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Classifying Information Technologies: A Multidimensional Scaling Approach

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Abstract:

Information technologies are an integral part of any organization and are constantly emerging and evolving. Theories explaining the impact of technological innovations on organizations and the individuals that populate them are developed as new technologies emerge, and future business applications are explored. Despite this richness of research, we have a fairly narrow view of how these technologies are related. Furthermore, new technologies are often assigned labels that strongly connote disconnect from existing technologies despite the fact that few true evolutionary leaps exist and, for the most part, information technologies evolve from each other and share many similarities. Consequently, our ability to apply knowledge gained from the application of one technology to interactions with another is limited. Developing general theories of information technologies require strong understanding of the different technologies that exist and how they are related. To this end, this article puts forward a concise classification of information technologies. Using a multidimensional scaling approach and survey data from IS academics, we identify three dimensions which capture the commonalities and differences among information technologies. We believe that the resultant classification will enable researchers to better integrate existing and future theories, and to move away from technology-specific theories toward more general ones.

Keywords: Information Technology classification, multidimensional scaling

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I. INTRODUCTION

This article tackles an important gap in IS research that, heretofore, has not been dealt with: How different information technologies relate to each other, what attributes they share and where they differ, and how a classification of information technologies commonly studied in IS research may be created. The contribution offered by such work is threefold: First, from a theory standpoint, the article addresses the call for greater theorizing about information technologies by establishing links between different technologies and by further enabling the creation of new theories, the extension of theories across different technologies, and a greater generalizability of IS research [e.g., Agarwal and Lucas, 2005; Benbasat and Zmud, 2003; Orlikowski and Iacono, 2001]. Second, it allows researchers and practitioners to better understand the requirements and impacts of various information technologies by examining related technologies. We believe that observing commonalities among various information technologies and acknowledging their key distinguishing characteristics provides for better understanding of the requirements and impacts of various technologies on end-users and organizations. And third, it enhances researchers' ability to draw upon existing knowledge when studying new information technologies, thereby bringing the pace of research closer to the pace of technological development, and, in turn, increasing the relevance of IS research.

Addressing the first contribution, the ongoing debate concerning the IS field's identity and core has developed side by side with a call for greater theorizing about information technologies [Orlikowski and Iacono, 2001], which has received far less attention. One approach to such theorizing, which we take in this article, is to explore the links and relationships between different information technologies and offer insights on the dimensions underlying similarities and dissimilarities among technologies. We suggest that this much needed classification of information technologies can provide a solid foundation for future development of core IS theories.

Addressing the second and third contributions, more than a decade and a half ago, Ein-Dor and Segev [1993] noted that the IS field tends to form new and specialized journals, conferences, and interest groups whenever a new information technology is being introduced, and that this tendency to fragment could lead to redundancy in research since similar research questions resurface for each new technology. Empirically investigating the evolution of information technologies, they discovered that in reality it presents few quantum leaps, and that older and newer technologies exhibit many similarities that do not justify such disciplinary fragmentation. They also found that unlike the observed technological evolution which exhibits strong continuity, the evolution of labeling—i.e., the naming process of new information technologies—connotes disconnected revolutionary progress. This distinction between the evolution of features and functionalities (i.e., actual technological changes) and evolution of labeling (i.e., the changes in the names assigned to new information technologies) highlight a potential problem: Since the labels we put on the phenomena we study tend to drive our perceptions of the field, we are often engaged in redundant study of specific information technologies that could hinder cumulative research and lead to unhealthy divergence in the field. Moreover, fragmentation can have negative consequences when little knowledge flows through the boundaries of the specializations.

This article tackles the above problem by carefully formulating a classification scheme, that identifies the relevant dimensions along which technologies can be mapped, and observed commonalities leveraged.

The objective of this article is to augment our collective understanding of the landscape of information technologies and the theoretical foundation of the IS field, first by creating a classification of information technologies and then by carefully analyzing the theory-relevant insights that can be obtained from such classification. To reach this objective, we take a grounded approach by exploring a wide range of information technologies and identifying what they share and where they differ. We then reduce these commonalities and differences into a small number of dimensions, creating a classification of information technologies. We suggest that this classification can serve as the foundation for developing more general theories of information technologies, as well as for distinguishing features that may support the theoretical treatment of new technologies as they emerge, and identifying evolutionary leaps when they occur.

The novelty of this work lies, first and foremost, in its subject matter—i.e., a concise, general, and recent classification of information technologies. This is not to say that other classifications do not exist. For example, past research developed useful classifications that were primarily focused on a single type of information technology (e.g., Nevo et al.'s [2008] classification of KMS) or associated with a specific IS theory (e.g., Lee et al.'s [2003]

classification of technologies studied in TAM research). Previous studies also created more general classification of technologies, which are not associated with a particular type of technology or theory. For example, Nevo et al. [2009] provide a general classification of information technologies based on an extensive analysis of papers published in MISQ and ISR. However, consistent with their objectives, the resultant classification is extensive and is not intended to be used as a foundation for theory development. On the other hand, a general and concise classification was generated by Ein-Dor and Segev [1993] but, given its timestamp, the classification might not reflect more recent technological developments. Hence, it appears that a concise, general, and recent classification of information technologies are absent, despite the importance of such classification for our ability to theorize about IT. An additional contribution concerns the methodology applied in this work—namely, multidimensional scaling (MDS)—which has not been used much in IS research, although it offers many benefits for exploratory research and support for construct development. Moreover, the respondents in this study are members of the IS community whose opinions are rarely collected and analyzed in a structured way. Accordingly, this study makes an important contribution by developing a much-needed classification of information technologies. In developing this classification, we bring together the knowledge and expertise of the IS community with the strength of the MDS technique.

II. CLASSIFICATION DEVELOPMENT

Given the paucity of academic classifications of information technologies, this article takes a bottom up, data-driven approach to expose links between various information technologies. Several different conceptualizations and definitions of information technologies have been offered by IS scholars in the past. Recently, Nevo et al. [2009, p. 4] offered the following definition based on a synthesis of some of those definitions. They defined an information technology as a composite made up of some combination of software, hardware, database and network components with an information processing capability aimed at enabling individual, group, and organizational tasks. We adopt this definition in the current study.

Based on an analysis of all papers published in the journals *Information Systems Research* and *MIS Quarterly* over three decades, Nevo et al. identified several information technology groups as central and enduring elements of the IS discipline's academic core. While their review of the literature indicates the existence of some naturally emerging groups of information technologies, as studied by IS scholars over time, there is still much to be explored about how different technologies relate to each other, what attributes they share and where they differ. Such exploration is instrumental to our ability to understand the requirements and impacts of various information technologies and to create IS-specific theories. The next section describes an empirical investigation aimed at creating an information technology classification that can be instrumental in developing IS theories.

Multidimensional Scaling

Before building our classification, we offer a brief overview of the analytical approach employed in this article, i.e., Multidimensional Scaling (MDS). MDS is a technique that translates perceptions of similarity or dissimilarity among a set of objects (e.g., behaviors, journal articles, technologies) in order to produce a visual distribution of the objects in a multidimensional space. MDS places similar objects in close proximity to each other and dissimilar objects farther apart on a spatial map [Borg and Groenen, 1997; Kruskal and Wish, 1978]. MDS is a useful tool for classifying objects in a manner conducive to exposing their relationships, thus assisting researchers in empirically deriving inductive categories. Additionally, MDS can be used to identify the dimensions underlying the perceptions of similarity or dissimilarity of a set of objects [Hair et al., 2009; Priem et al., 2002; Robinson and Bennett, 1995].

Similarity or dissimilarity judgments, in the form of overall object comparisons, are used as input in MDS and are transformed into geometrical distances in a multidimensional space. The objective of the technique is to produce a set of points on a spatial map in a multidimensional space in a manner that closely parallels the observed similarities or dissimilarities provided by the respondents. The dimensions underpinning the perceptual judgments are indicated by the axes of the spatial map. Hence, the farther apart objects are on the spatial map, the greater is the perceived difference between them [Hair et al., 2009; Huang et al., 2006; Zmud et al., 1990].

There are two main forms of perceptual judgments in multidimensional scaling: compositional and decompositional. A compositional approach to MDS requires respondents to judge the similarities or dissimilarities between pairs of objects based on a list of salient object characteristics, which are precompiled and presented by the researcher. While this approach to MDS may result in more easily-interpreted spatial maps, it also suffers from two important shortcomings. First, under the compositional approach, all salient object characteristics—assuming those can be identified—are assigned equal weights [Ein-Dor and Segev, 1993]. This could lead to an over- or under-emphasis of certain characteristics, potentially resulting in incorrect perceptual maps [Hair et al., 2009]. Second, since the objects' characteristics are provided by the researcher, it is prudent to avoid injecting bias and arbitrariness into the study by relying on characteristics from the literature [Ein-Dor and Segev, 1993]. Given the lack of an overarching

taxonomy of information technology attributes and functionalities, we considered it infeasible to provide all salient characteristics while at the same time minimizing the risk of respondent fatigue. On the other hand, parsimony would have likely meant omitting salient characteristics that should have been presented to the respondents in order to obtain meaningful perceptual judgments [Hair et al., 2009]. A Decompositional approach is the more popular form of MDS, in which respondents are asked to indicate their overall assessment of the similarities or dissimilarities between any two objects for all possible pairs of objects. Hence, respondents need not evaluate each object in terms of characteristics provided by the researcher, but rather use their own criteria, as they would normally do in typical circumstances. This has the benefit of alleviating the concern of researcher bias associated with the risk of excluding salient characteristics or including irrelevant ones. In addition, the researcher need not struggle to determine what weights to assign to each characteristic or how to combine them in order to obtain a complete similarity judgment [Hair et al., 2009].

After an MDS solution had been obtained in the form of spatial positions in a multidimensional space, the researcher interprets and labels the dimensions. Once the dimensions are identified and understood, more formalized perspectives may be developed regarding the relationships among the objects [Hair et al., 2009; Zmud et al., 1990]. This approach to obtaining similarity judgments has the shortcomings that labeling the resulting dimensions may not be easy as the respondents provide only judgment evaluations of objects rather than their individual characteristics. That is, respondents are not asked to say whether an object (e.g., O_8) has, for example, characteristics C_1 , C_3 , and C_9 , but rather how similar or dissimilar O_8 is to O_1 , O_2 , O_3 , etc. Consequently, researchers cannot conveniently aggregate the characteristics of the objects to obtain labels for the ensuing dimensions. Instead, researchers must interpret the dimensions by observing the objects that occupy the various quadrants and come up with labels that adequately explain relative positioning of the objects. Nevertheless, the benefits of the decompositional approach indicate that it is an appropriate technique for studies of an exploratory nature such as the one reported in this article [Hair et al., 2009]. Accordingly, the data collection and analysis stages followed the guidelines for decompositional MDS set forth by Hair et al. [2009], Kruskal and Wish [1978], and Malhotra et al. [1988].

Data Collection

The identification of relevant objects (in this case, information technologies) in an MDS study is an important step with three important considerations. First, MDS require that all relevant objects be included in the questionnaire, since their omission, or the inclusion of inappropriate objects, can have a negative effect on the quality of the solution [Hair et al., 2009]. In the context of MDS, *relevant* refers to those objects that may yield additional dimensions not identified by those objects included in the study. At the same time, however, MDS is also limited in the number of objects that may be included in the survey, due to the cognitive limitations of respondents. In particular, having N objects requires $N(N-1)/2$ pair-wise comparisons by respondents: ten objects, for example, would require forty-five comparisons and twenty objects would require 190 comparisons. Finally, the minimum number of objects required should be at least four times the number of dimensions. So a study with ten objects could produce only a meaningful two-dimensional solution. For three dimensions, a minimum of thirteen objects is needed.

Taking the above considerations into account, we included thirteen information technologies in our survey, allowing for the identification of up to three dimensions without imposing an unreasonable task on respondents. Our selection of information technologies was guided by, but not limited to, the information technology groups identified by Nevo et al. [2009] as central and enduring members of the IS discipline's core. Further attention was given to balancing the need for both similarity and diversity within the set of information technologies selected, to allow all underlying dimensions to emerge. We also aimed to include information technologies with high visibility that would be sufficiently known by our respondents and to incorporate both older and newer technologies. The final list of thirteen technologies was based on Nevo et al.'s [2009] ten IT artifact groups in the sense that each group was represented by at least one specific information technology. For example, TPS represented the Operational Systems category, and ERP and CRM represented the Enterprise Systems category. One category, which contained solely what appears to be obsolete technologies (i.e., the Resource Management Systems group), was not represented. In contrast, the emerging technology of virtual worlds was added to reflect the IS field's increasing interest in the affordability of these immersive, 3D virtual environments. The information technologies included in the MDS survey are presented in Table 1.

MDS requires that those who respond to the survey and judge the similarity among objects be familiar with the objects they evaluate [Robinson and Bennett, 1995]. The survey targeted primarily academics who study information technologies. Such respondents are likely to be appropriate judges capable of evaluating similarities and dissimilarities among the abovementioned information technologies for two reasons. First, some of the information technologies included may no longer be in common use and, as a result, information about them is often available only in academic publications. Second, many information technologies might be unfamiliar to IT professionals who specialize in a small set of technologies.

Table 1: Information Technologies Used for the MDS Study

Transaction Processing Systems (TPS)
Computer-Mediated Communication Systems (CMC)
Virtual Worlds (VW)
Webstores (WS)
Decision Support Systems (DSS)
Group Support Systems (GSS)
Databases (DB)
Interorganizational Systems (IOS)
Knowledge Management Systems (KMS)
Customer Relationship Management Systems (CRM)
Computer-Aided Design & Manufacturing Systems (CAD/CAM)
Enterprise Resource Planning Systems (ERP)
Knowledge-Based Systems (KBS)

An invitation to participate in this survey was submitted via the AIS Listserver, inviting members to complete an online questionnaire in which they were asked to rate the similarities between pairs of information technologies. Specifically, a list of all possible pairs of technologies (i.e., ERP and GSS, Database and IOS, IOS and CRM, etc.) was presented to the respondents who were asked to indicate how similar the two information technologies are (1 = Very Similar; 7 = Very Dissimilar). The rating of similarity was conducted based on respondents' knowledge of the technologies and their individual perceptions. In exchange for participation, respondents were offered a \$10 gift coupon. Eighty-seven completed questionnaires were obtained, resulting in a dataset comparable to other MDS studies (e.g., Goode and Gregor [2009]). Consequently, no further participation was solicited.

Of the respondents, 74 percent held a Ph.D. degree, and the rest were primarily Ph.D. students; 69 percent identified themselves primarily as academics, and the rest considered themselves as both academics and practitioners. In terms of experience with IT, 74 percent of the respondents had more than ten years of experience, 14 percent had between six and nine years of experience, and the remainder had between two and five years of experience. These characteristics suggested that the respondents would be able to evaluate the information technologies, thus generating adequate input data for the MDS.

Generating Spatial Maps

Data from the respondents were aggregated to form complete evaluation matrices. In particular, when the focus of the researcher is the dimensions underlying a set of objects, rather than the respondents themselves, it is useful to study the combined evaluations of the objects. Since respondents in this study provided a full assessment of similarities or dissimilarities among all information technologies, their responses can be aggregated by taking the average evaluations across all respondents to form composite maps [Hair et al., 2009]. Aggregations have a similar benefit to using scales with multiple items; while individual items are not sufficiently reliable, the scales they form often produce adequately reliable measures. In a similar manner, aggregations of individual perceptual responses can provide more stable perceptual maps [Day et al., 1976]. Accordingly, we combined the responses of the respondents and used the outcome as an input to the MDS technique.

The next step involved identifying the number of dimensions that best fits the data. When choosing a suitable MDS solution (i.e., the number of dimensions), the researcher should consider the likely difficulty of interpreting an n -dimensional solution compared with that associated with an $(n+1)$ -dimensional solution. Ideally, the researcher would use the smallest possible number of dimensions to explain the data. A more objective measure commonly used is the stress measure (also known as badness-of-fit) which represents the difference in distances between objects on the spatial maps and actual similarity judgments of respondents. By definition, the stress measure always improves with the addition of dimensions, and a score of 0.15 or below is considered acceptable [Day et al., 1976; Ein-Dor and Segev, 1993; Hair et al., 2009]. In order to identify the best number of dimensions, accounting for the trade-off between lower stress scores and complexity of the MDS solution, the common practice is to plot the stress values against the number of dimensions and set the number of dimensions at the elbow point.

Building on the above and based on the analysis of the data collected in this study (using SAS/STAT 9.22's PROC MDS), a three-dimensional solution was chosen, with the corresponding Kruskal stress score of 0.08 (a two-dimensional solution had a badness-of-fit score of 0.18). The maps representing this three-dimensional solution are presented in the three parts of Figure 1.

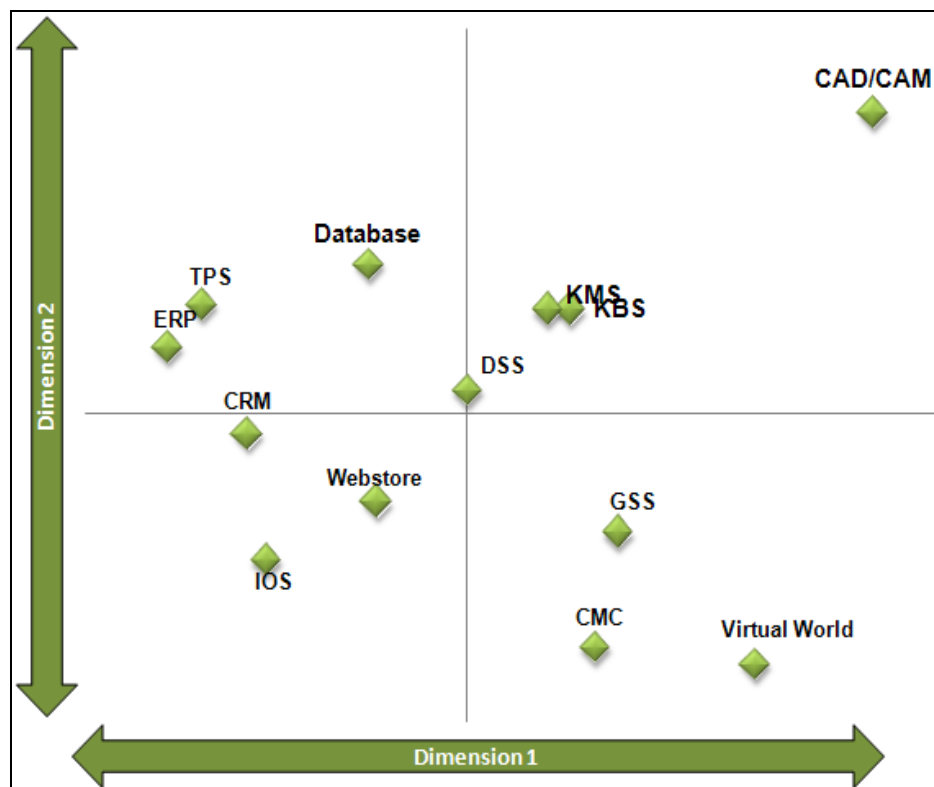


Figure 1a. Spatial Map of a Three-Dimensional Solution: D1 and D2

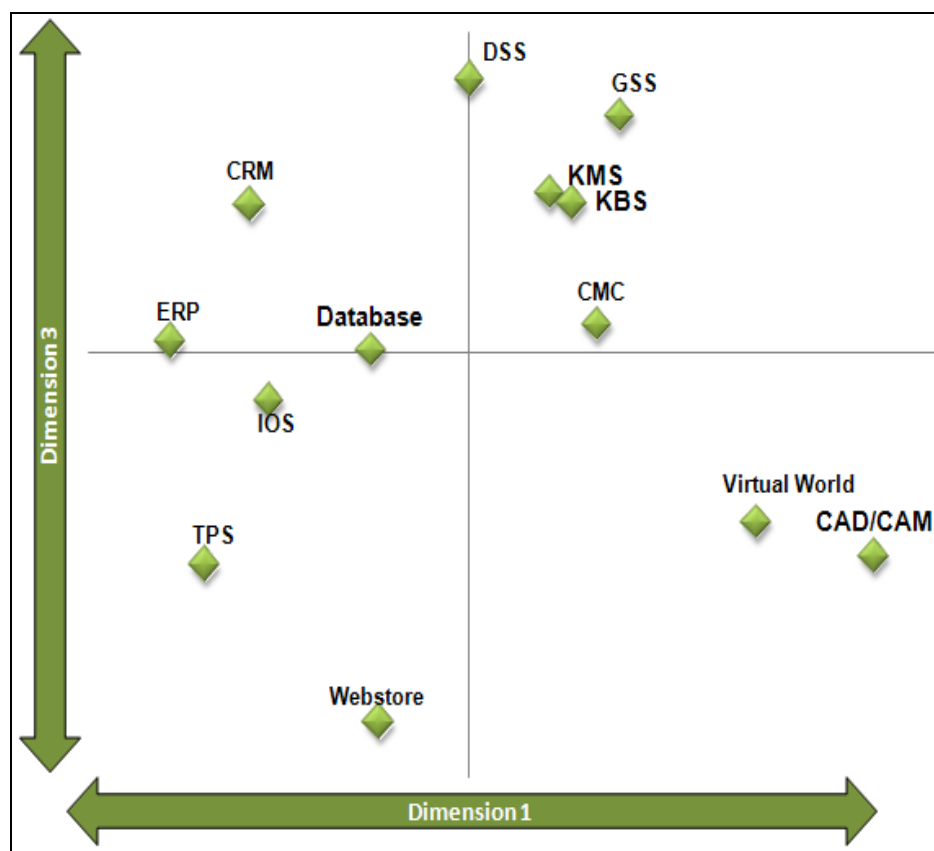


Figure 1b. Spatial Map of a Three-Dimensional Solution: D1 and D3

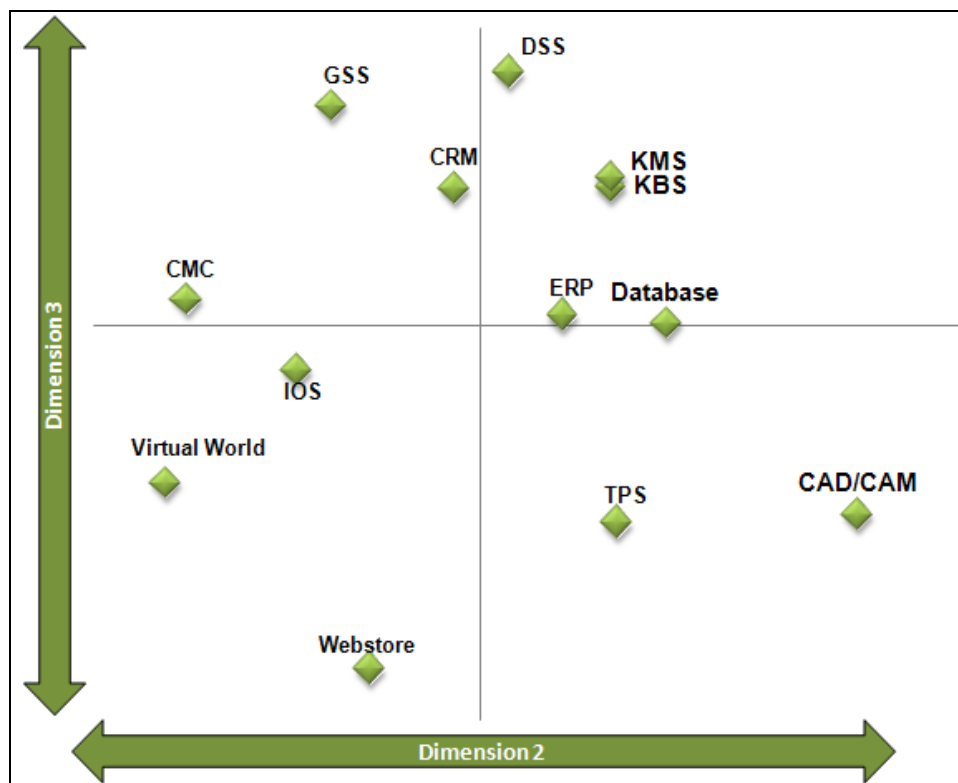


Figure 1c. Spatial Map of a Three-Dimensional Solution: D2 and D3

Another goodness-of-fit measure is R^2 , with a similar interpretation as in linear regression. Hence, higher values indicate that the MDS solution is able to explain more of the variance in the data. The R^2 measure for the three-dimensional solution was 0.96, indicating an acceptable goodness-of-fit [McCain, 1990]. Finally, to test the stability of the three-dimensional solution, MDS was executed twelve more times, each time excluding a different information technology. The resulting spatial maps did not change significantly, further indicating the stability of the original solution. This stability assessment technique was based on Ein-Dor and Segev [1993].

Interpreting the Spatial Maps

According to the MDS solution, three dimensions underlie the respondents' perceptions of similarity judgments (see Figures 1a, 1b, and 1c). These dimensions should be labeled in order to develop a meaningful classification. Further, only by understanding the meaning of these dimensions may we attempt to develop overarching theories of information technologies.

The interpretation of the spatial map involves linking the emerging dimensions, which are based on perceived judgments, to one or more known and objective characteristics [Hair et al., 2009]. As a first step in the interpretation of the dimensions, we studied the information technologies that appear at the extreme of each dimension. These information technologies are perceived to possess more of a certain characteristic compared with technologies placed away from the extreme points [Ein-Dor and Segev, 1993; Priem et al., 2002]. An initial interpretation of the three dimensions was then created by the authors.

Next, to assist in the interpretation of the emerging dimensions we asked prior respondents to look at the spatial maps associated with the MDS solution and attempt to interpret the visual output. Of the eighty-seven respondents who submitted a complete questionnaire in Stage 1, 42 indicated that they would be willing to further help with the study. We contacted those, sending them a link to an on-line questionnaire in which the three-dimensional solution was presented in three two-dimensional diagrams (i.e., Figures 1a, 1b, and 1c) and also in a simplified format (see Figures 2, 3, and 4 in the next section).¹ Respondents were asked to indicate their extent of agreement (1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree) with a series of statements regarding information technology characteristics (e.g., "This information technology facilitates communication") (see Table 2 for examples where L, M,

¹ No monetary incentives were offered in this second, follow-up survey.

and H stand for Low, Medium, and High association, respectively), as well as to come up with their own interpretations of the dimensions. Relying on the inputs of the respondents in labeling the dimensions also helped minimize researcher bias in this study. After an initial invitation and a follow-up reminder, twenty-four complete responses were received and studied to assist with the labeling of the dimensions.

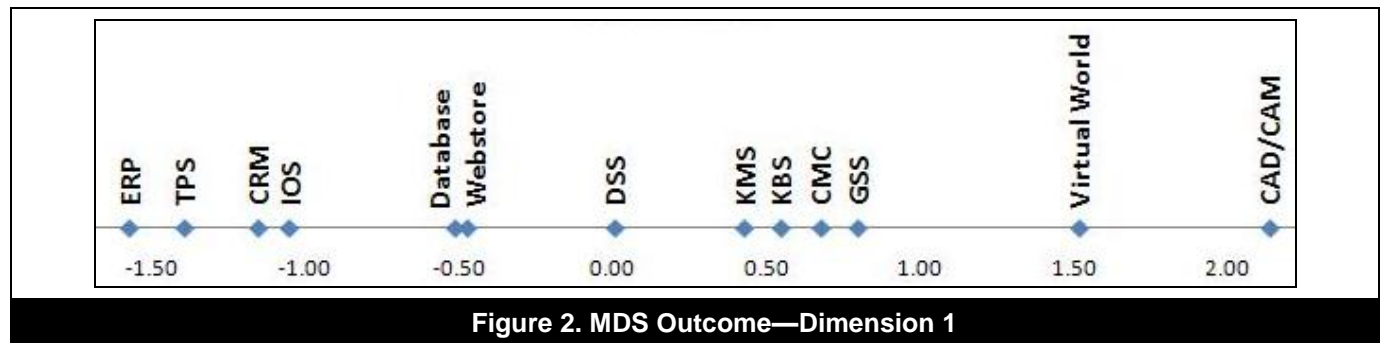
Table 2: Examples of Characteristics of Information Technologies					
Information Technology → Characteristic ↓	TPS	Webstore	GSS	...	KMS
Supports Commerce	H	H	L	...	L
Supports Communications	L	M	H	...	M
Internally Oriented	M	L	M	...	M-H
Supports Collaboration	L	L	H	...	M-H
...
Supports Operations	H	H	M	...	M

In the next section we discuss our findings in depth, exploring each of the three dimensions discovered in our MDS survey and offering an interpretation for each dimension.

III. DIMENSION INTERPRETATION

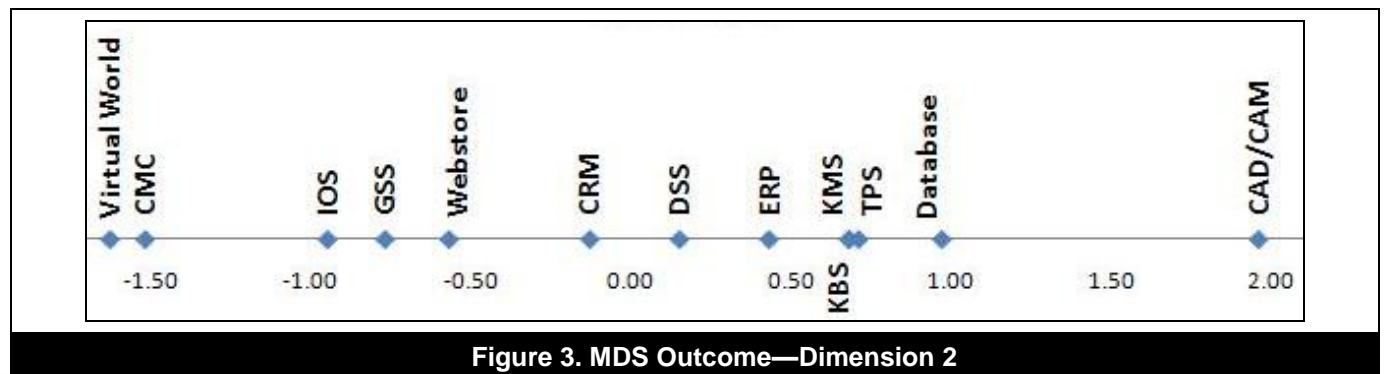
This section first offers an interpretation of each of the three dimensions before discussing the general contributions and implications of this study.

Dimension 1: Commerce/Transactions versus Product Design/Development



The first dimension can be interpreted as differentiating between information technologies with a product design and development versus commerce/transaction orientation. The respondents to the second survey characterized the information technologies on the left-hand side as providing support for commerce and transactions. Information technologies on the right-hand side were linked to product design and development. Indeed, examining the information technologies on the extreme left-hand side of dimension 1 we note that they tend to be commerce- and transaction-oriented systems, such as Enterprise Resource Planning (ERP) systems, Transaction Processing Systems (TPS), Customer Relations Management (CRM) systems, and Inter-Organizational Systems (IOS). On the extreme right-hand side are CAD/CAM and Virtual Worlds, both strongly linked to supporting product design and development processes.

Dimension 2: Internal versus External Focus



Dimension 2 was interpreted as differentiating among internally versus externally focused technologies. The respondents characterized the information technologies on the right-hand side as internal to the organization and highly dependent on data management capabilities. Technologies on the left were more strongly identified as externally focused and incorporating a communications capability. To a lesser extent, the richness of the media was associated with the information technologies on the left-hand side as well. Overall, however, the strongest distinction among information technologies along this dimension was the internal versus external focus, with the respective data management and communications capabilities.

Dimension 3: Operational versus Decision Support

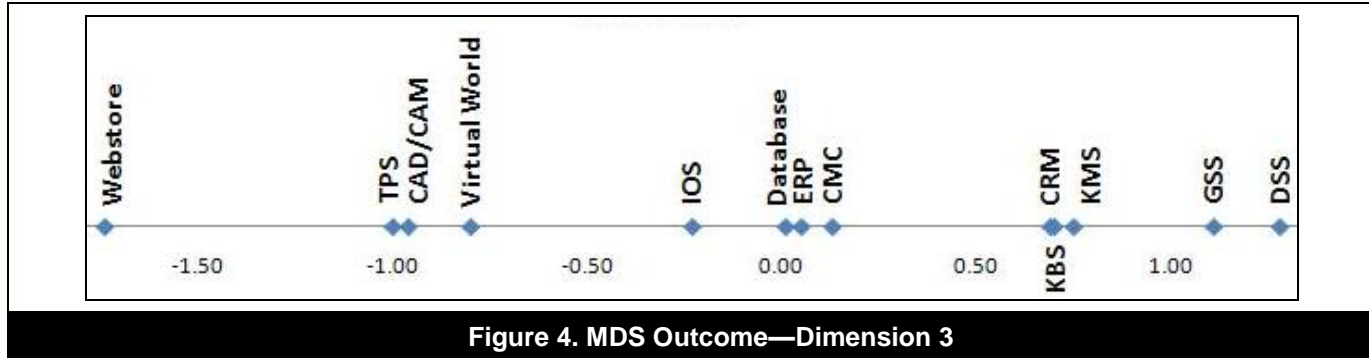


Figure 4. MDS Outcome—Dimension 3

In interpreting dimension 3, we looked at the information technologies located at the extreme ends of the scale. On the one side is the Webstore and on the other are Decision Support Systems (DSS) and Group Support Systems (GSS). These technologies represent the essence of dimension 3: operations versus decision-making. Indeed, the respondents indicated agreement with this characterization.

IV. THEORETICAL AND PRACTICAL IMPLICATIONS

We have thus far characterized the three dimensions identified in our MDS survey. These dimensions differentiate among the information technologies studied along the following three continua:

- Commerce/Transactions versus Product Design & Development
- Internal Focus versus External Focus
- Operational versus Decision Support

To better understand these dimensions, consider, for example, the Webstore technology. Webstore is characterized as operational, external, and commerce oriented, which fits well with the notion of a Website intended to support selling the organization's products to outside consumers. Another example is the CAD/CAM and Virtual World technologies. While located closely together along dimension 1 and dimension 3, these information technologies are at the opposite ends of dimension 2. Indeed, both technologies are strongly associated with product design, prototyping and simulations, and both can be seen as offering more operational than decision-making support, yet CAD/CAM are used internally within the organization while virtual worlds most commonly transcend physical organizational boundaries and enable external communications. Finally, consider the CMC technology, placed far right along dimension 2—the internal vs. external dimension—but more toward the center of the other two dimensions, indicating somewhat of a neutral role.

We now turn to discuss the theoretical implications of our classification and further development of the insights from our data. Recall that the goal of this study was to explore the relationships among key information technologies in order to identify common dimensions that can motivate and assist in the unification of research efforts and help develop theories in which information technologies play a key role. Such theories are expected to enhance the academic identity and legitimacy of the IS field [e.g., Benbasat and Zmud, 2003]. To support the development of theories concerning information technologies, a stronger understanding is needed regarding how various information technologies differ from each other and what they may share in common. The study described in this article identified and explored the interpretation of three underlying dimensions that may be used to classify information technologies (i.e., commerce/transactions versus product design and development, internal versus external focus, and operational versus decision support). This suggests that many of the information technologies we study, and often treat as distinct, are, in fact, variants of this small set of dimensions. Therefore, the classification obtained in this article can support the transfer of knowledge from one area to another, possibly reducing the challenges involved in implementing new information technologies in organizations.

Moreover, this finding can be used to concentrate research efforts on general types of information technologies rather than split up and expend efforts and resources studying technologies which are inherently similar in many of their characteristics. Consider the case of a Virtual World, dubbed a revolutionary technology and studied increasingly in recent years with several journals dedicating special issues to this technology. Our analysis shows a close relationship between Virtual Worlds and CAD/CAM, GSS, CMC, and IOS (see Figures 1a–1c, and the close-up view of these dimensions in Figure 5 below). This proximity to other information technologies can inform us about many areas related to the use of Virtual Worlds by organizations. For example, the close proximity of Virtual World and CMC/GSS (see Figure 5a) can inform us about the use of the former by virtual teams. Studies in which CMC/GSS was the focal technology can help us understand how Virtual Worlds may be used by teams which are distributed across time and space. Similarly, past research in which CMC/IOS was used to electronically connect business partners can inform our knowledge on the use of Virtual Worlds as tools to support interorganizational activities (see Figure 5b). In addition, our findings suggest that if researchers were interested in understanding the impact of Virtual Worlds on product design, a good starting point would be to examine studies on the organizational impacts of CAD/CAM and similar technologies. Recognizing that Virtual Worlds share two dimensions with CAD/CAM (see Figure 5c) can be useful in two ways. First, insights regarding technologies applied for product design can be used to inform new studies. Second, accumulation of knowledge is more likely to occur when new technologies are linked to older technologies, highlighting continuity instead of discontinuity. Clearly, Virtual Worlds differ from CAD/CAM technologies in other ways as can be seen from their opposite placement along dimension 2 (see Figure 3). In such cases, dissimilarities may highlight gaps in knowledge and help focus research efforts.

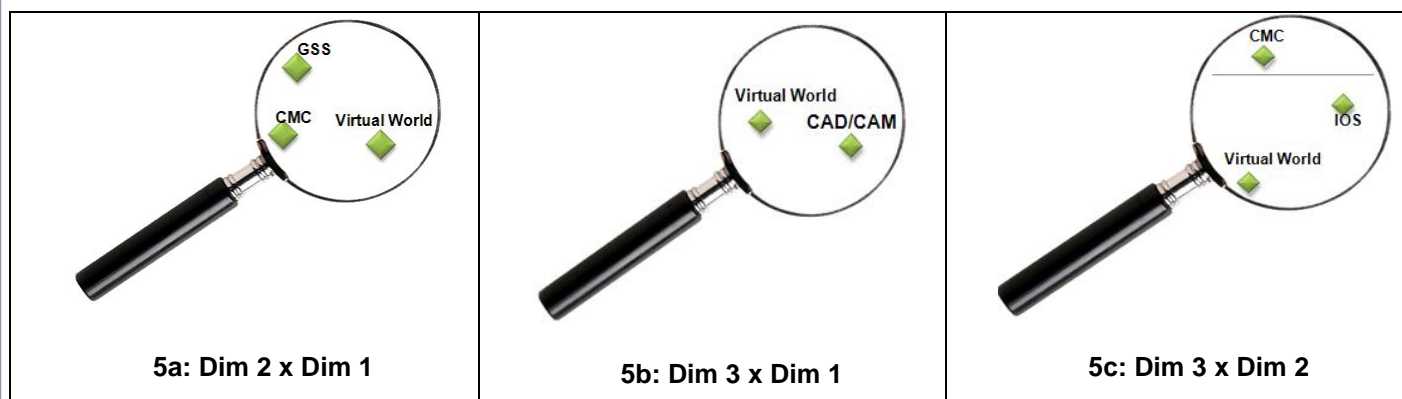


Figure 5 (Parts a, b, and c). Virtual World's Closest "Neighbors"

The main contribution of this study is therefore establishing a foundation upon which theories of information technologies may draw, identifying commonalities among technologies and pinpointing phenomena that span different technologies. With knowledge on how different information technologies relate to each other, IT professionals and IS researchers may better utilize and integrate existing knowledge when designing, developing, and studying new information technologies. In addition, the dimensions identified in our study offer a contribution to the development of IS theories by identifying the phenomena (i.e., the emerging dimensions) and offering sufficient information (i.e., the classification of information technologies) to enable researchers to theorize about why these dimensions exist, which attributes are most important, and what their impact is on end-users and organizations.

Concluding Remarks

This article took an exploratory approach to identifying the three dimensions emerging out of an MDS study. Given the state of our knowledge concerning such classifications, we feel that an exploratory approach is suitable at this stage. Building on our exploration, future work may identify specific attributes characterizing each of the three dimensions and take a more confirmatory approach to the emerging dimensions.

The nature of information technologies somewhat limits the generalizability of this work, as technological changes are constantly occurring. Although our proposed classification is not tied to specific information technologies, it is possible that a true evolutionary leap (as opposed to the evolution of labeling discussed earlier in this article) might introduce some new and relevant dimensions. Future work should study more closely such evolutionary changes. An additional constraint on generalizability stems from the profile of the typical respondent. As most respondents were academics who study and teach about information technologies, the results presented in this article may not parallel those that would be obtained from a study of IT practitioners. Therefore, we encourage future researchers to generate spatial maps based on similar evaluations performed by those who apply IT outside the world of academia. Notwithstanding this constraint, the results reported in this article can provide a foundation for theoretical

development and reduce research redundancy, since the study's respondents are representative of those who research and study information technologies.

In summary, this article provides important insights into the underlying common dimensions differentiating various information technologies that have been studied extensively by IS researchers and suggests that it may be possible to unite research efforts in a manner more conducive to producing cumulative findings. Another contribution made by this article is the exposition of relationships among information technologies that are often treated as unrelated. The findings can provide a conceptual bridge among these information technologies, thus enabling the development of general theories of information technologies. The classification also provides a parsimonious overview of key information technologies, an outcome useful to connecting the findings of past and future studies focusing on specific types of information technologies, which may assist in observing overarching empirical patterns that transcend specific technologies, and provide the foundations for new general IS theories.

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