Creating a Virtual Information Center for Industrial Design

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Abstract: - The purpose of this study was to propose a layout of an on-line information center for industrial design. Based upon literature review, the major component was revealed. The design information center should be a multimedia database which was designed to support the activities of industrial product designers globally. In this study, user data services were created. The multimedia data types, user interface issues, database construction, and intended audience were discussed. This paper provides a general outline of designing an on-line information center for industrial design. Its aims and objectives, the innovative application of technology, and the underlying network structures were also proposed.

Key-Words: - **O**n-line information center, industrial design

1 Introduction

On-line information is important knowledge source for professional activities. The web based information center plays a core role in our society-enabling broader dissemination of information and services than was previously available. Nonetheless, there is evidence that many sites have inadequate usability and accessibility. Clearly, the ways in which sites are designed can either facilitate or impede users' benefit from the vast resources that are available on the Web.

2 Problem Formulation

Industrial design deals with the planning and development for production of a variety of object and interrelated systems. Consumer appliances, tools, safety equipment, business machines, furniture, medical equipment, architectural products, and transportation devices make up a partial list of those areas of specialization in industrial design[1].

Industrial design falls within a broader category of design, which is the professional area of activity concerned with planning and developing a wide variety of objects and spaces. Relationships among the users of the designed item, the efficient production of the designed item, and the aesthetic characteristics of the designed item are of particular importance. Design activities at Ohio State are divided into three majors: visual communication design, industrial design, and interior design.

2.1 Aims and objectives

The services offered by the system had been designed to allow designers and design-based companies to:

- Interactively access multimedia databases of products, materials and services;
- Integrate data into their own design computing environments;
- Participate in distant work groups and receive online design tools and services;
- Implement projects at a distance.

2.2 Web-based on-line service

It is commonly accepted that the diffusion of the Web as a ubiquitous communication medium has fostered a novel type of applications, whose main focus is on capturing the user's attention by providing facilitated access to information and services. Applications in such domains as digital libraries and social activities are requested to support a form of computer-human interaction based on the exploratory access to information, rather than a predefined dialogue paradigm. As the Web-based on-line service has demonstrated, hyper textual navigation and content-based querying are the favorite access mechanisms for nontechnical users to browse through vast collections of data.

On the Web, information managed by applications changes very rapidly, is stored in many places, and assumes a variety of formats, both structured and unstructured. These issues demand a solid architecture, founded on well-established technologies for data management, in particular on database technology.

Moreover, Web applications must be designed for change, not only of their content, but also of requirements and architectures. Thus, their development needs to be organized into a well-defined process, amenable to the benefits of software engineering, among which automation of repetitive tasks is prominent.

An on-line information services center should allow the integration of white board design tools, enabling designers to work collaboratively in virtual spaces.

Collaborative working environments are required to support wide design projects. In these systems, designers need to share model data and software over Internet for support in the following areas: VR, Engineering, Prototyping, Design, Production preparation, Training and support. Some applications within this cluster of services require higher bandwidth networks to support the larger rates of information transmission that are required to support collaborative design work.

2.3 Development approach

A system development methodology refers to the framework that is used to structure, plan, and control the process of developing an information system. A wide variety of such frameworks have evolved over the years, each with its own recognized strengths and weaknesses.

One system development methodology is not necessarily suitable for use by all projects. Each of the available methodologies is best suited to specific kinds of projects, based on various technical, organizational, project and team considerations.

2.3.1 Waterfall

In this web system developing processes, there are six general steps[2,3]:

1. Initial investigation
2. Requirements definition
3. System design
4. Coding and testing
5. Implementation
6. Operation & support

The framework type is linear. Project is divided into sequential phases, with some overlap and splash back acceptable between phases.

This approach is focusing on planning, time schedules, target dates, budgets and implementation of an entire system at one time. The project control should be tight over the life of the use of extensive written documentation, as well as through formal reviews and approval by the user and information technology management occurring at the end of most phases before beginning the next phase.

This approach is ideal for supporting less experienced project teams and project managers. The orderly sequence of development steps and strict controls for ensuring the adequacy of documentation and design reviews helps ensure the quality, reliability and maintainability of the developed software. The developing is inflexible, slow costly and cumbersome due to significant structure and tight controls. Project progresses forward, with only slight movement backward.

Little room for use of iteration could reduce manageability if applied.

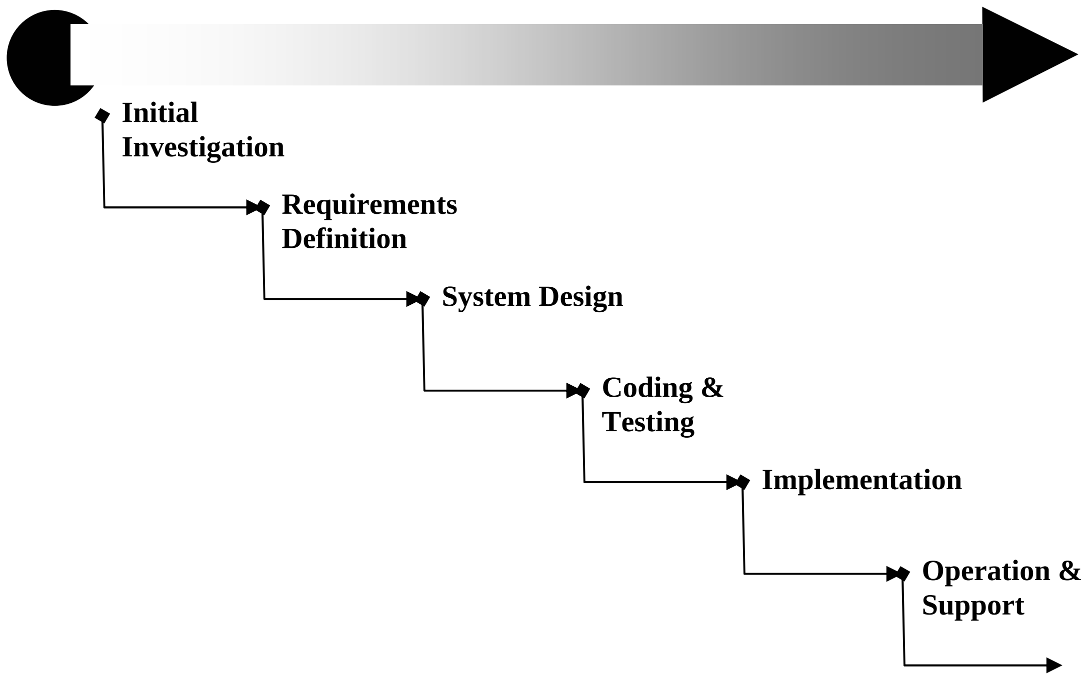

Figure 1 Waterfall approach of system development methodology

This approach is appropriate for following characteristics of project.

1. A mainframe-based or transaction-oriented batch system.
2. Large, expensive, and complicated.
3. Clear objectives and solution.
4. No pressure for immediate implementation.
5. Requirements can be stated unambiguously and comprehensively.
6. Requirements are stable or unchanging during the system development life cycle.
7. User with fully knowledgeable in the business and application.
8. Strict requirement exists for formal approvals at designated milestones.

This approach would not be appropriate for those real-time systems, event-driven systems, and leading-edge application.

2.3.2 Prototyping

Prototyping approach of system development tends to be iterative. In this web system developing processes, there are six general steps[2,3]:

1. Initial Investigation
2. Creating Prototype with sub-procedures of
    a. Requirements Define
    b. System Design
    c. Coding, Testing
3. Implementation
4. Maintenance

Not a standalone, complete development methodology, but rather an approach to handling selected portions of a larger, more traditional development methodology, Incremental, Spiral, or Rapid Application Development (RAD).

This approach addresses the inability of many users to specify their information needs, and the difficulty of systems analysts to understand the user's environment, by providing the user with a tentative system for experimental purposes at the earliest possible time.

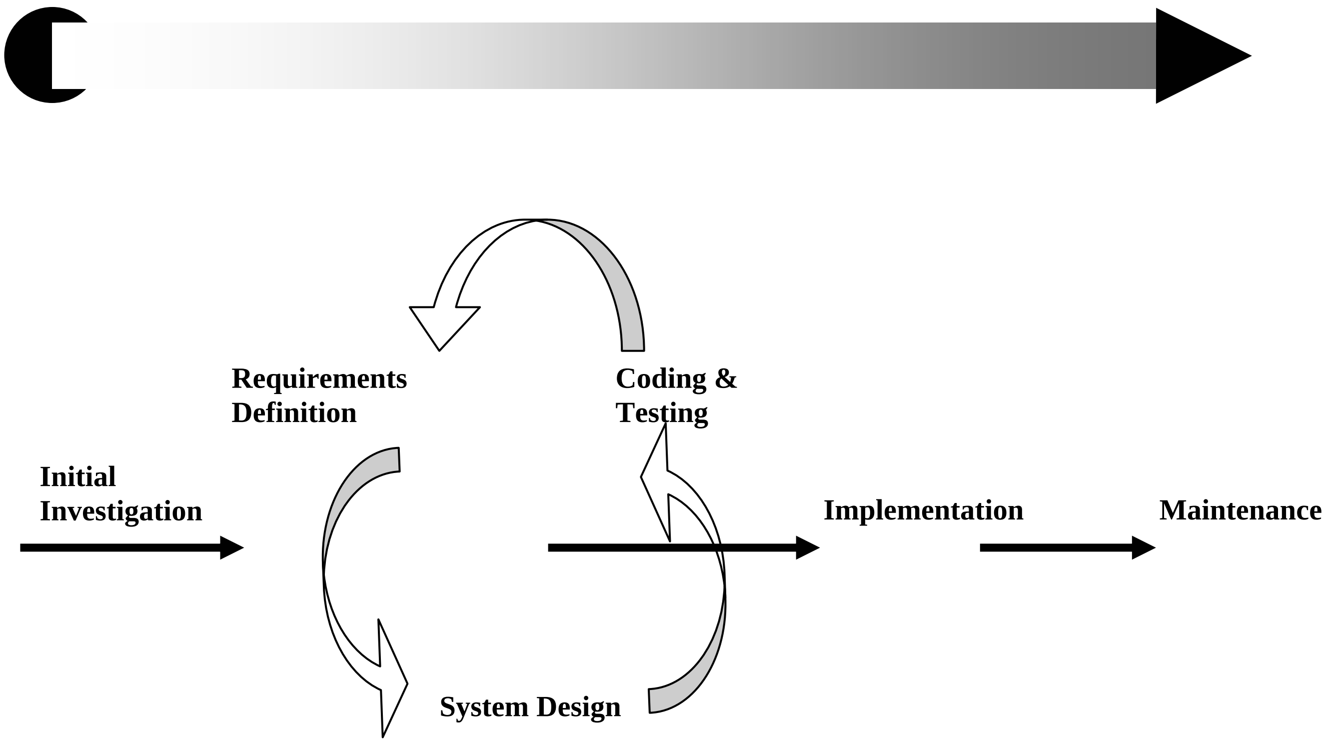

Figure 2 Prototyping approach of system development methodology

By referring to the prototype, communication among users and project stakeholders could be conducted. The communication could be much help for

- resolving unclear objectives;
- developing and validating user requirements
- experimenting with or comparing various design solutions;
- investigating both performance and the human computer interface.

This approach is appropriate for development of an online system requiring extensive user dialog, or for a less well-defined expert and decision support system. It also appropriate for those project objectives are unclear. It is suitful for which the pressure exists for immediate implementation of something. This approach is appropriate for following characteristics of project.

1. Functional requirements may change frequently and significantly.
2. User is not fully knowledgeable.
3. No strict requirement exists for approvals at designated milestones.

2.3.3 Rapid Application Development

This approach is iterative. The key objective is for fast development and delivery of a high quality system at relatively low investment cost. It attempts to reduce inherent project risk by breaking a project into smaller segments and providing more ease-of-change modules during the development process[2,3].

The system aims to produce high quality system quickly primarily through the use of iterative prototyping at any stage of development, active user involvement, and computerized development tools. The key emphasis is on fulfilling the business need, while technological or engineering excellence is of lesser importance.

3 Methodology

The purpose of this study was to design an on-line information center for industrial design. The RAP approach was applied to create the system. Efficiency model was identified for evaluated by using data envelop analysis technique.

The result of the efficiency analysis would be the foundation to re-arrange on-line information center for industrial design.

3.1 Revised RAP

Rapid application development integrates project management techniques, development techniques, users and tools to build quality application systems in a fixed time frame to deliver business value. Rapid development combines much focused teams working in a highly structured environment. Rapid development is a focused process in which the conceptual requirements of the application are fed into construction iterations. The construction iterations occur within a fixed time schedule that regulates the resources that can be expended during the iterations. The iterations ultimately result in the system that is rolled out to the production sites.

More speed and lower cost may lead to lower overall system quality. There is a need to avoid misalignment of developed system with the design business due to missing information. In our revised version, the efficiency evaluation was included for quality improvements.

Key functions were first analyzed for design modules. The system development procedures are:

1. Initial investigation
2. Requirements definition
3. System Module design
4. Coding and testing
5. Efficiency evaluation
6. Module re-arranges
7. Implementation

3.2 Social constructivism

From a constructivist point of view, people actively construct new knowledge as they interact with their environment. This platform should only promote information searching and exchanging but also industrial design knowledge creation.

Constructionism asserts that learning is particularly effective when constructing something for others to experience. This can be anything from a spoken sentence or an internet posting, to more complex artifacts like a painting, a house or a software package.

Social constructivism extends constructivism into social settings, wherein groups construct knowledge for one another, collaboratively creating a small culture of shared artifacts with shared meanings. When one is immersed within a industrial design culture like this, one is learning all the time about how to be a part of that culture, on many levels.

This idea looks deeper into the motivations of individuals within a discussion:

Separate behaviour is when someone tries to remain 'objective' and 'factual', and tends to defend their own ideas using logic to find holes in their opponent's ideas.

Connected behaviour is a more empathic approach that accepts subjectivity, trying to listen and ask questions in an effort to understand the other point of view.

Constructed behaviour is when a person is sensitive to both of these approaches and is able to choose either of them as appropriate to the current situation.

In general, a healthy amount of connected behaviour within a learning community is a very powerful stimulant for learning, not only bringing people closer together but promoting deeper reflection and re-examination of their existing beliefs.

3.3 Efficiency evaluation for further adjustment

The on-line information platform has become a borderless open place for project conducting. The efficiency evaluation of the on-line information plays core role for innovating service. The efficiency measurement would be defined as a term denoting the measurement of the degree of achieving expected goal of the organization bye the management.

$$Efficiency = \frac{Output}{Input} \qquad (1)$$

Requirements Planning	**User Design**	**Rapid Consstruction**	**Transition**
1. Initial investigation **2. Requirements definition**	**3. System Module design**	**4. Coding and testing**	**5. Efficiency evaluation** **6. Module re-arranges** **7. Implementation**

Figure 3 The system development procedures of revised RAP

Equation (1) is often inadequate due to the existence of multiple inputs and outputs related to different resources. Items chosen for evaluating performance include both quantifiable and non-quantifiable indicators. Those chosen indicators may be mutually exclusive, related, or independent of each other[4,5].

For resolving these problems, this study applies a data envelopment analysis technique to measure the efficiency. The DEA technique can be used to determine the efficiency of the on-line information center under group of criteria[6]. The criteria were divided into two groups. The first group is inputs: add, view, revise, delete. The second groups are outputs: assignment, chat, choice, forum, resource, workshop, journal, message, and database. Web based service could be used in multi-functions situation.[7] It was suggested to apply stress evaluation for understand the web efficiency.[8-9]

4 Problem Solution

4.1 Modules for key objective

The services offered by this on-line information center have been designed to allow designers and design-based institutions to:

- Form a social interaction environment with design professional culture
- Provide members with separate behaving space.
- Interactively access multimedia databases of products, materials and service
- Implement projects at a distance
- Participate in distant work groups

There were nine modules joined to provide services of key objective. They were described separately as follows:

1. Project assignment Module
   Project assignment can be specified with a due date and a maximum grade for raising a problem. Students can upload their finished assignments (any file format) to the server – they are date-stamped. Overdue finished assignments are allowed, but the amount of lateness is shown clearly to the teacher. Teacher feedback is appended to the graded assignment page for each student, and notification is mailed out. The teacher can choose to allow resubmission of another finished assignments revised by students after grading (for re-grading).
2. Chat Module
   It would allow smooth, synchronous text interaction between teachers and students who are on-line interacting when facing problems. It includes profile pictures in the chat window and supports URLs, smiles, embedded HTML, and images. All sessions are logged for later viewing, and these can also be made available to students.
3. Choice Module
   It works like a poll and can either be used to vote on something, or to get feedbacks from every student (e.g. problem content). Teachers see an intuitive table view of who chose what and students can optionally be allowed to see an up-to-date graph of results.
4. Forum Module (Storage Board)
   Different types of forums were provided, such as teacher-only, course news, open-to-all, and one-thread-per-user. Discussions could be viewed nested, flat or threaded, oldest or newest first. Individual forums can be subscribed to by each person so that copies are forwarded via email, or the teacher can force subscription on all. It would be the core place for knowledge exchanging and problem resolving. The teacher can choose not to allow replies (e.g. for an announcements-only forum) which provide certain one-way information. Discussion threads can be easily moved between forums by the teacher for spreading information among groups. Ratings are possible in forums and these can be restricted to a range of dates.
5. Resource Module
   This supports displays of any electronic content, Word, PowerPoint, Flash, Video, Sounds etc as on-line problem solving resources. Files can be uploaded and managed on the server, or created on the fly using web forms (text or HTML). External content on the web can be linked to or seamlessly included within the course interface. External web applications can be linked in with data passed to them.
6. Workshop Module
   It allows peer assessment of documents of solutions, and the teacher can manage and grade the assessment. It also supports a wide range of possible grading scales. Teachers can provide sample documents for students to practice grading so as to see the criteria for evaluating solutions.
7. Journal Module
   The teacher asks the students to reflect on a particular topic, and the students can edit and refine their answer over time. This is the personal problem solving recording spaces. It

can only be reviewed by the owner and the teacher.

Table 1 On-line module group of each design task

Tasks	On-line Module Used
Form a social interaction environment with design professional culture	Message Module Journal Module Forum Module (Storage Board) Chat Module Assignment Module Choice Module Resource Module
Provide members with separate behaving space	Resource Module Journal Module Forum Module (Storage Board)
Interactively access multimedia databases of products, materials and service	Database Module Resource Module Journal Module Chat Module Forum Module (Storage Board) Choice Module
Implement projects at a distance	Database Module Resource Module Journal Module Forum Module (Storage Board) Choice Module
Participate in distant work groups	Workshop Module Journal Module Chat Module Forum Module (Storage Board) Choice Module

8. Message Module
   This module allows users to start two-way dialogues with another person.
9. Database Module
   This module allows creating database for establishing on-line multimedia resources.

For achieving the functions of each task, modules were grouped to form the on-line information center for industrial design. In Table 1, modules were listed accordingly.

4.2 System structure

The system structures were introduced in basic overall functions and managing functions. n-line information center's overall design:

- Host professional learning groups.
- Promotes a social constructionist behaviors of collaboration, activities, and critical reflection
- Suitable for 100% online activities as well as supplementing face-to-face activities
- On-line activities listing show descriptions for every activity on the server, including accessibility to guests.
- Design activities can be categorized and searched – one on-line center can support thousands of activities
- Most text entry areas (resources, forum postings etc) can be edited using an embedded WYSIWYG HTML editor

On-line information center's site management:

- On-line information center is managed by an administrator user
- On-line information center is defined during setup. Defaults can be edited during setup or globally accepted
- On-line information center can be modified by a robust Site administration block.
- Plug-in "themes" allow the administrator to customize the site colors, fonts, layout etc to suit local needs
- Plug-in activity modules can be added to existing installations
- User management supports a range of authentication mechanisms through plug-in authentication modules, allowing easy integration with existing systems.
- Design project management provide project leader a full control over all settings for a project, including restricting other members.
- Choice of project formats of week or social discussion format.
- Project themes provide each project its own them of colors and layout.

4.3 System evaluation

There were two stage of system evaluation. The first stage was efficiency evaluation. The second stage was stress evaluation.

4.3.1 Efficiency evaluation

For test running the system, total seven on-line design projects were conducted by 285 senior students who are major in industrial design at a university. The DEA procedures were applied to evaluate the efficiency. All seven projects showed 100% efficiency. In figure **4**, the potential improvements of all factors were displayed. The value of potential improvements was all zero.

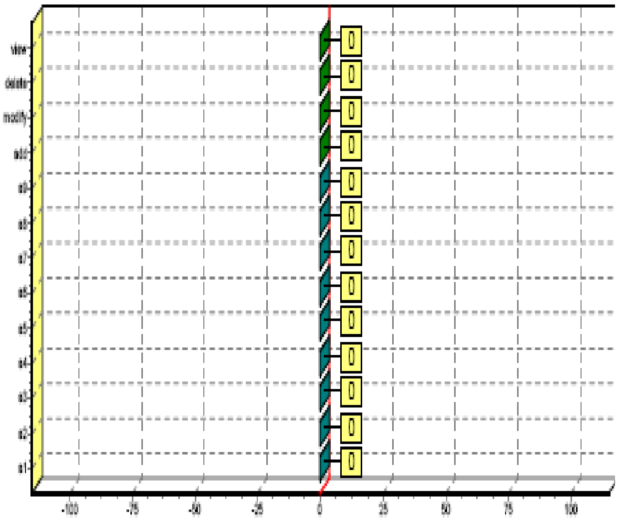

Figure 5 Potential improvements of efficiency evaluation

In table 2, it is an efficiency report of one unit of all thirteen units. All the input variables were add, modify, delete, and view. All the output variables were those nine activity modules.

Table 2 Efficiency report of one unit

Variable	Actual	Target	Potential improvement
add	56.00	56.00	00.00%
modify	6.00	6.00	00.00%
delete	5.00	5.00	00.00%
view	7.00	7.00	00.00%
Project assignment	5.00	5.00	00.00%
Chat	9.00	9.00	00.00%
Choice	56.00	56.00	00.00%
Forum	5.00	5.00	00.00%
Resource	9.00	9.00	00.00%
Workshop	7.00	7.00	00.00%
Journal	67.00	67.00	00.00%
Message	6.00	6.00	00.00%
Database	73.00	73.00	00.00%

The actual value, target value, and potential improvement of each variable were listed. Again, it is show that all modules work with high efficiency.

4.3.1 Platform stress evaluation

The platform stress evaluation was conducted on-line by using web server stress tool Enterprise edition. The detail setup was listed in table 3.

Table 3 Parameters of web stress test setup

Test Setup	
Test Type:	CLICKS (run test until 36 clicks per user)
User Simulation:	5 simultaneous users - 20 seconds between clicks
Logging Period:	Log every 10 seconds
URLs	
URL Sequencing:	Users follow complete sequence (top to bottom) and again (if not enough URLs available)
Browser Settings	
Browser Simulation:	User Agent: Mozilla/5.0 (compatible; Webserver Stress Tool 7; Windows)
	Browser Simulation: HTTP Request Timeout: 120 s
Options	
Logging:	Write detailed log(s) Timer :not enabled Using Local IPs:140.127.44.24
Client System	
System	Windows XP V5.1 (Build 2600) Service Pack 2, CPU Proc. Lev. 686 (Rev. 3592) at 1666 MHz,
Memory	1137 MB available RAM of 2146 MB total physical RAM, 1146 MB available page file, 16492 MB free disk space on C:
Test Software	
Webserver Stress Tool:	7.0.2.173 Enterprise Edition (1 User License)

The whole test was running until all nine modules had worked twice. There were five simultaneous users during the test. The waiting time between clicks was 20 seconds.

In table 3, the test-setup parameters were listed. For evaluating research platform functional feasibility, the web stress was tested under the minimal simultaneous users of five and all nine industrial design required functions.

The total number of URLs was 18. Those 18 URLs were pointed in and out all nine on-line activity-modules:

1. Project assignment Module
2. Chat Module
3. Choice Module
4. Forum Module
5. Resource Module
6. Workshop Module
7. Journal Module
8. Message Module
9. Database Module

In figure 6 , click times and errors were shown by each URL. The average response time of each URL could be read according to the left vertical scale. The range of response time was from 2000 ms to 50 ms.

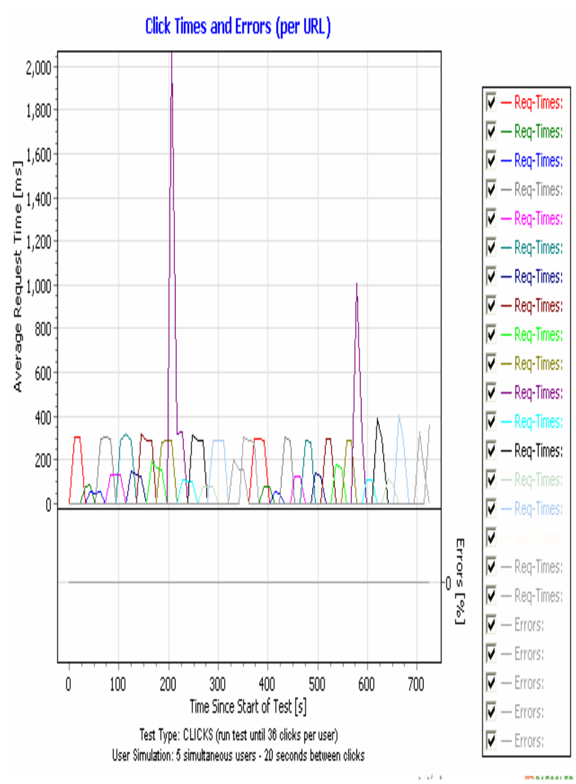

Figure 6 Click times and errors per URL of web stress test

According to the test result, there was no error of this industrial design information center. In figure 8, the tested system click time and hits were drawn. On the left hand vertical axis, the scale was click time by ms. On the right vertical axis, the scale was for both hits and clicks per second. The highest value of click time was around 1,200 at the unit of mini second. The highest value of hits per second was around 0.39.

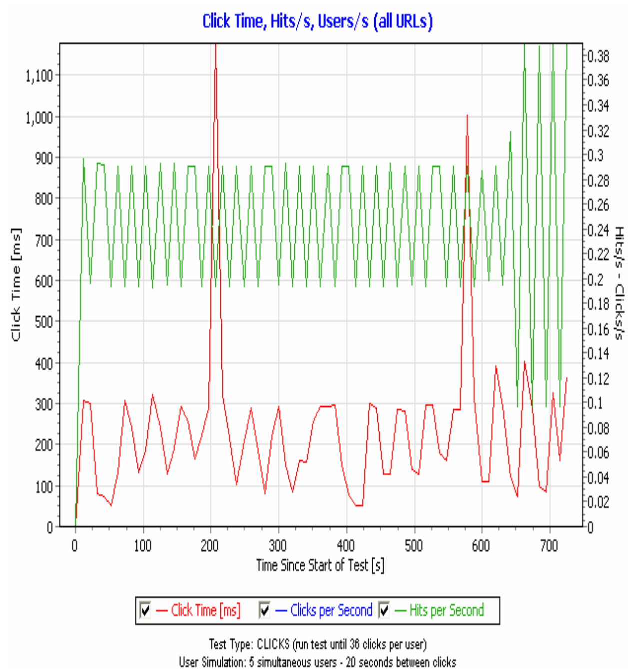

Figure 7 Click time and hits per second of web stress test

In figure 8, the pages requested were drawn according to the horizontal time scale to show the hierarchy of tested pages.

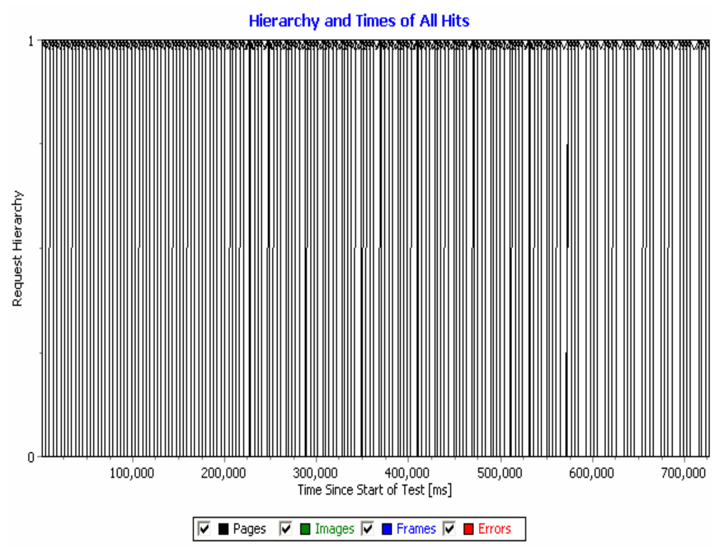

Figure 8 Hierarchy and times of all hits

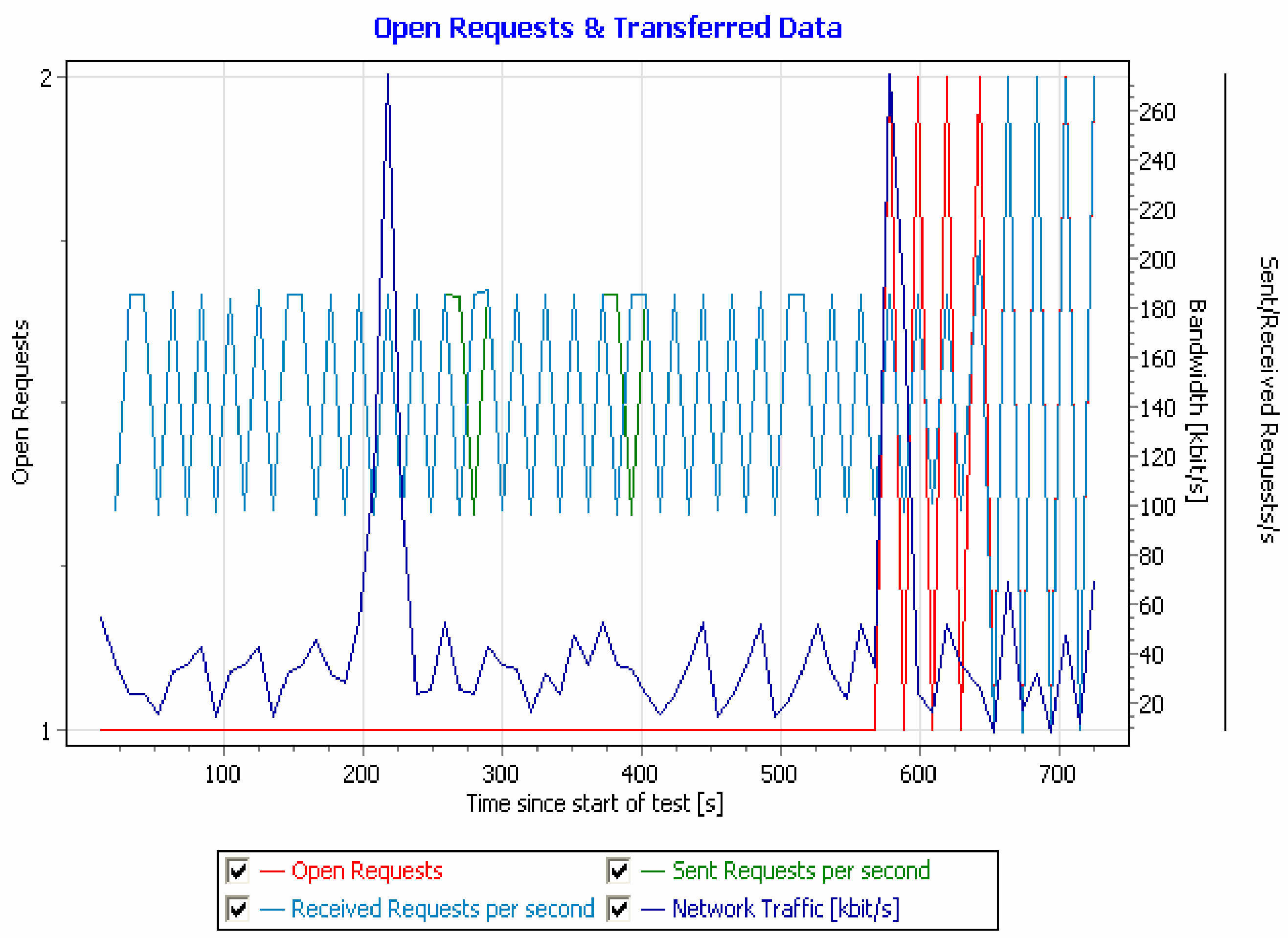

Figure 9 Open requests & transferred data of web stress test

The open requests were ranged from 1 to 2 during web stress test. The received requests were ranged from around 1.3 to 1.7 for the first 625 seconds and then shifted to 1 to 2 for the last 125 seconds. This figure 9 shows the number of open requests as well as the number of sent and received requests in comparison with the network traffic. Based on these results, the platform did provide low open requests and high received requests.

The bandwidth used during test time period was less than 70 kbits/s most of the time. The bandwidth cost was not high.

In figure 10, the spectrum of click time was drawn. Most of time, the user wait time was less than one second. Only 40 percent of users were experienced two second waiting time.

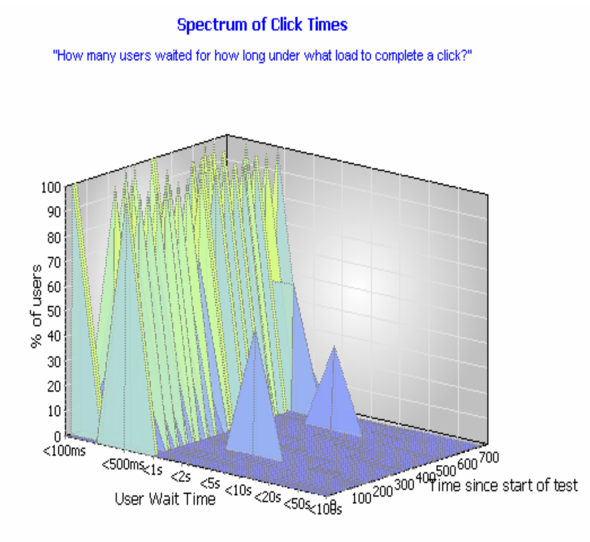

Figure 10 Spectrum of click times for the web stress test

All five users were experienced with no errors. All click god response from the web server. The average click time was rang from 201 to 340 mini-seconds. The total amount of transferred data was around 790 bytes. The band width was range from 516.53 to 872.58 kbits per second.

Table 4 Results of testing clicks, hits, errors, average click time, data bytes and band width.used by each user

User No.	Clicks	Hits	Errors	Avg .Click Time [ms]	Bytes	kbit/s
1	36	36	0	340	790,635	516.53
2	36	36	0	232	790,637	758.59
3	36	36	0	202	790,638	870.32
4	36	36	0	204	790,351	863.01
5	36	36	0	201	790,351	872.58

5 Conclusion

Implications of this study relate to develop an on-line information center for industrial design. The platform was designed by applied the revised RAD approach. Nine modules were constructed according to the key functions of on-line design service. Based upon DEA analysis, all tested projects were with 100% efficiency.

Prime objectives of on-line information center were pointed in this study. We have developed a prototype system capable of delivering the required services using the web-based platform.

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