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Toward an empirical taxonomy and model of evolution for telecommunications technologies

VARUN GROVER
College of Business Administration, University of South Carolina, Columbia, SC 29208, USA

MARTIN GOSLAR
College of Business Administration and Economics, New Mexico State University, Las Cruces, NM 88003, USA

A major group of information technologies pervading businesses in the 1990s are communication-based technologies. Given the diversity and complexity of these technologies, it is surprising that they have been the subject of precious little empirical research. This study examines the use of these technologies in American businesses. The data suggest preliminary patterns along which these technologies can be structured to facilitate both practice and research.

Introduction

Implementation of telecommunications technologies is becoming essential for business success. Cases of companies that use inter-organizational systems to link with their customers and suppliers are no longer unique. Systems are being used to create new markets, new products and expand services (Neo, 1988). Networks are being installed to increase capabilities for electronic communication, resource sharing and access of remote information. However, despite the pervasiveness of these technologies, the telecommunications environment remains complex. Technological developments, globalization, regulatory changes, political idiosyncrasies and an expanding need to transfer massive amounts of information are only some of the variables that corporations have to deal with regarding the use of these technologies. These variables, along with increasing costs of telecommunications, more choices due to deregulation and an intensely competitive global environment are making telecommunications more visible to top management. It is also making it an essential resource that needs to be planned for, in order to be utilized effectively.

With the convergence of communications and computing, telecommunications is increasingly becoming an indispensable component of IS practice and research (Scherr, 1983). Surprisingly, despite the acknowledged importance of telecommunications technologies (Scherr, 1983; Clemons and McFarlan, 1986; Hammer and Mangurian, 1987; Sullivan and Smart, 1987; Keen, 1988), there has been very limited academic research on how they are being used in business. Few articles in IS literature focus on telecommunications technologies. Those that do either discuss specific implementations of networks or applications (Crawford, 1982; McCauley, 1983; Montgomery and Benbasat, 1983; Kriebel and Strong, 1984; Grant, 1986; Manross and Rice, 1986; Railing and Housel, 1990) or the impact of telecommunications on business strategy (Barrett and Konsynski, 1982; Cash and Konsynski, 1985; Runge, 1985; Johnston and Carrico, 1988; Johnston and Vitale, 1988).

This paper examines the usage of a set of telecommunications technologies. Data were gathered from senior managers in 154 US corporations. Patterns of usage were identified in an attempt to derive a simplified structure for telecommunications technologies (henceforth referred to as TT). Various analyses were conducted and a framework for the evolution of TTs was proposed. While the conclusions derived from this study are preliminary, it represents one of the first attempts to evaluate empirically this group of technologies, which is growing in representation.

The study

Telecommunication technologies

An initial list of TTs, identified from published sources (e.g. Misra and Belitsos, 1987; Keen, 1988; Straub and Wetherbe, 1989; Fitzgerald, 1990; Roche, 1991; Grover and Goslar, 1993), was mailed to a panel of six experts – three academic and three practitioners – for evaluation. The academic experts were involved in the study of TTs and their impacts. The practitioner experts were integrally involved with the management and implementation of TTs. The panel was asked to add, delete or combine TTs from the list as they deemed necessary to arrive at a set of representative technologies. The researchers then reconciled feedback from the panel into a

set of 15 TTs that were used in the final questionnaire. It should be noted that these TTs are *not mutually exclusive*. They represent applications, technologies, and platforms that are independently initiated by an individual organization. The TTs are described below in no specific order:

(1) *Intelligent/mobile phones*. Cellular and associated wireless communication technologies that can and are carried within and external to the organization. Examples include executive mobile car phones, beepers, and service vehicle communications.
(2) *Voice/data PBX (internal telephone system)*. The traditional telephone system used by industry to transfer data and voice across corporate sites and to support individual on-line communications. PBXs typically contain features that facilitate the management and cost control of the intra-organizational telephone system.
(3) *Voice oriented systems*. Technologies that combine the features of telephone conversations and postal mail; the spontaneity of picking up the phone and the time independence of a letter. The voice system, usually attached to the PBX, facilitates asynchronous interpersonal communication (e.g. voice mail).
(4) *Integrated Services Digital Network (ISDN)*. An increasingly viable communications approach, requiring specialized hardware and software, enabling concurrent transmission of video, data, and voice media. End-to-end digital connectivity (as opposed to analog) and standardized network elements (line capacities, PBXs, switching facilities, etc.) are the goals of ISDN. Currently being installed and operated on a regional and often trial basis by larger firms.
(5) *Local Area Networks (LAN)*. Hardware and software installed to link individual and business unit computer workstations within a confined geographic region. Integration enables a variety of information flows including migration of data files, spreadsheets, mail, as well as common access to application and system software.
(6) *Wide Area Networks (WAN)*. Communication technologies that link widely dispersed business units.
(7) *Facsimile (FAX)*. Technology enabling transmission of documents electronically.
(8) *Electronic mail (e-mail)*. Electronic messaging normally conducted asynchronously based on person to person(s) flow (compared with computer to computer communications).
(9) *Video conferencing*. Those technologies which facilitate business seminars and meetings across physical distances. Conference participants may both view and talk with each other interactively without being present literally.
(10) *Video text*. Integration of video, text and user intervention for multimedia exposure. Usually allows users with no training to access information or graphics. This technology is often applied in educational and training environments.
(11) *Value Added Network (VAN)*. Communication lines offered through common carriers that facilitate timely and accurate information flow. 'Value added' includes processing services such as error checking, retransmission and alternate routing in case of network node failure.
(12) *Access to commercial databases*. The capability to logon to external databases (for a fee) for access to data to maintain and advance the competitive market position of a corporation.
(13) *Network management software*. Systems software to operate and monitor computer network communications activities. Examples of these activities include remote diagnostics, detection of link failure, dynamic on-line help/status facility, examination of network log to check parameters, etc.
(14) *Interorganizational communications links*. Bridging and conversion technologies that enable transmission and receipt of such items as documents, transactional data, functional information and planning perspectives across organizational boundaries. These include EDI, JIT or links with customers to facilitate sales of goods or services.
(15) *Corporate owned communication lines*. Corporate ownership of the communications medium (e.g. coaxial cable, fibre optic link, microwave link) as opposed to using links through a common carrier. This ownership implies that the company is totally responsible for the design, engineering, installation, operation and maintenance of the line.

Corporate owned communication lines and network management software were added to the initial list by three members of the panel. Systems involving EDI, JIT or links with customers to facilitate sales of goods and services were combined under interorganizational communication links.

Instrument development

A questionnaire was developed to measure the adoption and implementation of each TT identified. These constructs have been used in prior empirical work on organizational innovation (Thompson, 1965; Pierce and Delbecq, 1977). Similar to other studies on innovation adoption, respondents were asked whether a decision had

been made to *adopt* the TT (yes or no) (Moch and Morse, 1977; Zmud, 1982). *Implementation* was measured on a 7-point Likert scale ranging from 'not implemented' to 'extensively implemented' for each TT. Since the instrument was directed at corporate centres, the extent of implementation should reflect the degree to which the TT had been implemented (i.e. set up) throughout the organization. Similar measures were used by Zmud (1982) in measuring the implementation of individual software practices. Another measure, *innovativeness* was assessed for each IT. This represents the uniqueness or novelty of the technology as perceived by the respondent. The diverse and dynamic nature of TTs warranted a measure with the ability to separate the more routine technologies from the novel ones. While there is no theoretical basis to evaluate the novelty of a technology, empirical work in technological innovation has used similar measures (e.g. Moch and Morse, 1977; Dewar and Dutton, 1986). The concept is similar to the dichotomy of radical (departure from existing practice) *vs.* incremental (minor improvements) technologies, described in the innovation literature (Ettlie *et al.*, 1984). This variable was also captured on a 7-point scale ranging from 'not innovative' to 'very innovative'. Since the objective of this study was primarily descriptive, respondents were asked to evaluate the innovativeness of each technology from the point of view of their own organization.

Sample

The respondents were senior IS executives randomly selected from the Standard and Poor's 1991 *Corporate Guide* and *The Information Week 500*. There were 777 questionnaires effectively mailed (i.e. were not returned due to change of address). Of the 165 responses received, 154 were usable resulting in a response rate of about 21%.

Most of these organizations are presumably forerunners in the use of information technologies by virtue of their larger size (average sales over $300 million). 63% of the sample consists of manufacturing and finance firms. Almost 65% of the respondents surveyed were at the Director, Vice-President or higher level in the organization as indicated by their title. Most of them were in charge of significant IS/Telecommunications operations which enables their ability to respond to questions on specific telecommunications technologies.

Relationships between telecommunications technologies

Tables 1 and 2 report insights into the relationships between various TTs. Table 1 identifies the basic relationships between adoption of various combinations of TTs, while Table 2 statistically groups the technologies along different dimensions.

Pairwise technology adoption

Table 1 illustrates the results of 105 Chi-square analyses between the dichotomous adoption measures for each pair of technologies. A significant relationship (depicted by a YES in the corresponding cell) indicates that the null hypothesis (i.e. independence between technologies) is rejected and that adoption of one technology is related to the adoption of the other. Following the relationships for each technology can provide insight into the co-adopted TTs. Particularly interesting observations from Table 1 are discussed below.

Pervasive technologies

There are some technologies in the list that do not exhibit relationships with other technologies. These technologies exist in organizations regardless of other TTs. For instance, adoption of PBX systems is not related to the adoption of any other TT. This indicates that the pervasiveness and widespread use of PBXs is taking place regardless of the use of any other TT. Computerized PBXs (called CBXs) are probably becoming the *de facto* standard. Also, the use of FAX technology for document transfer seems to be so pervasive as an office tool that it is adopted independently of all other TTs.

Backbone technologies

In contrast to the technologies above, adoption of wide-area networks (WAN), and value added networks (VAN) tends to be related to adoption of almost all other TTs. This would suggest that the existence of a backbone network infrastructure is a precursor, not only to network traffic, but also to most TT applications (like e-mail, ISDN, videoconferencing, videotext, network management software, etc.).

Advanced technologies

Adoption of the two most innovative TTs, videoconferencing and ISDN, is related to the adoption of most other TTs. This suggests that users of more 'advanced' TTs tend to also use the less advanced ones.

In summary, the pairwise comparisons provide preliminary indication of TT usage patterns. Certain technologies are pervasive and independently implemented; others form the backbone that facilitates other implementations. Users of advanced TTs tend not to do so in isolation but in conjunction with other TTs.

Table 1 Relationship between adoption of individual TTs

	PBX	Voice System	ISDN	LAN	WAN	E-Mail	Video-Conf.	Videotex	VAN	Network Software	Corp. Lines	Mobile Phones	FAX	Comm. Database	Interorg. Links
PBX	XX														
Voice System		XX													
ISDN		YES	XX												
LAN			YES	XX											
WAN		YES	YES	YES	XX										
E-Mail				YES	YES	XX									
Video-Conf.		YES	YES	YES	YES	YES	XX								
Videotex			YES		YES		YES	XX							
VAN		YES		YES	YES	YES	YES	YES	XX						
Network Software		YES	YES	YES	YES	YES	YES		YES	XX					
Corp. Lines		YES	YES	YES	YES	YES	YES	YES	YES	YES	XX				
Mobile Phones			YES		YES			YES	YES		YES	XX			
FAX													XX		
Comm. Database				YES	YES	YES	YES	YES	YES	YES	YES	YES		XX	
Interorg. Links		YES	YES		YES		YES		YES	YES					XX

YES indicates a relationship between the TT pair (i.e. chi-square value significant at $p < 0.05$). Chi-square was used since the measures of adoption were dichotomous (nominal).

Table 2 Factor analysis: innovativeness and implementation of TTs

Factor analysis: technology innovativeness				Factor analysis: technology implementation				
	Factor 1 (Routine)	Factor 2 (Innovative)	Factor 3 (Very innovative)	Factor 1 (Wide area)	Factor 2 (Local area)	Factor 3 (Future)	Factor 4 (Telephone)	Factor 5 (Specialist)
PBX	0.775						0.778	
Voice system	0.589	0.505					0.530	
ISDN			0.723			0.764		
LAN	0.601	0.559			0.768			
WAN	0.601			0.689				
e-mail	0.517	0.566			0.529			
Video-conferencing			0.539			0.597		
Videotex			0.742					0.626
VAN			0.606	0.784				
Network software		0.546			0.593			
Corporate lines		0.766			0.628			
Mobile phones	0.684							0.693
FAX	0.773						0.594	
Commercial database access	0.500			0.571				
Interorganizational links		0.748		0.662				
Percentage of variance	41.6	10.3	7.1	24.9	9.4	8.0	7.2	7.1
Eigen value	6.2	1.6	1.1	3.7	1.4	1.2	1.1	1.1

Telecommunications taxonomies

Exploratory factor analysis was conducted on two dimensions: innovativeness and implementation. As indicated earlier, both variables were measured on 7-point scales for each technology. Values for each scale for all the 15 TTs were independently factor analysed. Orthogonal factors were derived using varimax rotation in an attempt to see how the technologies reduced dimensionality and grouped together along these two dimensions (Green, 1978). Table 2 illustrates the results for both innovativeness and implementation respectively. Only factor loadings of greater than 0.5 are shown.

Examination of Table 2 provides some further guidelines for a TT taxonomy. Factor 1 includes PBX, LAN, WAN, voice systems, e-mail, mobile phones, FAX and commercial databases. All these technologies are fairly mature and most organizations are using them on a fairly routine basis as and when needed. This factor has been named *routine TTs*.

Factor 2 includes LAN, e-mail, voice systems, corporate-owned lines, interorganizational links and network management software. While LAN, e-mail and voice systems are repeated in this group, overall it represents more innovative use of TTs. This set of technologies might evolve after a basic infrastructure (PBX, leased lines through the common carrier, etc.) is already in place. For instance corporate ownership of lines tends to occur in cases where leasing is not possible or too expensive. Interorganizational links have been known to evolve from existing internal systems (Runge, 1985). Network control software is generally implemented in an attempt to control runaway network costs. This factor has been named *innovative TTs*.

Factor 3 represents the next level of TT use. ISDN, VAN, videoconferencing and videotext are included in this category. All these technologies are potentially very exciting and are being used by firms that are at the highest level of sophistication of TTs, unless their particular context warrants the use of a particular technology. This technology set has been named *very innovative TTs*.

While the first analysis summarizes the group movement of technologies on the innovativeness dimension, the second analysis does the same for the implementation dimension. Factor analysis along the implementation dimension yields a 5-factor solution illustrated in the second half of Table 2. The implementation level for TTs in any group tend to move together. In other words there is a correlation between the implementation levels of technologies in a group (i.e. they tend to be implemented together). The five groups are categorized below with a representative title.

Factor 1 includes WAN, VAN, commercial database access and inter-organizational links. All these

technologies typically require network access over an area wider than a few adjacent buildings. This set has been named *wide area technologies*.

Factor 2 includes LAN, e-mail, corporate-owned lines, network management software. This might indicate that most LANs are constructed with lines under company ownership and implement network control software and e-mail. Accordingly, this set of TTs has ben labelled *local area technologies*.

Factor 3 represents *future technologies*: Video-conferencing and ISDN.

Factor 4 represents *telephone network technologies*: PBX, voice systems and FAX. These technologies require a telephone system to effectively implement.

Finally, Factor 5 represents *specialist* technologies: mobile phones and videotext. While it is not clear why they load together, both these technologies are potentially powerful, but are currently being used in specific contexts.

Looking across each row of Table 2, the two taxonomies can be compared. For instance, *wide area technologies* while implemented together include a myriad of routine (commercial database access), innovative (inter-organizational links) and very innovative (VANs) TTs. All the *local area technologies* are innovative, while all the *future technologies* are perceived as highly innovative. *Telephone network technologies* tend to be routine or innovative.

Collectively, these groupings represent initial empirically derived taxonomies for telecommunications technologies. Figure 1 provides a pictorial representation of the groupings.

Building an evolutionary model

A convergence of computing and communications is currently underway, both technologically and organizationally. With the undeniable importance of telecommunications technologies in the IS arena, it is surprising that the literature is sparse on this area. The objective of this study was to identify a set of representative telecommunications technologies and to provide insight into their joint usage. This provides an important first step toward an empirical taxonomy for telecommunications technologies. However, the fundamental question of the practical utility of such taxonomies remains unanswered. Based on the results of pairwise adoption comparison and factor analyses of innovativeness and implementation, a stage model of TT evolution is proposed. Such models provide descriptive insight into how TTs are being absorbed into contemporary business organizations. When adequately validated, an evolutionary model can be used to derive prescriptions for effective telecommunications planning.

Four stages of TT evolution in organizations are proposed. These stages are called the utility stage, localization stage, integration stage and innovation stage. The model is illustrated in Figure 2 and discussed below.

Stage 1: the telecommunications utility

Organizations in Stage 1 tend to use the telephone network as their basic telecommunications facilitator. The deregulation and increasing competitiveness among common carriers allows corporations to rely on the service of the traditional POTS (plain old telephone system). The basic objective of telecommunications in these organizations is to ensure a reliable communication service. These organizations typically use the wide area switched phone network for basic communication. They use a PBX for their internal phone system management and they routinely use common carrier lines (mostly switched, but often point–to–point leased lines) for data and FAX communications. Other routine technologies like mobile phones, commercial database access etc. might co-exist in these organizations but they are often serving isolated constituencies based on needs and resources.

Stage 2: exploiting localized telecommunications

Organizations in Stage 2, while retaining their reliance on the phone network, are relatively more advanced users of TTs. Local area networks are developed by user groups or as a cohesive IS effort. The objectives of telecommunications in these organizations is not only reliable communication, but resource sharing. Local groups can share data and applications. Almost inevitably applications like e-mail proliferate with the LAN infrastructure. Network management software is installed to monitor usage and control costs. Most LANs are constructed through corporate owned lines and not through common carriers.

Stage 3: integrating the chaos

Organizations realize in Stage 3 that there is too much isolation of TTs. There is often a concerted effort to integrate TTs through a WAN so the telecommunications resource can be utilized effectively at the organizational level. The basic objective reflects this in terms of facilitating coordination among groups and integration of diverse platforms. Often intelligence is distributed in the WAN creating value added services (VANs). Other innovative uses of an integrated infrastructure expand, like database access and interorganizational linkages.

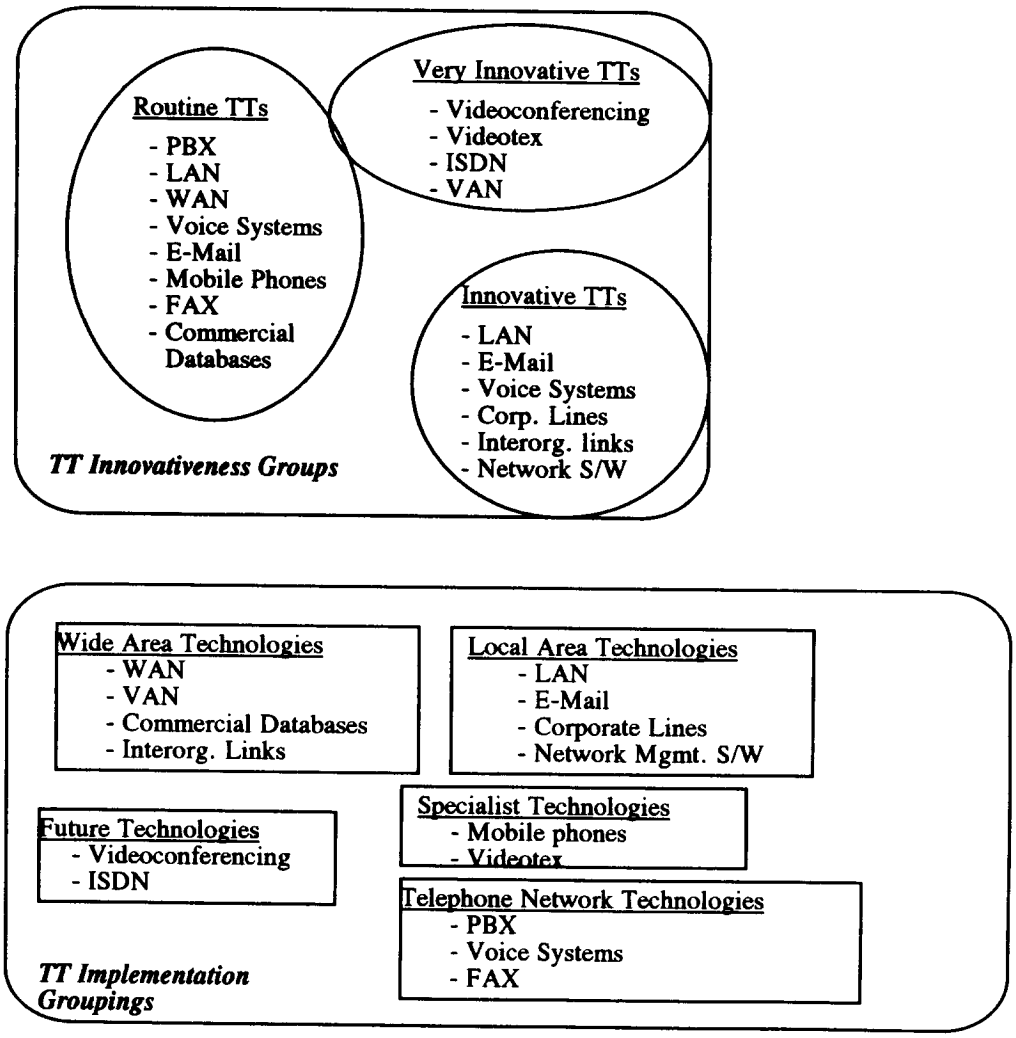

Figure 1 Illustration of technology groupings

Stage 4: being innovative

Once a backbone infrastructure is in place, applications at both the local and wide area levels proliferate. Investment in sophisticated technologies like videotex and videoconferencing might take place. The telecommunications resource is no longer a series of isolated innovations but an integrated technological backbone that can be utilized toward corporate effectiveness.

These four stages are proposed as a synthesis of the results from the study. It assumes that routine technologies start at stage 1 and exist through the four stages. It evolves through a series of steps increasing in innovativeness. It also recognizes the cohesiveness of TT groups that are implemented together. While the results are preliminary and the model requires further research, it provides a potentially powerful basis for telecommunications planning.

Conclusion

A number of classifications of telecommunications technologies, while providing useful frameworks for structuring the myriad of diverse TTs, also have implications for practice and research. For instance, the five sets of technologies derived from factor analysing the TTs on the implementation scale strongly suggest that wide-area technologies, local area technologies and telephone-system based technologies are implemented together within their respective groups. Corporations that implement individual technologies piecemeal, rather than together, might be losing out on the technological synergy within a group. TT specialists should be able to deal with the commonalities within technology groupings, rather than focus on individual technologies without evaluating the opportunities for those technologies that are natural

Stage 1: Utility	Stage 2: Localization	Stage 3: Integration	Stage 4: Innovation
			Existing infrastructure facilitates technologies with major investments undertaken like videotex and videoconferencing.
		Concerted effort to integrate isolated technologies through a WAN.	More strategic application of technologies.
		Basic objective expanded to include integration and coordination.	
		Additional value-added services acquired (VAN)	Concerted effort to integrate isolated technologies through a WAN.
		Distributed architecture	Basic objective expanded to include integration and coordination.
		Telecommunication network extends to other organizations through database access, interorganizational linkages, etc.	Additional value-added services acquired (VAN)
	Local Area Networks are developed		Distributed architecture
	Basic objective exapanded to include resource-sharing (i.e., data, peripherals)		Telecommunication network extends to other organizations through database access, interorganizational linkages, etc.
Reliance on wide area telephone network	Applications on LAN expand (e-mail, management software)	Local Area Networks are developed	
Basic objective to ensure reliable communication	Lines are owned, leased and switched	Basic objective exapanded to include resource-sharing (i.e., data, peripherals)	
Phone related technologies: PBX, FAX and Voice Mail		Applications on LAN expand (e-mail, management software)	Local Area Networks are developed
Switched and leased lines	Reliance on wide area telephone network	Lines are owned, leased and switched	Basic objective exapanded to include resource-sharing (i.e., data, peripherals)
Other "routine technologies" may exist, like, mobile phones, commercial databases, e-mail but they are piece-meal and isolated	Basic objective to ensure reliable communication		Applications on LAN expand (e-mail, management software)
	Phone related technologies: PBX, FAX and Voice Mail	Reliance on wide area telephone network	Lines are owned, leased and switched
	Other "routine technologies" may exist, like, mobile phones and commercial databases but they are piece-meal and isolated	Basic objective to ensure reliable communication	
		Phone related technologies: PBX, FAX and Voice Mail	Reliance on wide area telephone network
			Basic objective to ensure reliable communication
			Phone related technologies: PBX, FAX and Voice Mail
			Other "routine technologies" may exist, like, mobile phones and commercial databases but they are piece-meal and isolated

Figure 2 Evolution of telecommunications technologies

extensions or conjointly implementable. Researchers pursuing lines of inquiry related to TTs might find it appropriate to re-evaluate their technological unit of analysis to include technology sets or stage of evolution, rather than individual technologies or applications. Further, there is opportunity for researchers to refine and extend the measures and relationships examined. For instance, a unidimensional measure of implementation was used in this study which does not capture the breadth and depth of implementation through the organization. Relationships between organizational and other contextual factors and various types of implementations can provide richer insights into the business assimilation of telecommunications technologies.

In conclusion it is important for IS research, and practice, to begin to recognize the inextricable nature of these technologies as a part of the IT infrastructure of firms. The descriptive work reported here is only a first step to deriving prescriptive implications for management of these technologies.

References

Barrett, S. and Konsynski, B. (1982) Inter-organization information sharing systems. *MIS Quarterly* **Special Issue**, **6**, 93–105.

Cash, J.I. and Konsynski, B. (1985) IS Redraws Competitive Boundaries. *Harvard Business Review* **March–April**, 134–142.

Clemons, E.K. and McFarlan, W.F. (1986) Telecom: hook up or lose out. *Harvard Business Review* **July–August**, 91–97.

Crawford, A.B. (1982) Corporate electronic mail – a communication intensive application of information technology. *MIS Quarterly* **6**(3), 1–14.

Dewar, R.D. and Dutton, J.E. (1986) The adoption of radical and incremental innovations: an empirical analysis. *Management Science* **November** 1422–1433.

Ettlie, J.E., Bridges, W.P. and O'Keefe, R.D. (1984) Organization strategy and structural differences for radical versus incremental innovation. *Management Science* **June**, 682–695.

Fitzgerald, J. (1990) *Business Data Communications: Basic Concepts, Security and Design* (John Wiley and Sons, New York).

Grant, J.C. (1986) Electronic banking and telecommunications. *Information and Management* **11**, 3–7.

Green, P.E. (1978) *Analysing Multivariate Data* (Dryden Press, Hinsdale, IL).

Grover, V. and Goslar, M. (1993) Information technologies for the 1990s: the executives' view. *Communications of the ACM* **36**(3), 17–19 & 102–103.

Hammer, M. and Mangurian, G.E. (1987) The changing value of communications technology. *Sloan Management Review* **Winter**, 65–71.

Johnston, H.R. and Carrico, S.R. (1988) Developing capabilities to use information strategically. *MIS Quarterly* **12**(2), 153–165.

Johnston, H.R. and Vitale, M.R. (1988) Creating competitive advantage with interorganizational systems. *MIS Quarterly* **12**(2), 153–165.

Keen, P.G.W. (1988) *Competing in Time: Using Telecommunications for Competitive Advantage* (Harper & Row, Cambridge, MA).

Kriebel, C.H. and Strong, D.M. (1984) A survey of the MIS and telecommunications activities of major business firms. *MIS Quarterly* **8**(3), 171–178.

Manross, G.G. and Rice, R.E. (1986) Don't hang up: organizational diffusion of the intelligent telephone. *Information and Management* **10**, 161–175.

Misra, J. and Belitsos, B. (1987) *Business Telecommunications – Concepts, Technologies and Cases in Telematics* (Irwin, Homewood, IL).

Moch, M.K. and Morse, E.V. (1977) Size, centralization and organizational adoption of innovations. *American Sociological Review* **October**, 716–725.

Montgomery, I. and Benbasat, I. (1983) Cost/benefit analysis of computer based message systems. *MIS Quarterly* **7**(1), 1–14.

McCauley, H.N. (1983) Developing a Corporate Private Network. *MIS Quarterly* **7**(4), 19–33.

Neo, B.S. (1988) Factors facilitating the use of information technology for competitive advantage: an exploratory study. *Information and Management* **15**, 191–201.

Pierce, J.L. and Delbecq, A.L. (1977) Organization structure, individual attitudes and innovation. *Academy of Management Review* **2**, 27–37.

Railing, L. and Housel, T. (1990) A network infrastructure to contain costs and enable fast response: the TRW process. *MIS Quarterly* **14**(4), 405–419.

Roche, E.M. (1991) *Telecommunications and Business Strategy* (The Dryden Press, Orlando, FL).

Runge, D.A. (1985) Using telecommunications for competitive advantage. Unpublished PhD Dissertation (Oxford University, UK).

Scherr, A.L. (1983) A perspective on communications and computing. *IBM Systems Journal* **22**(1/2), 5–9.

Straub, D.W. and Wetherbe, J.C. (1989) Information technologies for the 1990s: an organizational impact perspective. *Communications of the ACM* **32**, 11, 1328–1339.

Sullivan, C.H. and Smart, J.R. (1987) Planning for information networks. *Sloan Management Review* **Winter**, 39–44.

Thompson, V.A. (1965) Bureaucracy and innovation. *Administrative Science Quarterly* **10**, 1–20.

Zmud, R.W. (1982) Diffusion of modern software practices: influence of centralization and formalization. *Management Science* **December**, 1421–1431.

Biographical notes

Varun Grover has a BTech degree in electrical engineering from IIT, New Delhi, an MBA, and a PhD from the University of Pittsburgh. He is currently an Assistant

Professor of MIS in the College of Business Administration, University of South Carolina. He has published over 30 papers on the management of information systems in numerous journals.

Martin Goslar has a PhD from Arizona State University. He has worked on numerous consulting projects for the US government. Currently, he is an Associate Professor at New Mexico State University.

Address for correspondence: Professor Varun Grover, College of Business Administration, University of South Carolina, Columbia, SC 29208, USA. Phone: (803)777-5923 Bitnet: FSU00028@BAGAMCOK Internet: VGROVER@DARLA.BADM.SCAROLINA.EDU.