Businesses as Buildings: Metrics for the Architectural Quality of Internet Businesses

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Metrics for the architectural quality of Internet businesses are essential in gauging the success and failure of e-commerce. This study proposes six dimensions of architectural metrics for Internet businesses: *internal stability, external security, information gathering, order processing, system interface,* and *communication interface.* The metrics are based on the three constructs that have been used to evaluate buildings in the real world. The structural construct indicates that Internet businesses need to be stable internally and secure externally. The functional construct implies that Internet businesses should provide convenient functions in the information-gathering and order-processing phases. Finally, the representational construct indicates that they need to provide a pleasant interface both to the system and to those using it. For each of the six metrics, we have constructed questionnaires to measure the perceived level of architectural quality and identified feature lists that may be closely related to the perceived quality level. Large-scale empirical studies were conducted both to validate the proposed metrics and to explore their relevance across four Internet business domains. The validity of the metrics has been obtained in three ways. First, the content validity of the metrics was assured by pretests and pilot survey. Second, the results from the confirmatory factor analysis showed that the metrics had high convergent and discriminant validities. Finally, the reliability coefficients were found to be high enough to establish the reliability of the proposed metrics. The relevance of the metrics has been explored in two ways. Structural equation models were used to test the causal relations between the three constructs and user satisfaction, as well as customer loyalty, in four domains. Correlation analyses were used to explore the relations between the perceived architectural quality and objective design features in four domains. This paper ends with the implications and limitations of the study results.
(Internet Business; Architectural Quality; Structural Firmness; Functional Convenience; Representational Delight; Subjective Questions; Objective Feature Lists)

1. Introduction

Internet businesses, such as E*trade and Amazon, are entities that perform commercial activities on the Internet (Adam et al. 1997, Margherio et al. 1998, Kim 1999). As the number of Internet businesses has grown, so has the variety of individual businesses (The Yankee Group 2001). At the beginning of the digital economy era most Internet businesses were created to announce the existence of traditional companies on the Web (Sullivan 1999). Today, Internet businesses include those that provide physical and digital goods (e.g., Chau et al. 2000), cyber communities (e.g., Kodama 1999), and even online network games (e.g., Mulligan 1998).

As the variety of Internet businesses expands, scholars and practitioners need a diverse array of metrics to comprehensively capture the current state of individual business. This paper proposes and validates metrics for

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architectural quality that can be used to evaluate the quality of individual Internet businesses. In this regard, Internet business architecture is related to the understanding and conveying of a big picture (Rosenfeld and Morville 1998, Bauer and Scharl 2000, Park and Kim 2000). It consists of individual features that include not only various system characteristics such as link structures and screen layout (e.g., Kim and Yoo 2000), but also important managerial characteristics such as the amount of provided information and security policies (e.g., Huizingh 2000).

Metrics for architectural quality are especially important because providing an optimal experience for customers is an important tool for maximizing the profit of an Internet business (Hoffman and Novak 1996, Kim and Moon 1998, Nel et al. 1999). Because most Internet businesses are eventually implemented through Web sites[1] and architectural metrics are closely related to Web site development, our metrics can provide direct recommendations for how to enhance the quality of the customer experience.

The architectural metrics in this study have three characteristics for improving prior studies in this field (e.g., Selz and Schubert 1998): (a) strong theoretical background, (b) methodological rigor, and (c) relevance of the architectural metrics to practice. First, in terms of theoretical background, the proposed metrics are based on a conceptual framework, which has been used in architecture for more than a thousand years (Britannica 2001, Giedion 1941). The importance of the constructs in the framework has also been supported by various studies in information systems (e.g., Liang and Huang 1998), software engineering (e.g., Kodama 1999), and e-commerce (e.g., Kim and Moon 1998). Second, in terms of rigor of metrics, we have conducted pretests, pilot surveys, and large-scale main surveys to test validities and reliabilities of the proposed metrics (Straub 1989). The validations have been conducted in four different business domains to test whether the proposed architectural metrics can be applied to a wide variety of Internet businesses. Third, in terms of relevance of metrics, we have investigated the managerial and technical relevance of the metrics for the four different domains individually to provide domain-specific implications. Causal relations among the constructs measured by the proposed metrics and important managerial goals, such as customer loyalty, were tested for managerial relevance. Important objective features that were closely related to the perceived quality of Internet business were identified for technical relevance.

[1]It is difficult to distinguish the architecture of an Internet business from the architecture of its Web site because most Internet businesses are eventually implemented as Web sites. However, this paper focuses on the architecture of Internet business because the Web site architecture has been used traditionally in a very limited sense. It tends to include only interface features, such as navigation and labeling of menu structure and search functions, and not to include any information contents and managerial characteristics. Therefore, the metrics proposed in this parper are to measure the architectural quality of Internet businesses, even though they are being measured through Web sites.

2. Literature Review

2.1. Analogy Between Businesses and Buildings

The analogy of a software system as a building has been used frequently in system design (Kapor 1996, Winograd and Tabor 1996, Mitchell 1995) and applied specifically to the MIS discipline (Lee 1991). Just as the building is the typical artifact that people construct in real space, so in the Internet business is it the typical artifact people build in cyberspace. Internet businesses can be regarded as buildings in cyberspace for two reasons. First, Internet businesses and buildings serve similar objectives. Buildings offer physical living space in the real world; Internet businesses can be considered to offer virtual living space in the cyber world. In other words, buildings such as marketplaces and schools in the real world can be compared with Internet businesses such as virtual malls and online education sites (Mitchell 1995). Second, user perspectives are important both for Internet businesses and for buildings, because one of the main objectives of both is to provide appropriate experiences for users (Gonzales et al. 1997, Liao and Cheung 2001), e.g., convenient functions and visual aspects are important factors for both Internet business customers and building residents. The architectural quality of Internet businesses, therefore, can be argued to be similar to that of buildings.

The building metaphor yields a conceptual framework of architectural quality that has been used to measure the quality of buildings for more than a 1,000 years (Giedion 1941). Buildings have usually been appraised based on three interrelated constructs developed by the famous Roman architecture critic Vitruvius: *firmitas*, *utilitas*, and *venustas* (Rasmussen 1959). These three constructs have subsequently been elaborated in the domain of Post Occupancy Evaluation, which is the standard process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time (Zimring and Reizenstein 1980, Preiser et al. 1988, Gonzales et al. 1997).

Firmitas refers to the structural firmness of architecture (Giedion 1941). A building has to be firm enough to protect inhabitants from external threats, such as winds and snow. It also has to stand firm through internal erosions to avoid collapsing. *Utilitas* denotes the appropriate spatial accommodation of architecture. A building should provide space suitable for the purposes for which it is intended (Giedion 1941). Finally, *venustas* represents the representational delight of architecture (Rasmussen 1959). A building should have a pleasant appearance to arouse pleasurable emotions. In sum, to be evaluated as a good building, it has to provide structural firmness, functional convenience, and representational delight. The conceptual framework of architectural quality is used in this study as a useful tool to organize numerous quality metrics of Internet business into a systematic evaluative framework.

2.2. Six Dimensions of Architectural Metrics

We propose that the previously mentioned architectural constructs be used to evaluate Internet businesses in the same systematic and rigorous manner as buildings. Based on these three constructs, we propose six architectural subconstructs for Internet business: *internal stability* and *external security* for the structural firmness construct, *information gathering* and *order processing* for the functional convenience construct, and *system interface* and *communication interface* for the representational delight construct (Kapor 1996, Winograd and Tabor 1996).

The *structural firmness* construct in Internet business can be defined as the solidity of the system structure in overcoming all expected and unexpected threats. We hypothesize that structural firmness is an important construct of architectural quality for Internet business, because customers want to feel safe and secure before they initiate any transactional activities (Shankar 1996). Structural firmness on the Internet has received considerable attention, both directly in the form of safe and secure transfer of money and indirectly in the form of transaction risks (National Computer Board 1997).

The firmness construct of Internet business can be measured according to the source of threats: internal stability vs. external security. The *internal stability* metric denotes the safety of Internet business from internal bugs (Huang and Wang 1999). Internal stability is important for the structural firmness of Internet business because unstable systems frustrate customers and diminish the consumption experience. Online shopping adoption depends on the perceived stability of the customer's experience (Liang and Huang 1998), for instance. The internal stability of Internet business can be measured by rapid access, quick error recovery, and correct operation and computation (Bhimani 1996). The *external security* metric represents the safety of Internet business from external threats (Zona Research 2000). External security is important for the structural firmness of Internet business because an unsafe electronic market would not attract any customers (Liu et al. 1997). Perceived risks of security exert significant effect on the willingness to be involved in transaction activities (Liao and Cheung 2001). The external security of Internet businesses can be measured by such factors as the quality of firewalls and privacy policies (Panurach 1996).

The *functional convenience* construct of Internet business is defined as the provision of convenient functions for customer processing of transaction activities. Therefore, this construct ensures that our metrics are specific to Internet businesses rather than personal and/or noncommercial entities on the Internet. We hypothesize that providing convenient functions for customers to complete their intended business activities is an important architectural construct for Internet business. In traditional information systems, usefulness and ease of use are the important antecedents to system use (Davis 1989), and this may be true on the Internet as well.

The convenience construct can be measured by two metrics relating to phases of the transaction process: information gathering vs. order processing (Lohse and Spiller 1998, Schmid 1995, Selz and Schubert 1998, Kim 1997, Huizingh 2000, O'Keefe and McEachern 1998). The *information-gathering* phase refers to activities that customers conduct in collecting relevant information about products and services (Perry and Bodkin 2000, Huang and Yang 1999). Convenient functions for customers to obtain all the information they need to make a purchase decision are important for the functional convenience of Internet businesses (Miles et al. 2000). Such features as accurate product listings or comprehensive information about specific products can measure the convenience of information gathering. The *order-processing* phase includes all the activities of purchasing and postpurchasing (Selz and Schubert 1998). A convenient order-processing phase, such as one-click ordering at Amazon.com, is an important aspect of the functional convenience in Internet business, because it is in this phase that the revenue for the business is realized (Rhee and Riggins 1999). The convenience of the order-processing phase can be measured by such functions as confirming the completion of the order process and tracking the ordered products during delivery (Lucas 1996).

The *representational delight* construct in Internet business refers to interface aspects of the Web site with which the user comes into contact. Interface is the representational aspect that users actually see and hear in computer systems (Moran 1981). Representational delight is an important architectural construct of Internet business, because it enhances customers' esthetic experience as they learn to browse and find relevant information (Benjamin 1995, Liu and Arnett 2000).

The delight construct can be measured by two metrics according to the target of the interface: interface-to-system vs. interface-to-human. This classification is based on the fact that interaction in Internet business can either be with the system or with those using the system. The *system interface* refers to the measure of the pleasantness of the interface between humans and computers (Lohse and Spiller 1998). Providing a pleasant system interface is an important measure for representational delight (Kim and Moon 1988), because customers return when provided with an interesting and entertaining interface experience (Rice 1997, Ho and Wu 1999). The delight of a system interface can be measured by such design features as varieties of interface buttons and layouts (Kim and Yoo 2000, Park and Kim 2000). The *communication interface* refers to the measures of the pleasantness of the interface between humans. These are mostly implemented by communication systems (Wilson et al. 1997, Daft and Lengel 1986). Providing pleasant communication interfaces among customers is important because communicating with other people in a community is the heart of Internet business (Armstrong and Hagel 1996, Kim 1999). The communication interface can be measured by such factors as bulletin boards and contact pages with e-mail addresses.

3. Methods

Metrics need to be valid and relevant to be useful (Davenport and Markus 1999, Benbasat and Zmud 1999). Validity in the current study was tested via content and construct validity and reliability. Relevance was investigated through relationships between objective features and subjective measures, and relationships between six dimensions and latent constructs.

3.1. Pretests and Pilot Surveys

Pretests and pilot surveys were conducted before the main empirical study to enhance the content validity of the proposed architectural metrics (Straub 1989). Questionnaires measuring subjective items were developed initially through a project with the National Computing Agency to survey E-Commerce (EC) consumer attitudes (Kim et al. 2000). A team of three faculty members, including the first author and researchers in the National Computing Agency, constructed a generic set of questions related to the architectural qualities of Internet businesses based on relevant prior research (e.g., Parasuraman et al. 1988, Lewis 1995). Content validity of the questions was verified (Boudreau et al. 2001) through personal interviews with industry experts from 45 Internet business companies. We also conducted a pilot survey using subsets of the subjective instruments during the pretests. Ninety-five undergraduate students participated in the pilot survey, evaluating eight virtual malls in a classroom setting. The results from the pilot survey indicate that the

subset of subjective questions have appropriate reliability, at least within the virtual mall domain (Kim et al. 2000).

The final set of questions used in this study for the virtual mall domain is presented in Table 1. The first column of Table 1 presents the three constructs in architecture; the second column indicates the corresponding six architectural metrics; and the third and fourth columns present the actual questions used in the empirical study.

Objective measures for these central constructs were devised as part of the effort to construct a Korean e-business award system mandated by the Prime Minister of Korea. Web features were selected by a committee that consisted of nine experts: one from the ministry of commerce, one from the university, one from the consumer protection agency, one from a search portal site, two from virtual mall sites, one from an online brokerage site, and two from online game companies. The committee chaired by the first author

Table 1 Questionnaire of the Six Subdimensions for the Virtual Mall Domain

Concepts			Questionnaires
Firmness	IS	IS-1	It is reliable.
		IS-2	It does not take a long time to load the front page of the site.
		IS-3	It provides fast loading speed in any environment.
	ES	ES-1	It protects users' personal information effectively.
		ES-2	It manages and maintains personal account records.
		ES-3	It provides thorough protection, preventing any invasion from intruders.
		ES-4	I can rely on this business whenever I want to purchase important products.
		ES-5	I will use this business always to do shopping in any urgent situations.
Convenience	IG	IG-1	It provides various assortments of goods and services.
		IG-2	Information related to goods and services offered in this business is accurate.
		IG-3	The latest information related to goods and services is adequately provided.
		IG-4	Information provided is easy to understand.
	OP	OP-1	In comparison with other virtual malls, the price of the goods and services (including postage handling) are reasonable.
		OP-2	The processes of ordering goods and services are convenient.
		OP-3	It provides adequate information to check the ordered items and their location during the process of ordering the items.
		OP-4	It maintains my personal information, so I can make repeated orders more conveniently.
		OP-5	Ordered items are delivered right at the promised time.
		OP-6	There is no difference between the ordered items and the delivered items.
		OP-7	It is convenient to make claims when there are problems in the delivered goods and services.
		OP-8	It is convenient to make exchanges and obtain refunds for the purchased goods and services.
Delight	SI	SI-1	It is pleasant to follow the overall flow.
		SI-2	It is a delight to recognize where I am and what I am doing in the business.
		SI-3	It is easy to learn the steps to use the system.
		SI-4	It is pleasant to follow and use the menu structure.
		SI-5	It is easy to remember the business address (URL: Domain Address).
		SI-6	The images and typographies used in the sites are stylish.
		SI-7	The overall atmosphere and screen displays of the sites are well coordinated.
		SI-8	It is pleasant to see the provided information on each screen in this site.
		SI-9	Information provided in this site is consistent throughout.
	CI	CI-1	It is easy to share individual information with others.
		CI-2	A well-coordinated community has been formed among the users of this site.
		CI-3	It offers various ways to communicate between the customer and the company.
		CI-4	It provides fast and accurate answers to the customers' inquiries (Q&A).
		CI-5	It offers custom-made communication services to individual users.

IS = Internal Stability; ES = External Security; IG = Information Gathering; OP = Order Processing; SI = System Interface; CI = Communication Interface.

constructed an initial set of site-feature lists for each of the six metrics based on prior relevant studies (e.g., Lohse and Spiller 1998, Perlman 1996, Lin et al. 1997). To assure the comprehensiveness of the set of objective features, the initial draft was then discussed in a public hearing and modified according to opinions expressed at the hearing. Because they were first set in 1999, these objective features have been used to select the winner of the e-business award. Every year, a committee consisting of industry experts reviews the set of objective features and updates them. The most current version available at the time of data collection was used for this research. The full set of the objective features list for the virtual mall domain is presented in Table 2.

The first column of Table 2 shows the three constructs and the corresponding six architectural metrics. The bold items on top of the second column denote the high-level objective features that will be used in our correlation analyses. The value in this column has been obtained by averaging the values on the corresponding detailed features described under the high-level objective features.

3.2. Main Surveys

To test the construct validity and reliability of the proposed metrics, as well as managerial and technical relevance, four independent surveys were conducted in four different business domains: (1) virtual malls, (2) online stock brokerages, (3) search portals, and (4) online network games.

Virtual malls were selected because they were one of the most common types of general stores on the Internet (Kim and Yoo 2000). Moreover, virtual malls have been the subject of many prior studies and, therefore, provided greater background for the construction of subjective questionnaires and objective measures (Park and Kim 2000, Lohse and Spiller 1998, Chau et al. 2000). The online stock brokerage business was selected because it was one of the most common types of specialty stores on the Internet (Fan et al. 2000). In particular, the volume of this business was greater than that of any other business in the Korean Internet market and accounted for almost 60% of total trading volume (KSDA 2000). Moreover, it is one of the rare domains in which reliable financial performance data for individual businesses are available to the public, owing to strong regulation by the Korean government. The search portal domains, including such firms as Yahoo and Lycos, were selected because they provided various communication and community tools in addition to search engines. This has made them one of the oldest and largest communities in the Korean Internet business market (I-biznet 2000). Finally, the online network game domain was selected because it was one of the largest businesses in the content markets and a domain in which Korean businesses have attained technological and managerial superiority over companies in other countries (Korea Engineering Services Association 2000).

A preliminary survey was conducted online to identify the major players in the four domains of the Korean Internet business market. People who had completed at least one transaction in the four domains were solicited to participate, with monetary compensation, in the survey. In total, 14,594 participated in the preliminary survey. Respondents were asked to provide the name of Internet businesses that they used more frequently in each domain. Based on the results from the survey, we chose the most frequently mentioned businesses in each domain. All the firms in the search portal and network games were online-only companies, whereas 4 out of the 10 virtual malls and all the selected firms, except one in the stock brokerage domain, were both on- and offline companies. Therefore, we may infer that the selected Internet businesses accounted for not only pure online firms, but also several traditional firms entering the Internet business market.

A large-scale main survey was conducted in the third quarter of the year 2000. Respondents to the survey were recruited through banner advertisements on several popular Korean Web sites. Among those who applied, only those who had used one of the selected Internet businesses sites more than twice during the week before the survey were solicited with monetary compensation. First, respondents were asked to answer demographic questions (e.g., age, gender, occupation). Then, for the target Internet businesses, they answered one question for customer loyalty and another for user satisfaction. These questions allowed a testing of the predictive validity of the instrument,

Table 2 Objective Features Lists of the Six Metrics for the Virtual Mall Domain

Constructs	Detailed Level
Firmness	
Internal Stability	**Completeness of link structure**
	Number of bad links
	Stabilization of error
	Number of HTML errors
	Number of problems (browse version errors)
	Relevance of page loading time
	Loading time of first page according to network lines (28 kb, 56 kb, ISDN line)
External Security	**Protection of personal information**
	Whether it provides explicit policies on personal information protection (y/n)
	Whether it provides rights to modify the customer's personal information (y/n)
	Whether it asks for the customer's consent to the process of joining the membership (y/n)
	Completeness of transaction condition
	According to transaction conditions of the Fair Trade Commission (y/n)
	Completeness of system security
	Whether it provides explicit policies for system security (y/n)
Convenience	
Information Gathering	**Completeness of help information**
	Whether it provides enough information about the order process and claims process (y/n)
	Whether it provides advice on payment methods (y/n)
	Whether it provides advice on delivery charge, region, and duration of time (y/n)
	Whether it provides advice on exchange/refund condition, scope, and method (y/n)
	Whether it provides advice on joining membership, modification
	Whether it provides advice on withdrawal and loss of password (y/n)
	Whether it provides advice on product search (y/n)
	Completeness of main content
	Whether it provides information on item name, brand, price, item images (in the product info page) (y/n)
	Completeness of extra content
	Whether it provides information on detailed description, renewal data, buyer, review information, price comparison, and suggested goods (in the product info page) (y/n)
	Completeness of abstract content
	Whether it provides information on goods name, manufacturer, price, and mileage information (in the product list page) (y/n)
Order Processing	**Convenience of information searching and browsing**
	Whether it provides the function of key words search, source selection search, search from the results, brand name search, search on other shopping mall sites (y/n)
	Whether it provides a search engine that presents information on item name, price, accuracy, manufacturer, origin, item image, and explanation of the item goods in the search result (y/n)
	Whether it provides the function of comparing goods and services in various aspects other than price (y/n)
	Whether it provides the function of list sorting by name and price (y/n)
	Convenience of order process
	Whether it provides explanations at each level of order process (y/n)
	Whether it makes use of existing customer's personal information (address, phone number, . . .) in order process (y/n)
	Whether it provides tools to modify recipient's message, postage-related message (y/n)
	Whether it provides tools to choose delivery package and delivery at the appointed date (y/n)
	Whether it provides information on manufacturer's name, name of the item, price, total amount, item code, mileage, and postage handling fee (y/n)
	Whether it provides function of deleting items, removing entire items, continuing shopping, making payment, and changing quantities (y/n)
	Whether it provides a variety of payment methods (online remittance, credit card, etc.) (y/n)
	Whether it provides a variety of delivery methods (quick service, mail, FedEx, etc.) (y/n)
	Whether it provides the function to track delivery (y/n)

Table 2 (cont'd.) Objective Features Lists of the Six Metrics for the Virtual Mall Domain

Constructs	Detailed Level
	Convenience of order completion
	Whether it provides the function of order confirmation (y/n)
	Whether it provides information on order data, order quality, delivery place, payment (y/n)
	Whether it provides a variety of solution windows for customer's complaint (e-mail, call center, etc.) (y/n)
Delight	
System Interface	**Relevance of screen layout**
	Whether it harmonizes well with the screen size and screen layout
	Relevance of user's location interface
	Whether it provides information on its location check
	Relevance of user's navigation interface
	Whether it provides a variety of navigation tools (home button on each level page, number of available navigation links in each level, back button on the end product page, shortcut navigation link, and site map) (y/n)
Communication Interface	**Convenience of business-to-customer communication interface**
	Whether it provides communication tools between the customer and the company (y/n)
	Whether it provides notice boards (y/n)
	Convenience of customer-to-customer communication interface
	Whether it provides communication tools between the customer and the customer (providing chat rooms and message systems) (y/n)

which may be taken to indicate managerial relevance (Campbell 1960). The question for customer loyalty was, "I am going to revisit this Internet business when necessary," an item borrowed from Czeipiel and Gilmore (1987). The question for user satisfaction, "Overall, I am satisfied with the Internet business," was adapted from Lewis (1995). Finally, they answered the questionnaires on architectural qualities, such as those shown in Table 1 for virtual malls, using a seven-point Likert scale. Respondents in other domains[2] answered different versions of the questionnaire, which paraphrased literal expressions according to the domain characteristics.[3] Only those respondents who answered all the questions faithfully were retained for further analysis. Table 3 presents the number of effective respondents after user verification included in the final dataset for the four business domains, with the gender and age ratio.

Objective features of architectural quality were measured for each of the selected Internet business sites. To code the objective features of selected Internet businesses, a total of 30 people were recruited through advertisements on campus. Then they were trained in the coding schema for the objective features with two sample Internet business sites. At the end of the training session, the coders were asked to evaluate a test site, and the authors verified the results of their coding for the test site. The training session lasted for the entire day; all the coders were able to code the test site correctly by the day's conclusion. The selected Internet businesses were then randomly assigned to a team of two coders. The two coders in each team investigated the objective features of the selected businesses independently. After both had coded an Internet business,

[2]The questionnaires and feature lists for the stock brokerage, search portals, and online network games are not presented in this paper, because they are similar to that of the virtual mall domain; all were converted from the same generic set of questions. For further details on the questionnaire related to the stock brokerage, search portals and online network games refer to Lee and Kim (2000) and Choe et al. (2000). The entire set of qustionnaires and feature lists are also available upon request from the authors.

[3]For example, Question OP-7 for the virutal mall, as shown in Table 2, is something like: "Is it convenient to make claims when there are problems in the delivered goods and services?" The corresponding question for the stock broekerage is something like: "Is it convenient to clear disputes when there are problems in the stock traded?"

Table 3 Number of Effective Respondents for Main Survey

			Sex (%)		Age (%)			
Four Domains	Number of Sites	Total Respondents	Male	Female	10–19	20–29	30–39	40–49
Virtual mall	10	4644	64.9	35.1	11.6	51.1	29.7	7.6
Stock brokerage	29	6582	88.6	11.4	—	19.8	56.8	23.6
Search portal	7	3462	57.0	43.0	13.5	60.9	22.6	3.0
Online game	16	1991	82.7	17.3	43.5	46.0	9.7	0.8

they were asked to reconcile their codings if there were any inconsistencies. Finally, the authors of this paper randomly selected one Internet business in each domain and coded the objective features list for reliability tests. A kappa ratio for intercoder reliability was calculated as 0.954 on average (0.96 for virtual malls, 0.95 for stock brokerages, 0.96 for search portals, and 0.94 for online games), with all ratios being high enough to have proceeded to further analysis.

3.3. Data Analysis

To assess the reliability, and discriminant and convergent validities of the six architectural measures in our questionnaires, we performed confirmatory factor analysis and reported the average variance extracted (Gefen et al. 2000). The analyses for reliability and validity were conducted with all different domains pooled because the underlying structure of the constructs was believed to be consistent across different domains. In other words, the six measures should be valid and reliable, regardless of the domains to which they are applied.

The relevance of the proposed metrics to Internet businesses was investigated with two relations: relations between subjective questionnaire and objective feature lists, and relations between the six metrics and latent constructs.

First, we hypothesized that there exist close relations between the subjective architectural quality and the objective feature lists for each of the six dimensions. In other words, the objective features in a dimension should be closely related to the subjective perception in the same dimension of quality. For example, users may perceive a high level of internal safety if the Internet business provides appropriate features related to the safety of its systems. This research identifies important objective features that are closely related to the subjective level of the architectural quality for each of the six measures. The underlying methodology is revealed in the logic developed in Campbell and Fiske (1959). Different methods that result in convergence on a construct validate each set of measures in an egalitarian way.

Correlation analysis was conducted for each of the six dimensions in each of the four Internet business domains. Therefore, correlation analysis was conducted a total of 24 (6 x 4) times. The analyses was conducted to identify important high-level objective features that were closely related to the corresponding subjective measure of each Internet business site For example, in terms of the internal stability dimension of the virtual mall domain, the correlations between the average of responses from the respondents to the three questions related to internal stability (as shown in Table 1) for one business and the three high-level objective features related to internal stability (as shown in Table 2) for the same business were investigated. The units of the analysis are individual businesses, because the objective features should be coded at the Internet business level, not at the individual respondent level. Therefore, we averaged the questionnaire responses for an Internet business to move from the individual respondent level to the Internet business level.

Second, the architectural quality of Internet businesses can have an impact on the level of user satisfaction and, in turn, on the level of customer loyalty. In other words, an Internet business with high architectural quality may provide a higher level of user satisfaction, which then provides a higher level of customer loyalty. User satisfaction is a subjective

Table 4 Construct Loadings from Confirmatory Factor Analysis

		Latent Construct Loading (Error)			
Construct		Firmness	Convenience	Delight	Reliability Coefficient
Firmness	Internal Stability	0.81 (0.34)*			0.8029
	External Security	0.83 (0.32)*			
Convenience	Information Gathering		0.79 (0.38)*		0.8205
	Order Processing		0.88 (0.23)*		
Delight	System Interface			0.81 (0.34)*	0.7284
	Communication Interface			0.70 (0.51)*	

evaluation of the consequences of using the Internet business on a pleasant-unpleasant continuum (Seddon 1997, Lewis 1995). User satisfaction is one of the most frequently used measurements of system success, because the success of a system is usually related to what its users say they like (DeLone and McLean 1992). It is also clearly related to customer loyalty, which is the customer's intention to visit the Internet business site again based on previous experiences as well as future expectations (Czepiel and Gilmore 1987, Berry 1995). It is especially important for Internet businesses to ensure that customers visit their sites repeatedly, because the number of loyal customers who frequently visit their site determines their value (Rose et al. 1999). Therefore, we selected customer loyalty as the final dependent variable in our causal model. Structural Equation Modeling analyses (LISREL version 8.30) were conducted. The correlation matrix using the average of questions for each dimension was used as an input to the LISREL analysis. The units of the LISREL analyses were the individual respondents who participated in the main survey.

Whereas analysis of rigor of the metrics was conducted with the four domains pooled, analyses of relevance of the metrics were conducted independently in the four individual domains for three reasons. First, conducting four smaller analyses and showing that the three constructs (firmness, convenience, and delight) are important across the four domains can provide stronger evidence for external validity than conducting one large analysis with all data merged together (Cook and Campbell 1979). Second, the relative importance of the three constructs may vary across different domains. This is consistent with Calongne's (2001) argument that different categories of Internet businesses have different goals and solutions. Therefore, conducting LISREL analyses in the four domains independently may provide more concrete implications specific to the domain. Third, the important design features that are closely related to a construct may vary across different domains. This is consistent with Ivory et al. (2001), who argue that important design features differ among Internet businesses. These differences among important design features across domains provide concrete implications.

4. Results

Study findings are explicated in terms of the rigor of the proposed metrics, followed by their relevance to managerial aspects of Internet business. The rigor of the proposed metrics was evaluated through convergent validity, discriminant validity, and reliability. The managerial relevance of the metrics was evaluated through two forms of analysis: structured equation modeling and correlation analysis.

4.1. Convergent Validity

Table 4 presents construct loadings from confirmatory factor analysis for the six measures. The six measures (internal stability, external security, information gathering, order processing, system interface, and communication interface) converge well with their three corresponding constructs (structural firmness, functional convenience, and representational delightfulness), based on correlations with data pooled from the four domains. Also, the several indices of goodness of

fit are found to be within acceptable limits (Gefen at al. 2000) across the four business domains (goodness-of-fit = 0.97; adjusted-goodness-of-fit = 0.94; root mean residual (RMR) = 0.05). Therefore, we may conclude that the six architectural metrics have appropriate convergent validity across the four business domains.

4.2. Reliability

Table 4 also presents the reliability coefficient calculated from confirmatory factor analysis in the rightmost column. As shown in Table 4, all coefficients are larger than 0.7, which indicates that the metrics have appropriate reliability in the four business domains (Gefen et al. 2000).

4.3. Discriminant Validity

Table 5 presents the correlation and average variance extracted (AVE) from confirmatory factor analysis. The diagonal elements in Table 5 are the square root of AVE, and the off-diagonal elements are interconstruct correlations. The three diagonal elements in Table 5 are all larger than 0.5 and also larger than their corresponding correlation coefficients, which indicates that the metrics have appropriate discriminant validity in the four business domains (Gefen et al. 2000).

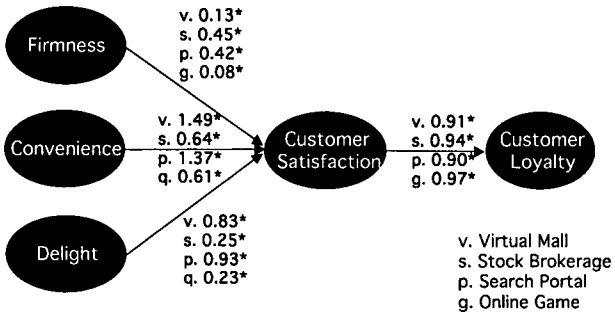
4.4. Managerial Relevance of the Proposed Metrics

Figure 1 summarizes the four LISREL models for each of the four business domains. Using structural equation modeling analysis, the hypothesized sequence of relationships among the models was tested holistically. The figure shows the causal relations among the three architectural constructs, user satisfaction, and customer loyalty. Coefficients for the paths in the figure represent the proposed relations among the three constructs, user satisfaction, and customer loyalty.

The fit of the model was assessed using several indicators, including adjusted goodness-of-fit test and root mean square residuals. As shown in Table 6, GFIs for all the four models are well above 0.90, the four AGFIs are again well above 0.80, and the four RMRs are well below 0.05, the benchmarks suggested by Gefen et al. (2000). Therefore, the results indicate that all the four models explain the overall relations among the constructs well, indicating that the construct shows good predictive validity (Boudreau et al. 2001).

Because the fitness of the models was above the threshold, the set of paths hypothesized by the model was tested using maximum-likelihood estimation. The standardized coefficients were calculated because they allowed comparison of size of path coefficients within the same model. Results in Figure 1 indicate two important findings. First, the three constructs (firmness, convenience, and delight) were found to have significant impacts on customer satisfaction and, in turn, customer loyalty in all the four business domains. Second, the relative magnitude of the path coefficients from the

Figure 1 Summary of LISREL Models for the Four Business Domains



*denotes significance at the $p < 0.05$ level.

Table 5 Correlation and AVE for Constructs from Confirmatory Factor Analysis

	Firmness	Convenience	Delight
Firmness	0.819		
Convenience	0.56	0.834	
Delight	0.45	0.69	0.757

Table 6 Summary of Goodness of Fit of LISREL Models for the Four Business Domains

	LISREL				
Domains	*df*	χ^2	RMR	RMSEA	GFI (AGFI)
Virtual mall	16	247.03	0.019	0.056	0.99 (0.97)
Stock brokerage	16	231.67	0.015	0.045	0.99 (0.98)
Search portal	16	338.49	0.029	0.076	0.99 (0.98)
Online game	16	66.94	0.014	0.034	0.99 (0.98)

three constructs to customer satisfaction varied across different business domains. The path coefficient from firmness to customer satisfaction was larger than that from delight to customer satisfaction in the stock-brokerage domain, whereas delight had a stronger link to satisfaction than firmness in the other three domains.

In summary, all four LISREL models clearly indicate that the proposed three architectural constructs measured by the six metrics faithfully represent architectural quality, which is also related to user satisfaction and customer loyalty across the four Internet business domains. Likewise, these results indicate that their relative importance to user satisfaction varies across business domains.

4.5. Technical Relevance of the Proposed Metrics (Multimethod Comparisons)

4.5.1. Formal Analysis of Construct Validity and Managerial Relevance. A technical or formal analysis of construct validity (Straub 1989) was also carried out by correlating the subjective measure indices and corresponding objective features. The general reasoning behind such a formal analysis is similar to that proposed by Campbell and Fiske (1959). Metrics thought to be measuring the same construct should be invariant with respect to method, which, in our case, is subjective versus objective measures.[4] The results of Spearman correlation analyses for the four business domains are shown in Table 7. The first column of Table 7 shows the three constructs and their corresponding six dimensions. For each of the six dimensions, the second column presents the high-level objective features presented in Table 2. The next four columns present correlation coefficients for virtual mall, stock brokerage, search portal, and online game, respectively. Results in Table 7 indicate two important findings.

First, at least one objective feature was found to be closely related to corresponding dimensions in all four domains, with one exception. The exception is for the search portal in which no design features were found to be closely related to the system interface dimensions. Many of the correlations are high, although not all are significant, most likely because of the low sample sizes. This offers evidence of construct validity and implies that we can identify at least one concrete way to improve the architectural quality of Internet businesses in all domains, except for the system interface dimension in search portals.

Second, objective features that were found to be closely related to corresponding dimensions vary across different domains. For example, the relevance of page loading time was found to be closely related to the internal stability dimension in the virtual mall domains, whereas stabilization of error is found to be closely related in the search portal domain. This also implies that effective ways to increase the architectural quality of Internet businesses vary across different business domains.

5. Conclusions and Discussion

To measure the architectural quality of Internet business, this study has proposed new architectural metrics that consist of six dimensions: *internal stability, external security, information gathering, order processing, system interface,* and *communication interface.* The six measures achieved validity and reliability through pretests and pilot and main surveys in four Internet business domains. They were also found to be relevant to important technical and managerial aspects of Internet business.

However, this study has several limitations, which should be dealt with in future studies. First, the four Internet business domains and individual businesses selected from those domains might not be able to represent the ever-increasing variety of Internet businesses. Second, this study collected empirical data only from the Korean market, which might delimit the use of the proposed metrics in other global contexts. Third, data were collected through an online survey, which is liable to a self-selection bias. Fourth, this paper did not explore the relationship between architectural and financial metrics, which make it difficult to conduct a comparison analysis between the cost of improving architectural quality and the benefit derived from the in-

[4]This is not, technically, a multitrait, multimethod (MTMM) analysis in that the units of analysis were quite different. This comparison was undertaken to tease out areas where objective features and subjective measures corresponded and differed across business domains and to inspire future research in utilizing and refining such correspondences.

Table 7 Summary of Results of Correlation Analysis Across the Four Domains

Sample Variable		Virtual Mall $N = 10$	Stock Brokerage $N = 29$	Search Portal $N = 7$	Online Game $N = 16$
Firmness					
IS	Completeness of link structure	0.59	0.79*	0.48	0.60*
	Stabilization of error	0.67	0.19	0.93*	0.67*
	Relevance of page loading time	0.91*	0.77*	0.33	0.34
ES	Protection of personal information	0.91*	0.76*	0.20	0.71*
	Completeness of transaction condition	0.59	0.36	0.92*	0.77*
	Completeness of system security	0.21	0.44	0.30	0.47
Convenience					
IG	Completeness of help information	0.18	0.65*	0.08	0.77*
	Completeness of main content	0.20	0.63*	0.82*	0.67*
	Completeness of extra content	0.52	0.24	0.70*	0.69*
	Completeness of abstract content	0.76*	0.12	0.42	0.18
OP	Convenience of information searching and browsing	0.24	0.61*	0.28	0.75*
	Convenience of order processing	0.48	0.26	0.56	0.71*
	Convenience after order completion	0.69*	0.07	0.69*	0.24
Delight					
SI	Relevance of screen layout	0.22	0.63*	0.21	0.67*
	Relevance of user's location interface	0.69*	0.32	0.25	0.38
	Relevance of user's navigation interface	0.19	0.21	0.10	0.04
CI	Convenience of business-to-customer communication interface	0.78*	0.71*	0.23	0.78*
	Convenience of customer-to-customer communication interface	0.33	0.24	0.21	0.33
	Customization of interface	0.53	0.74*	0.72*	0.54

IS = Internal Stability; ES = External Security; IG = Information Gathering; OP = Order Processing; SI = System Interface; CI = Communication Interface.

*$p < 0.05$.

vestment. Fifth, because the conceptual model of the architectural quality was used in the study, other important quality metrics might have been overlooked, which were not included in the building architecture. Sixth, this study focused mostly on purely digital firms, which led to insufficient attention to the Internet businesses of traditional brick-and-mortar firms. Finally, this study conducted intercoder reliability tests and pretests only with a few selected domains and individual businesses.

Despite the limitations described previously, the results have several theoretical and practical implications. From a theoretical perspective, the study has at least two major implications. First, this study provides a comprehensive framework of architectural quality for Internet business. As described previously, a conceptual model of architectural quality for buildings was used as a guiding analogy in the study. This comprehensive framework led us to include important dimensions that had not been addressed in previous studies, such as representational delight (Liu and Arnett 2000). Neither Technology Adoption Model (Davis 1989, Malholtra et al. 1999) nor Theory of Reasoned Action (Fishbein and Ajen 1975, Ajen 1991) has dealt with this dimension. However, the study results show that representational delight is more important than structural firmness in three of the four Internet business domains. The representational delight may be important because Internet business can be used almost anywhere by anybody in everyday life, whereas traditional information systems are used mostly for work.

Second, this study aims at both the rigor of the metrics validation and its relevance to technical and managerial aspects of diverse Internet businesses, because achieving both rigor and relevance of the proposed metrics significantly increases their usefulness (Davenport and Markus 1999, Benbasat and Zmud 1999). In terms of rigor, the results as well as the procedures of this study can be used as guidance in developing evaluation metrics, because architectural metrics in Internet business have been proposed and administered so frequently without any empirical validation. In terms of relevance, the three constructs measured by the six metrics were found to be important for user satisfaction across the four different domains, implying that the three constructs were worth being measured. Similarly, most of the correlations in the domains uncovered concrete design features closely related to the six dimensions.

From a practical perspective, the metrics can be used for two purposes. First, they can be used to gauge the current level of architectural quality of various Internet businesses. The metrics are currently being used by the Internet Business Research Center in producing consumer reports for various Internet businesses ⟨www.ibiz.re.kr⟩. The Center has been accumulating data by evaluating several hundred Internet business companies for the past three years. The accumulated data can be used as a comprehensive quality index through which individual companies can compare their architectural quality with industry average, as well as with their own past quality levels.

Second, the metrics can be used to provide a concrete guideline for how the architectural quality of Internet businesses in a certain domain can be improved. The results of the LISREL analyses help to determine which constructs should receive more attention in each business domain. For example, in the online stock brokerage domain, structural firmness is more important than representational delight, whereas it is vice versa in the other three domains. Therefore, given the limited resources of Internet business firms, those in the virtual mall domain should invest more in their efforts to enhance delight, whereas the opposite is true for online brokerage firms. The correlation results also show what types of investment should be made to strengthen the three constructs of the business. For example, providing complete abstract information, such as product lists, is crucial for the convenience of virtual malls. Therefore, given the limited resources, the virtual mall developers should invest heavily in efforts to increase the amount of data for abstract information such as product lists.

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