by clicking a link, the user will see a table of data for card loans. Two rules (one for the data overview content, and the other for the data tables content) were defined using the content rules component, so that

the appropriate HTML content file is included conditioned on the current user model. The captions on the right hand side of each image points out the key characteristics of the content designed for a particular user group.

Data (overview)

Data (tables)

Designed for: ANALYTIC-DELIBERATIVE-HIERARCHICAL-INDIVIDUALISTIC

- **ANALYTIC**: Overview of the card loan data is broken down into pieces of smaller graphs, displayed separately

- **ANALYTIC**: Table has more columns, displaying more details about card loans

- **DELIBERATIVE**: Extra text is given as a caption to each of the graphs for those who wish to take the time to understand each graph through supplementary text

- **DELIBERATIVE**: All the different card loan options are displayed for those who wish to evaluate all options before making a buying decision

Data (overview)

Data (tables)

Designed for:
ANALYTIC-IMPULSIVE-HIERARCHICAL-INDIVIDUALISTIC

- **ANALYTIC**: Overview of the card loan data is broken down into pieces of smaller graphs, displayed separately

- **ANALYTIC**: Table has more columns, displaying more details about card loans

- **IMPULSIVE**: Extra text is not given

- **IMPULSIVE**: Only the top three card loans in each category is displayed

- **INDIVIDUALISTIC**: Language is added to suggest that the top 3 card loans were chosen to be most suitable for *"you"*.

Data (overview)

Morph Designed For:
HOLISTIC DELIBERATIVE HIERARCHICAL INDIVIDUALISTIC x1000x

Data (tables)

Morph Designed For:
HOLISTIC DELIBERATIVE HIERARCHICAL INDIVIDUALISTIC x1000x

Designed for: HOLISTIC-DELIBERATIVE-HIERARCHICAL-INDIVIDUALISTIC

- **HOLISTIC**: Overview of the card loan data is displayed as a single graph

- **HOLISTIC**: Table has less columns, displaying less details about card loans

- **DELIBERATIVE**: Extra text is given as a caption to each of the graphs for those who wish to take the time to understand each graph through supplementary text

- **DELIBERATIVE**: All the different card loan options are displayed for those who wish to evaluate all options before making a buying decision

Data (overview)

Morph Designed For:
HOLISTIC IMPULSIVE EGALITARIAN COLLECTIVISTIC x1111x

Data (tables)

Morph Designed For:
HOLISTIC IMPULSIVE EGALITARIAN COLLECTIVISTIC x1111x

Designed for:
HOLISTIC-IMPULSIVE-EGALITARIAN-COLLECTIVISTIC

- **HOLISTIC**: Overview of the card loan data is displayed as a single graph

- **HOLISTIC**: Table has less columns, displaying less details about card loans

- **IMPULSIVE**: Extra text is not given

- **IMPULSIVE**: Only the top three card loans in each category is displayed

- **COLLECTIVISTIC**: Language is added to suggest that the top 3 card loans were the most popular card loans (to indicate community trends).

For the fixed-morphs study, the Web site does not dynamically morph on each click. Instead, each user is presented with a randomized version of the Web site, and the before-and-after effect is measured. There are 16 user groups, specified by all the possible combinations of the 4 binary cognitive and cultural dimensions. The priming fixed-morphs

study aimed to: (1) estimate parameters for the math engine, (2) collect data for the factor analysis on user groups, and (3) measure the effectiveness of morphing[6]. The hypothesis is that by tailoring the Web site to the user, the user would be more likely to purchase a product. To measure that effect, participants of the study are asked to give an evaluation of the Web site. Also, the study measures the changes in preferences and consideration for card loans before-and-after the site visit were used as metrics to determine how well morphing has worked[7].

5.2 SURVEY AND MEASUREMENTS

A screening survey serves to exclude those who are not in the market for a card loan and do not live in the greater region of Tokyo. The screening questions also filtered those who did not meet the age requirement, and those who were not in the market for Card loans. Then, a series of questions (in the pre-site visit survey) were asked to measure the participants' preferences of card loan providers.

After the pre-site visit survey, each user is given the opportunity to explore the Web site. The Web engine uses the rules engine and content generation engine to serve up any one of the 16 versions of the Web site for each participant. For reliability, the participant is

---

[6] The study was also conducted to measure the effect of advocacy, but the subject is beyond the scope of the paper. Screenshots of the Web site used and results on the effect of consumer advocacy can be found in Yoshio Tokoro's thesis, "Improving Customer Experience through Advocacy and Morphing: A Web Application for Suruga Bank."
[7] A copy of the survey used can be found in Tokoro's thesis.

required to spend a minimum amount of time and performed a minimum number of clicks

to qualify to finish the survey. Those who did not spend enough time or had enough clicks

on the Web site were thrown out of the survey[8].

The post-site visit survey includes a set of questions on card loans preferences and

consideration, similar to the pre-site visit survey. In addition, the post-site visit survey with

general questions on the participant's impression and thoughts on the Web site content

and usability.

The survey also asks the participant a series of questions to determine which of the 16

groups did the participant fall into[9]. By knowing the classification, one can measure the

effectiveness of the morphing Web site by looking at the effect of matching the morph with

the actual group that the user falls into. The expectation is that the more matches a morph

has (number of dimensions), the user would be more likely to purchase a product.

Data analysis over 501 participants showed that 7 out of the 13 questions (rated on a 5-

point scale with 1=strongly disagree and 5=strongly agree) for Web site evaluation had

positive correlation between the number of dimensions matched and the score Web site

---

[8] To ensure that the participant has spent enough time on the Web site, a counter for the number of clicks made, and a counter for time spent on the Web site was used to screen out "insincere" participants. If a user spent less than 60 seconds on the Web site, participants were rejected from the survey. If a user spent between 60 seconds to 150 seconds on the Web site with no less than 10 clicks made, the Web site would warn the user of not spending enough time, and redirects the user back to the Web site to continue browsing. If a user spent more than 150 seconds on the Web site, the user is directed to the next section of the survey.
[9] Refer to Tokoro 2008 for the exact list of questions used.

satisfaction at the 95% significance level (Tokoro, 2008). On average over all 13 questions, ratings had a positive correlation of 0.11 with a p-value of 0.013. The data analysis on the site evaluation questions are shown in the following table, questions with a statistically significant positive correlation is highlighted in red text:

Site Evaluation Questions	Number of Dimensions Matched					Correlation	p-value	Judge
	0	1	2	3	4			
The site is easy to use.	3.25	3.39	3.58	3.55	3.89	0.11	0.012	<5%
The site provide accurate and relevant info.	3.57	3.40	3.62	3.60	3.70	0.08	0.081	
The site provide me with sufficient info to make a decision on all card loans being offered.	3.18	3.26	3.52	3.57	3.70	0.14	0.001	<1%
The site has useful support tools (such as a calculator or planner.)	3.54	3.74	3.81	3.82	4.07	0.09	0.040	<5%
Card loan offerings can easily be compared.	3.50	3.50	3.72	3.65	3.85	0.09	0.057	
The site is helpful to me in reaching my acquisition decisions.	3.57	3.56	3.85	3.75	4.07	0.11	0.015	<5%
I enjoy the overall experience of the site.	3.43	3.38	3.57	3.50	3.97	0.09	0.046	<5%
This site appears to be more trustworthy than other sites I have ever visited.	3.11	3.21	3.42	3.39	3.74	0.13	0.004	<1%
I would acquire a card loan at this site.	2.93	2.64	2.89	2.73	2.81	0.01	0.801	
I would recommend this site to a friend.	2.89	2.73	2.96	2.97	2.96	0.06	0.207	
I would book mark this site.	2.71	2.75	2.87	2.90	3.04	0.07	0.134	
The content was written in a way that I found very appealing.	3.29	3.29	3.36	3.45	3.44	0.06	0.184	

The info and content was presented in a way that I am most comfortable with.	3.29	3.34	3.51	3.49	3.81	0.10	0.032	<5%
Total Average Point	3.25	3.25	3.44	3.41	3.62	0.11	0.013	<5%

The questions with a positive correlation indicated that users who had seen the Web site that best fit their dimensions would find the Web site:

- more helpful,

- more trustworthy, and

- presents content in a way that they are most comfortable with.

A linear correlation between the number of dimensions matched with the average score (5-point scale) showed that an increase in one match in dimensions equates to an increase of 0.088 points on the site satisfaction score.

To test whether morphing has increased the participants' probability of purchasing a card loan product, other measures extracted from the survey to measure changes in consideration for a particular card loan provider. The survey asks the participant to choose up to 5 card loan providers that he or she would consider. Then, the participant is asked to rank the providers by allocating 100 chips for each provider. The probability of purchase for a card loan provider is the ratio of chips allocated out of the total number of chips given (the number of chips allocated out of 100 chips represents the probability of purchase). If morphing is effective, then the probability of purchase would increase as the number of

dimensions matched increases. This is an important measure because the increase in probability of purchase can lead to an increase in sales.

Linear regression between the number of dimensions matched versus the probability purchase showed that for every additional dimension matched, there is an increase of 0.2 to 1.2 percentage increase in the probability of purchase. Logit regression analysis (Lee, 2008) revealed that a higher probability of purchase is observed when:

- Collectivistic viewed morphs with less textual information
- Holistic users viewed morphs with less textual information
- Hierarchical users viewed morphs with less content

The effect of morphing was found to be strongest for Web site evaluation. Users had a more positive experience when the number of dimensions matched increased. Though it was not clear whether morphing significantly increased the probability of purchase, the data suggests that there is a positive relationship with the number of dimensions matched with the probability of purchase.

I can reasonably expect that better user experience and increased user satisfaction can increase the usage of a fee-based Web application. For instance, if a user is more satisfied with a Web site that allows you to learn more about taxes and file taxes online, a company can generate more revenue from the increased usage of the product. A better Web site experience can prevent users from leaving the Web site due to user frustration, and also keep users coming back to the Web site in the future.

CHAPTER 6

DISCUSSIONS AND CONTRIBUTIONS

With the success of the initial market research panel, the basic engine will be used for future projects. If the system were to be implemented again, one should be aware of the limitations with the rules engine, and the current morphing projects described in this chapter.

6.1 LIMITATIONS OF THE EXTERNAL RULES ENGINE

The look-and-feel rules engine has limitations because it relies heavily on the defined set of presets that the Web site can take on. For instance, the rules can parameterize the color of the Web site depending on user dimensions, but the parameters are restricted to a set of colors that the programmer has coded in the PHP presentation logic. If the programmer only coded to accommodate for values:"pink", "blue", "green", and "yellow" background colors, the content designer cannot change the rules to make the background color "brown" using the rules engine.

Also, the content rules engine has a couple of disadvantages. The filenames are of length n, where n is the number of dimensions the system is designed for. If the system is to be modified to have more or less dimensions, the content designer will have to rename all the files in the databank to reflect the change in codification of the dimensions. Namely, a script would be needed to rename all files to new specifications of the code. This disadvantage is

due to the fact that the rules of the system were embedded in the filenames. On the other

hand, the system has the advantage to scale to a large number of dimensions because the

content designer can turn off dimensions that does not have to consider. Even if a system

has 100 dimensions, a rule can specify how many dimensions the content rules engine

needs to look at, and which other dimensions to disregard. The number of files that are

needed for each rule does not always, and usually does not depend on the number of

dimensions.

6.2 CURRENT WORK ON A VARIATION OF THE ENGINE

Due to the scale of the morphing engine system, companies may be reluctant to invest and

develop a completely new Web site with brand new content and site architecture. Most

large companies employ companies like Digitas to manage their entire Web presence, a

brand new Web site would definitely consume a large amount of resources and would

require a lengthy budget approval process for starting a new Web site project (not to

mention the amount of bureaucracy involved). Other team members and I have discovered

that it may be more feasible to design a morphing engine that is modular enough to work

with an existing Web site and minimize the amount of changes to the current corporate

Web site. Not only the scale of the project is more manageable, it is easier to convince

companies to adopt our solution if the system can be offered as an add-on system.

Jimmy Li and Kevin Wang implemented a beta prototype of this system for General Motors

(Li, 2008). The general architecture allows the morphing of a banner ad instead of the

entire Web site. In order to gather informative user clicks, the existing Web site is changed

slightly to accommodate links to a new, non-morphing Web site. While gathering clicks on the non-morphing Web site, an external math engine can update the user model. The information about the user model can be then used to control the banner ad displayed. Given a particular user, a banner ad can tailor to the user's cognitive and cultural styles. Measures can be put on the Web site to allow the math engine whether the user is likely to purchase a product or not (ex. user clicks on "request an appointment for a test drive at the local car dealership"). The measurement enables the math engine to update statistics on finding the optimal advertisement for each user group. In addition to the cognitive and cultural dimensions, the morphing engine now incorporates a user dimension on how far along the user is in the buying process.

6.3 FUTURE WORK

A second stage field test of real-time morphing system will be conducted in the summer of 2008. Given the results from the fixed-morphs study, the system will be updated with estimated parameters. To take into the account of switching costs (the cost of changing the Web site on the user), the math engine will include logic to calculate tradeoffs on changing the Web site on users. The system is expected to be tested with 1,000 real users in the metropolitan area of Tokyo. With the same pre- and post-site visit, the study would ask participants to experience the dynamic morphing Web site. To determine how well the math engine works in finding the optimal version of the Website, a simulation engine would be built to simulate Web site visits on the Web site. Results from 80,000 simulated user visits would be used to evaluate the math engine.

The current rules engine is meant to be used for content designers who do not have any programming background. The rules files are currently in XML. A potential future project is to implement a user interface that allows users to define rules. This would make the rules system usable to those who are not familiar with XML, and would prevent users from being bogged down by syntax, or small errors in the XML code. In addition, the user interface can verify that the user inputs are correct, ensuring that the XML rules generated are error-free.

6.4 LESSONS LEARNED

When designing a user adaptive Web engine, systems designers should have the following tips in mind:

- Devote a good amount of time on system design
    - o the modularity of the system has paid off in cutting time to make new prototypes and push out version changes
    - o the rules engine has made it simple to change the behavior of the Web site during the development cycle
- Be aware of the time it takes to create morphing content
    - o traditional Web design requires only one version of the content, but a morphing Web site requires significantly more versions
    - o work closely with content designers early on to determine what library of behaviors the system needs to provide to the content designer

6.5 CONTRIBUTIONS

- Identified systems design issues with an existing Web morphing system.

- Designed the system architecture for a user adaptive Web site that tailors Web pages to match user characteristics.

  - Improved the system design of older systems with the newly added benefits of scalability, flexibility, extensibility, and modularity.

- Created rules format for changing the look-and-feel and content of a Web site, to be used by content designers who do not have any programming background.

- Created content generation engine that can create Web pages on the fly according to business rules, allowing rules to cope with the quick changing environment of business and marketing.

- Specified and implemented two working user adaptive Web sites for two industry partners, British Telecom and Suruga Bank of Japan.

- Tested a fixed-morphs system with 501 users from the greater Tokyo region

- Shown statistically significant results of how morphing positively impact user experience of a card loan consumer advocacy Web site.

WORKS CITED

Hauser, J., Urban, G., & Liberali, G. (2008). Website Morphing. *Marketing Science* .

Lee, C. (2008). User Adaptive Web Morphing: An Implementation of a Web-based Bayesian Inference Engine with Gittins' Index. Cambridge, MA, U.S.

Li, J. (2008). Design and Implementation of a User-Adaptive Website with Information Pallettes. Cambridge, MA, U.S.

Rust, R. T., & Cooil, B. (1994). Reliability Measures for Qualitative Data: Theory and Implications. *Journal of Marketing Research* .

Tokoro, Y. (2008). Improving Customer Experience through Advocacy and Morphing: A Web Application for Suruga Bank. Cambridge, MA, U.S.

APPENDIX

Example score sheet used for panelists to rate links:

	Q1 — Do you expect the page pointed by this link to have graphs?	Q2 — Do you expect the page pointed by this link to have detailed, technical content?	Q3 — Do you expect the page pointed by this link to have textual content?	Q4 — Do you expect the page pointed by this link to have options and alternatives available?	Q5 — Do you expect the page pointed by this link to have content regarding popular trends?	Q6 — Do you expect the page pointed by this link to have content directly addressed to you?	Q7 — Do you expect the page pointed by this link to use formal or informal language?	Q8 — Do you expect the page pointed by this link to have hierarchical images?
Rate "3" if:	This link indicated a page with graphs	The link indicated a page with detailed, technical content	The link indicated a page with textual content	The link indicated a page with options and alternatives available	The link indicated a page with content regarding popular trends	The link indicated a page with content directly addressed to you	The link indicated a page that uses formal language	The link indicated a page with hierarchical images
Rate "2" if:	Probably a page with graphs	Probably a page with detailed, technical content	Probably a page with textual content	Probably a page with options and alternatives available	Probably a page with content regarding popular trends	Probably a page with content directly addressed to you	Probably a page that uses formal language	Probably a page with hierarchical images
Rate "1" if:	Probably a page with no graphs	Probably a page with no detailed, technical content	Probably a page with no textual content	Probably a page with no options and alternatives available	Probably a page with no content regarding popular trends	Probably a page with no content directly addressed to you	Probably a page that uses informal language	Probably a page with no hierarchical images
Rate "0" if:	The link indicated a page with no graphs	The link indicated a page with no detailed, technical content	The link indicated a page with no textual content	The link indicated a page with no options and alternatives available	The link indicated a page with no content regarding popular trends	The link indicated a page with no content directly addressed to you	The link indicated a page that uses informal language	The link indicated a page with no hierarchical images
Rate "NA" if:	I cannot judge	I cannot judge	I cannot judge	I cannot judge	I cannot judge	I cannot judge	I cannot judge	I cannot judge
	3 2 1 0 NA	3 2 1 0 NA	3 2 1 0 NA	3 2 1 0 NA	3 2 1 0 NA	3 2 1 0 NA	3 2 1 0 NA	3 2 1 0 NA

#Link
1 Data
2 Advisor
1 Test Solutions
2 Exam & info
1 Forums
2 Your Web Site