CONVERGENCE IN COMMUNICATIONS AND BEYOND

EDITED BY

ERIK BOHLIN
SCHOOL OF TECHNOLOGY MANAGEMENT & ECONOMICS,
CHALMERS UNIVERSITY OF TECHNOLOGY
S-412-96 GÖTEBORG,
SWEDEN

KAROLINA BRODIN
CENTER FOR COMMUNICATIONS AND INFORMATION RESEARCH
STOCKHOLM SCHOOL OF ECONOMICS
S-113-83 STOCKHOLM
SWEDEN

ANDERS LUNDGREN
CENTER FOR COMMUNICATIONS AND INFORMATION RESEARCH
STOCKHOLM SCHOOL OF ECONOMICS
S-113-83 STOCKHOLM
SWEDEN

BERTIL THORNGREN
CENTER FOR COMMUNICATIONS AND INFORMATION RESEARCH
STOCKHOLM SCHOOL OF ECONOMICS
S-113-83 STOCKHOLM
SWEDEN

2000
ELSEVIER
AMSTERDAM – LONDON – NEW YORK – OXFORD – PARIS - SHANNON – TOKYO

ELSEVIER SCIENCE B.V.
Sara Burgerhartstraat 25
P.O. Box 211, 1000 AE Amsterdam, The Netherlands

First edition 2000

Library of Congress Cataloging in Publication Data
A catalog record from the Library of Congress has been applied for.

ISBN: 0 444 50216 5

♾ The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).
Printed in The Netherlands.

PREFACE

The International Telecommunications Society (ITS) convened its 12th Biennial Conference in Stockholm, June 20-24, 1998. The conference was organised by the Center for Communications Research (CIC), Stockholm School of Economics, upon the leadership of the Conference Chair and CIC Director, Professor Bertil Thorngren. The event had two main sponsors – Telia and the Swedish Transport and Communications Research Board. The conference theme was entitled "Beyond Convergence", picking up not only a hot topic – convergence – but also asking what comes next.

The conference was a significant success. The theme attracted a large amount of submissions. In fact, it drew the largest pool of submissions to an ITS conference ever (more than 360 paper proposals), and the conference was the largest ever (more than 500 participants) from all over the world. Conference evaluations were very positive after the event. The conference also brought to the fore new research and policy agendas. Most notably, the conference attracted a sizable number of contributions dealing with Internet and electronic commerce, topics which had for obvious reasons received less attention at the previous ITS biennials.

This book is based upon selected and edited conference papers. The editors have been careful to select a wide range of papers in order to capture the convergence issue from a number of perspectives, and to achieve a historical state-of-the-art. The volume succeeds in providing a multi-faceted and rich view of convergence, and on emerging issues.

Göran Belfrage
Senior Adviser
Strategy and Corporate Development
Telia

Erik Hörnell, Ph.D.
Head of Telematics Division
Swedish Transport and Communications
Research Board

Acknowledgements

The conference and this volume had not come to pass without critical assistance and support. The editors would like to thank and acknowledge these contributions:

- *Main Sponsors of the Conference*: Swedish Transport and Communications Research Board and Telia
- *Targeted Sponsors of the Conference*: A.T. Kearney; Ericsson Mobile Communications; L.M. Ericsson; Nordbanken; Squire, Sanders & Dempsey; Stockholm School of Economics Executive Education; Telecom Italia; Telia Research; Telstra; Öhrlings, Cooper & Lybrand
- *Sponsors of this Volume*: Swedish Transport and Communications Research Board and Telia
- *Editorial Assistance for this Volume*: Eva Burford, and Jon van Leuven
- *Conference Organisers and Conference Committee*: the Organising Team of CIC (Karolina Brodin, Anders Lundgren, Bengt Mölleryd and Bertil Thorngren) and the Conference Theme Coordinators (Cristiano Antonelli, Jacques Arlandis, Erik Bohlin, Alain de Fontenay, Eric de Fontenay, Peter Hagström, Sandy Levin, and Tatsuya Omura)
- ITS Executive Committee and ITS Board of Directors

List of Contents

Part III: Internet and User Demand

Part IV: Convergence and Business Networking

Part V: Convergence, Strategy and Structure

List of Tables

List of Figures

PART I

CONVERGENCE IN COMMUNICATIONS: AN OVERVIEW

Convergence in Communications and Beyond
E. Bohlin, K. Brodin, A. Lundgren and B. Thorngren (Editors)

CHAPTER 1

Convergence in Communications and Beyond: An Introduction

Erik Bohlin
School of Technology Management & Economics,
Chalmers University of Technology, Göteborg

in collaboration with

Karolina Brodin, Anders Lundgren, and Bertil Thorngren
Center for Communications Research (CIC), Stockholm School of Economics, Stockholm

1. INTRODUCTION

The implications of convergence are unfolding continuously. Almost daily the press reports on convergence – how markets in communications and information technology are merging; how the Internet and mobile communications are being integrated; how new network-based media applications are emerging; how microprocessors are becoming part of our everyday life and household gadgets; etc. Streams of further examples could be given, but the point remains the same – the implications of convergence are still fresh and growing. We can hardly expect that the convergence issue will diminish in importance in the future.

Notwithstanding this freshness, convergence as a conceptual idea and engineering prospect has been with us for some time. Journal articles envisioned integrated communications already in the 1950s; the concept of "télématique" was coined in the 1970s to convey the integration of telecommunications and information technology (informatics); standardization work relating to ISDN (Integrated Services Digital Network) started in the 1970s; etc. Hence, there is an important legacy in convergence that should not be neglected.

This book deals with the implications of convergence. It illustrates the complex and far-reaching impacts of convergence from a broad point of view, encompassing users (individual and institutional), technologies, strategies, market structures, policies and fruitful research directions. The book represents a holistic approach to convergence, bringing to bear a number of critical perspectives: economics, engineering, business, organization theory, psychology, policy analysis, and even analysis related to international relations. Moreover, the approach here is not blind to history, but builds upon research efforts and perspectives that have been in progress for a number of years. It brings together selected and edited papers by expert scholars

and policy analysts in the field, originally presented in 1998 in Stockholm at the International Telecommunications Society (ITS) 12th Biennial Conference.[1]

However, before going into the various chapters, this introductory chapter will set the stage by describing some fundamentals of convergence and provide a brief historical overview. The chapter will also provide a brief summary of the book, and take up some pivotal issues for future research and policy. What will be the critical issues beyond convergence?

2. SOME CONVERGENCE FUNDAMENTALS

A prerequisite of convergence in communications is digitization, as pointedly suggested by this (relatively) early quote:

> "With digitization all of the media become translatable into each other – computer bits migrate merrily – and they escape from their traditional means of transmission... If that's not revolution enough, with digitization the content becomes totally plastic – any message, sound, or image may be edited from anything into anything else."
>
> S. Brand in OTA (1990, p. 3)

What are the basic features of digitization? At the very basic level, all digital information transmitted and processed is in the form of discrete information signals, represented by so-called binary digits (bits), whereas analog signals are continuously varying signals.[2] This simple change in information structure provides a platform for a whole new set of communication capabilities and opportunities, when complemented by computer software and electronics. The bit streams in communications are of the same kind as data in computers – with appropriate software telecom, bits can be stored, copied, retrieved and manipulated as in computers.

What then is convergence more specifically? As already suggested above, convergence raises wide-ranging issues, with a number of far-reaching implications. In the literature, precise and rigorous definitions are lacking except that convergence relates to the merging of previously separated fields. What is primarily being conceived as merged relates to technology – the integration of communications (including broadcasting) and computers – but in a secondary sense, a number of other fields come into play: services, markets, related actor configurations (industry alliances and mergers), and policy and regulation. To give these thoughts some more content and imagination, figures are appended. Figure 1 provides an early illustration of how the traditional fields of telecommunications, broadcasting and computing are becoming interlinked by software and digital interfaces. Figure 2 shows a possible evolution of convergence, going from technology to markets and policy. Figure 3 puts the user in the center, illustrating "convergence everywhere", including electronic/mobile transactions

[1] For more information on the conference, see Preface of this volume.

[2] The bits structure relies upon three theoretical achievements: sampling, quantizing and coding. The sampling theorem shows that any complex waveform can be reconstructed from an adequate number of discrete samples. This property is fundamental for the transformation of complex (analog) speech frequency curves into digital with adequate resemblance. Once the amplitude of this waveform has been sampled and a value obtained, the value must be quantized into a digital measurement scale without introducing large errors. Lastly, the discrete numbers obtained are to be coded. Here it was found that binary coding was the most efficient.

(commerce) everywhere. The figures thus exhibit the vast domain being captured by the term convergence.

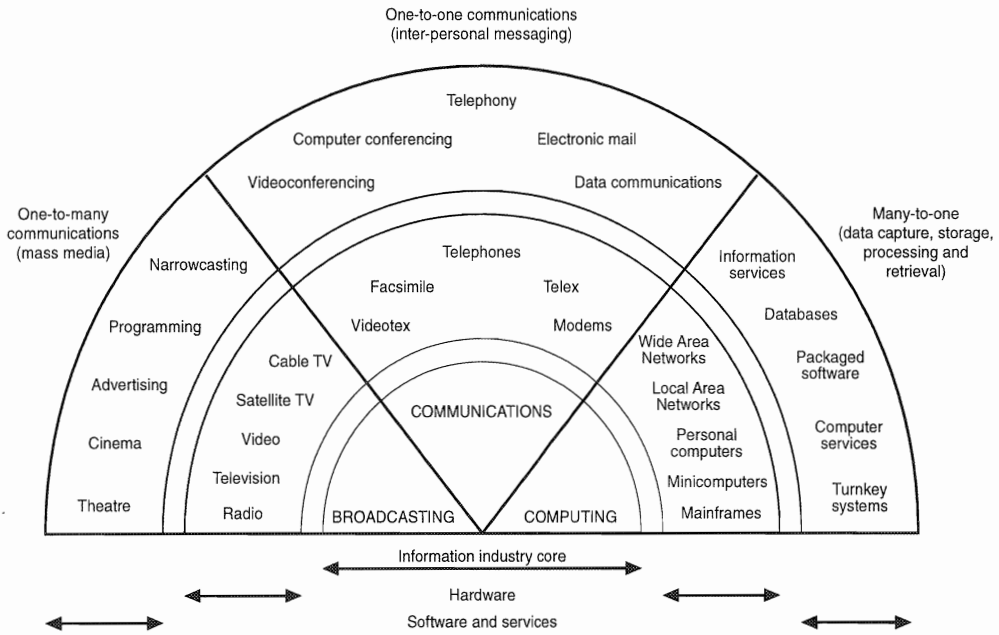

Figure 1. Convergence in the Information Industry

Source: OECD (1992, p. 12)

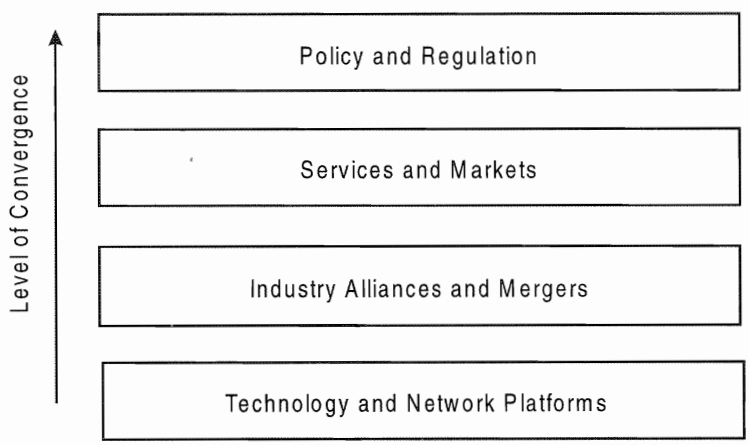

Figure 2. Stages of Convergence

Source: Adapted from European Commission (1997, p. 2)

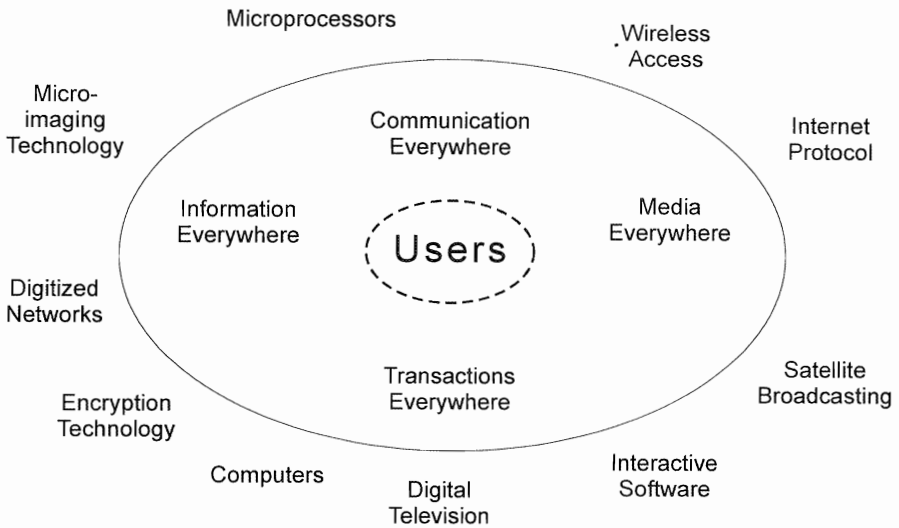

Figure 3. A User Perspective on Convergence

3. THE EVOLUTION OF CONVERGENCE

What are the critical steps in the evolution of convergence and beyond? We suggest several phases below:[3]

- initial ideas on integration between computers and communications (–1970)
- launch of specific convergence-related concepts, such as INS, ISDN, C&C and télématique (1970–1979)
- trials and initial implementation of various integrated network solutions (1980-1991)
- escalation of high-level policy statements on telecommunications and converged information networks (1992–1995)
- Internet surges to become the main convergence medium and policy topic (1995–present)
- convergence between Internet-based mobile and fixed networks, driving an e-society (1999–present)

Convergence based on digital communications was probably first published by H.E. Vaughan of Bell Laboratories (Vaughan, 1959). He coined the phrase "integrated communications" based on the idea that digital switching and digital transmission would work together in concert, and not be separated by analog interfaces – which was the typical solution envisaged at the time. Although the approach was almost completely technology-oriented,

[3] In the Appendix of this chapter, we provide a more detailed chronology of some early convergence and digitization events.

Vaughan (1959, p. 932) noted that the approach would provide "flexibility for new services". As modems and data communications started to spread in the 1960s, the idea of an integrated and converged network acquired momentum. When the 64 kbit/s vs. 56 kbit/s digital transmission speed was debated in standardization bodies in the 1960s, the notion of an integrated network began to gain ground.[4] These efforts triggered a process to conceptually develop the so-called Integrated Services Digital Network (ISDN) in the standardization body CCITT. Formal standardization committees were formed in the early 1970s, and the final standard was issued by CCITT in 1984. In parallel to the initial standardization activities, visionary engineers and corporate executives, especially in Japan, promoted ideas of a new digital era. Concepts in this vein were C&C (Computers & Communication), launched by NEC's CEO Dr. Kobayashi in 1977, and INS (Integrated Network Services), presented by NTT's Chief Engineer Dr. Kitahara in 1979. Not only engineers dreamed dreams – in France "télématique" became a key-word through the Nora and Minc Report, submitted to the President of France in 1978 (Nora and Minc, 1978).

Subsequently, in the 1980s and early 1990s, there was a period of testing and launching of pilot trials. The ISDN network was most vigorously pursued in Japan by NTT, with extensive trials starting in 1984 (in Mitaka, outside Tokyo), with a vision of a nationwide ISDN network in mind. In 1989, the vision was extended to include broadband ISDN (B-ISDN), embracing multimedia services, custom-made services and visual communications. In 1990, NTT's B-ISDN evolved into the Visual, Intelligent and Personal (VI&P) service concept, later to be reformulated into a vision of a Multimedia Era, but with few changes in basic import

Project Agency (ARPA) of developing a distributed network to withstand a nuclear attack. When Internet was "privatized" in 1995, as the U.S. government-sponsored National Science Foundation (NSF) exited as Internet backbone provider, a surge of Internet activity followed – and Internet growth has surpassed all expectations, as will be elaborated upon in other chapters.[5] Indeed, the convergence policy debate, as evidenced by the extraordinary response and hit rate to the web-posted Convergence Green Paper of the European Commission in 1997, took hold and gained significance as the Internet started to spread like wildfire.[6] Applications within electronic commerce have subsequently mushroomed, with spectacular stock price listings of e-commerce companies, and recognition has not been lacking, even to the point that the electronic bookstore Amazon.com's CEO became the Time Magazine Person of the Year in 1999.

A further convergence step has been the integration of mobile communications with Internet, and a number of new key-words, applications and issues have emerged. Mobile commerce, or m-commerce for short, turns the mobile terminal not only into a new communications device, but also into a wallet. Purchases can be made remotely on the spur of the moment, anywhere and everywhere. However, applications are still in the nascent stage, as are mobile terminals compatible with Internet-based protocols. Even Internet sites have to be specifically designed for wireless access, with new hypertext codes. Concurrently, so-called ubiquitous computing is taking hold, suggesting that microprocessors will be embedded into numerous everyday devices and appliances, such as walls, doors, chairs, clothes and even pharmaceuticals.[7] Some of these microprocessors will communicate with other devices based on wireless protocols, although standards are still being formed. Expected benefits are strong, as are growth prospects.

The rest – we could say – is history. Convergence will not stop with ubiquitous computing and mobile Internet; new technologies and applications will emerge, among them new microprocessor designs, high-speed wireless access, new materials and imaging technologies, getting us into "convergence everywhere". Most importantly, convergence will deeply affect life-styles, values and attitudes – moving us beyond convergence.

4. AN OVERVIEW OF THE BOOK

4.1 How the Chapters Fit Together

The book is divided into seven parts, each being tuned to different themes and aspects of the convergence issue. The book commences with two overview parts which provide macro perspectives, the first one dealing with convergence per se, while the second one brings together some policy perspectives from the triad by informed insiders and policy-makers. The

[5] See Chapters 7 and 8 below, detailing the diffusion of Internet.

[6] The European Commission's Green Paper on Convergence topped the hit list on web-site of the Information Society Promotion Office, and generated an unusual number of public comments (Clements, 1998).

[7] A large-scale pan-European foresight exercise was carried out by the Institute for Prospective Technological Studies (IPTS) of the European Commission between the years 1998 and 2000 – see <http://www.jrc.es/Futures>. In the information and communications technology field, a major issue identified was "ubiquitous computing", elaborated upon by Ducatel (1999).

remaining parts are organized to represent an increasing level of aggregation in terms of the perspective and issue raised relating to convergence:

- Internet and user demand
- business networking and vertical integration
- business strategy and market structure
- regulation and policy
- future issues and research agendas.

Within each part of the book, the chapters are organized according to a theme. In the part on Internet and user demand, the contributions start with global overviews and macro scenarios of Internet diffusion. The chapters then move into more detailed pricing and demand issues, including results from surveys of Internet demand and Internet shopping.

Likewise, all the chapters on business networking pursue various dominant theoretical perspectives on vertical integration and business-to-business relationships and convergence. The individual chapters move from the old and go into new aspects of convergence. The first chapter deals with the impacts of technological change on the traditional telco–equipment supplier relationship, while the second takes up how information technology changes business relationships in a traditional industry (printing). The last chapter illustrates how electronic commerce and computer networking change the (grocery) retail and supplier relationships.

The chapters on business strategy and market structure build upon a similar flow, moving from an interest in the impact of convergence on the existing structures to a concern with new structures. The first chapter asks important questions about the long-range impact of Internet on the traditional telecommunications service provision industry, while the second addresses whether traditional telcos will be able to change their capabilities so as to deliver multimedia effectively. The remaining two chapters analyze the impact of electronic commerce from two respective viewpoints: industrial organization and corporate strategy.

The chapters on policy and regulation also pick up the theme of building on the past and extending into new issues. The first two chapters provide theoretical perspectives on two fundamental issues in traditional telecommunications policy – liberalization and universal service – and their respective relationships to convergence. The following three chapters deal with more concrete aspects of convergence: Internet telephony regulation in the triad; convergent broadcasting and communications regulation in Europe; and electronic commerce policies in a globalized context. A common thread between the last three chapters is the identification of concrete new regulatory approaches, where electronic commerce in particular raises a host of new issues, with corresponding needs for policy coordination.

The final part of the book deals with future outlooks and research agendas, aiming to capture some issues beyond convergence. The first chapter surveys the increasing embeddedness of microprocessors into everyday life, contributing to what could be denoted "convergence everywhere". The second chapter addresses future research issues based on wide perspectives upon an even grander topic – the information economy. The final chapter presents a challenging overview of the impacts of convergence, including even geopolitical considerations.

4.2 Convergence in Communications: An Introduction

Chapter 2, by Martin Fransman, suggests that convergence and the evolution of Internet have led to a new paradigm of innovation in communications, and to a fundamentally new type of industry. The traditional telecommunications paradigm is compared with the new Internet paradigm, yielding a number of implications. Among others, the Internet paradigm has generated a new system of innovation that works in radically different ways from the traditional innovation process, with consequences for the dynamic evolution of the new industry. The paper also discusses convergence along a number of essential dimensions: networks, industries/markets, products/services, firms, and technologies.

Chapter 3, by Pekka Tarjanne, also provides an overview of convergence, with a particular focus on users, strategies and regulation. A critical conclusion is that, while convergence creates a need for cooperation, competition will increase at the same time due to standardization. End-user applications are discussed as well, such as electronic commerce and intelligent agents.

4.3 Practical Policy Perspectives from the Triad

Chapter 4 by Richard Cawley, a permanent official of the European Commission, examines some of the practical questions that the European policy and regulatory framework on telecommunications, digital television and broadcasting is facing as Internet develops. The paper argues that Internet developments do not fundamentally change the basic aims and goals of the regulatory framework. However, Internet may reveal weaknesses of the framework. In contrast to proposals on large-scale regulatory overhauls due to convergence, the author argues that incremental adjustment will be more conducive towards achieving the main regulatory objectives.

Chapter 5 by Edward Malloy, a former coordinator of telecommunications and information technology policy in the U.S. State Department, reviews the U.S. policy on global electronic commerce and the Internet. While the U.S. policy has strongly advocated a "hands-off" and minimalist approach, government initiatives have not been lacking. Electronic commerce is intimately tied to Internet policy, and hence includes many non-commercial issues. Among others, U.S. electronic policy covers the administration of the Internet addressing and domain name system, content control, data protection, cyber-crime and encryption.

Chapter 6 by Masatsugu Tsuji, a university professor who also serves on advisory committees of Japan's Ministry of Posts and Telecommunications, gives an overview of some telecommunications policy developments in Japan that aim to foster competition and stimulate growth. The Japanese telecommunications scene has been focusing for a number of years on how to restructure the dominant incumbent, NTT. This issue has surpassed other issues for a long time, including convergence, and it is therefore important to understand the legislation changes for NTT in order to gain perspective on the convergence initiatives. Other measures to ensure fair and effective competition in Japan are also discussed in the chapter, such as interconnection pricing rules.

4.4 Internet and User Demand

Chapter 7 by Banani Nandi, Miklos Vasarhelyi and Jae-Hyeon Ahn develops a global Internet demand model that serves to explain past growth of international Internet traffic and to make forecasts. A critical aspect of the model is that network externalities are explicitly modeled,

being directly related to the relative number of hosts available in each country. The model is used to predict future traffic flow among seven regions in the world, distinguishing between domestic and international traffic, and inbound versus outbound traffic for each region. In this way, the global model estimates future bandwidth impacts around the world.

Chapter 8, by Gary Madden and Scott Savage, provides an overview of Internet demand and pricing issues. Global Internet growth is surveyed and some Internet pricing schemes that deal with Internet congestion are elaborated upon. Based on econometric estimation from the Australian residential Internet market, the authors show that flat-rate pricing systems are associated with more extensive Internet usage, while more usage-sensitive pricing schemes will tend to reduce congestion at peak hours, although total Internet usage may decline relative to flat rates. Usage-sensitive pricing schemes are therefore not cost-free measures to reduce congestion problems.

Chapter 9 by Micael Dahlén presents a survey study of web-shopping. An important implication of the study is that the most promising market segment consists of those who are most favorable towards distance shopping in general and are frequent mail-order buyers. Also, consumer confidence is critical for success. The active web-shoppers had in general a higher belief in their ability to judge quality before the purchase. In order to appeal to consumers with less confidence, the seller must raise confidence. In this context, the interactive dimension of the Internet network has hardly been used to its full potential yet, nor the vast information storage possibilities on the network.

4.5 Convergence and Business Networking

Chapter 10, by Denis Phan and Thierry Sommer, takes stock of how vertical integration has changed in the public switching industry during the evolution of the main technological regimes: electromechanical devices, digital interfaces, intelligent architectures, and Internet protocol. The evolution of buyer-supplier networks is analyzed with transaction cost theory, emphasizing a neglected issue – technology. For each technological regime in the industry, the technological interface has become increasingly standardized and possible to divide into smaller assets (reducing asset specificity), with corresponding impacts on the industry trend towards disintegration. A case study on the evolution of AT&T illustrates the disintegration trend.

Chapter 11 by Marcus Garbe also addresses the evolution of vertical integration and technological change, although the focus here is on information technology. The author argues that information technology will contribute towards integration only under specific conditions. In particular, there is a trade-off between a flexibility and a complementarity effect of information technology, and depending on the overall direction of these two, information technology will support a trend towards integration as well as disintegration. The two effects are discussed in terms of two recent branches of the theory of the firm – transaction cost theory and property rights theory – and a case study of the printing industry in Germany provides illustrations.

Chapter 12 by Alice Chan builds upon a study of computer network use between U.S. grocery retailers and their suppliers, and elaborates upon the main findings of the study from a number of theoretical perspectives. The chapter suggests that network use of electronic coordination was influenced by the nature of transactions, asset attributes and the social environment characterizing the buyer-supplier trading relationships. Several implications are elaborated upon. At a practical level, this research shows that technology use is influenced not

only by considerations of efficiency and cost savings, but also by pre-existing social-relational conditions, which play an important role in how computer networks are used.

4.6 Convergence, Strategy and Structure

Chapter 13, by William Lehr and Petros Kavasallis, suggests that the traditional organization in the communication industry, involving vertical integration of service provisioning and facilities ownership in telephone and cable television service provision, applies with weaker force to the Internet. The inherent design of the Internet protocol allows separation of applications from the underlying facilities infrastructure. This reduces the asset-specificity inherent in earlier infrastructure and service architectures, and enables industry participants to more flexibly organize and reorganize firm-specific assets. This process will support an industry with both integrated and non-integrated firms, coexisting and supporting new markets.

Chapter 14 by Massimo Colombo, Paola Garrone and Raffaello Seri provides econometric estimation of a number of hypotheses relating to a strategy model that includes the evolution of internal capabilities. The evidence conveys that multimedia is not "competence-enhancing" with respect to the distinctive capabilities of traditional telecommunications carriers. Under these conditions, the study suggests that interactive learning through alliances is a very effective capability-building mechanism for carriers bent on entering multimedia service provision, while internal learning devices (such as R&D, learning by doing) perform poorly. Future evidence is needed to clarify whether multimedia is competence-destroying.

Chapter 15 by Steven Globerman discusses the impact of electronic commerce upon industrial organization attributes such as ease-of-entry, seller concentration and average firm size. In contrast to much literature, the chapter offers a more qualified appraisal of the prospect that electronic commerce will profoundly change the industrial organization attributes of many markets, in the direction of making them more contestable. Indeed, electronic commerce will reduce barriers to entry, seller concentration and average firm size, but these effects are not likely to be significant for many products, especially those which have "experience" or "credence" types of qualities.

Chapter 16 by Charles Steinfield, Alwin Mahler and Johannes Bauer raises the case for locally focused electronic commerce strategy. It is argued that developments in electronic commerce should not always be considered free from the constraints of geography. This holds in particular for those local retailers who offer products that are readily available elsewhere. These retailers may need a web strategy that emphasizes the synergy between their local presence and their web storefront. On the other hand, a global web strategy makes sense for local players with niche products that are not readily available.

4.7 Convergence and Regulatory Transformation

Chapter 17 by Gene Mesher and Edward Zajac presents a theory on the worldwide movement to liberalize telecommunications with implications for convergence. The model integrates several existing public choice/political economy models, in which the pace of liberalization hinges upon how the politicians are influenced by interest groups in the economy, and how the politicians gain support from voters by managing the pace of liberalization. Major regulatory change and transformation related to convergence are likely to be adversely affected by these political-economic considerations as well, possibly to the detriment of large-scale regulatory overhaul.

Chapter 18 by Michael Latzer proposes that an integrated mediamatics policy approach is desirable to deal with the policy issues that arise from convergence. While convergence has merged previously separate communications and media fields, traditional regulation is still separated along old lines. As a case study, an integrated approach to universal service is developed which combines two goals: universal access to the communications system (telecommunications) and universal availability of socially desirable content (public broadcasting). An integrated policy approach may, moreover, impact universal service obligations for postal services.

Chapter 19 by Ryota Ono delivers an overview of Internet telephony and the regulatory responses among the major trading blocs (Europe, United States, Japan) and in Singapore. A common response among regulators is to apply the existing regulatory framework designed for basic telephony to Internet telephony, where Internet telephony is treated as a value-added service with no universal service obligation. However, the author argues that this approach will not be sufficiently proactive in the long run. Regulation should be less tied to specific services and less tied to specific technology platforms, while still being responsive to public objectives.

Chapter 20 by Christopher Marsden examines the increasing alignment of telecommunications and broadcasting regulation in Europe, the two fields moving together and being increasingly influenced by competition law. Thus, convergence in technology and services contributes toward convergence in regulatory approaches and philosophies. A case study of pay-TV regulation illustrates these points, containing a comparative analysis of regulation in the United States and Europe. The author concludes that since European governments tend to favor incumbent national champions, the competitive paradigm will be implemented more slowly in Europe than in the United States.

Chapter 21, by Richard Taylor and Meheroo Jussawalla, surveys the state of the global regulation of electronic commerce, and the various actors involved in this regulatory process. A global regulatory regime is emerging because businesses need an environment of stability and predictability, and consumers need a sense of trust and confidence in safety and fair dealing. This is in spite of the calls that have been made for self-regulation and the American-led initiative to keep the Internet free of regulation and taxation. Various multilateral organizations (e.g. WTO, OECD) are engaged in this process, and the chapter discusses fundamental issues for such a regime.

4.8 Convergence, Futures and Research Agendas

Chapter 22 by Edward Steinmueller asks fundamental questions about how convergence will influence our daily lives and how industries will develop in the future. Convergence does not only deal with merging information and communication (ICT) fields in a conceptual fashion; as microprocessors get into more and more artifacts, our daily lives will change, as will business relationships. The chapter emphasizes three types of influences that are likely to be pivotal – popularization, virtualization and intermediation. It is argued that the processes of resistance, adjustment and accommodation will impact the rate and direction of these convergence dynamics. Future research needs are explored in relation to these dynamics.

Chapter 23 by Donald Lamberton develops a wide-ranging perspective on the information economy, and how the convergence trend is related to the "new economy". The author argues that fruitful intellectual approaches to the information economy should abandon a narrow technology perspective, and focus on the workings of information in various types of

economic organizations. Economic research should give priority to the characteristics of information, forms of organization, information-related aspects of policy, employment impacts, social consequences, and statistical collections. Development of an information perspective needs to be conducted in collaboration across borders, whether they are cultural, political or disciplinary.

The final chapter of the book, by Eli Noam, engages in a thoughtful outlook on the long-term impacts of convergence. The author suggests that digital convergence may lead to trade wars, disruption and disagreement, instead of creating bridges and harmonization. As the United States entertainment industry will gain dramatically over the next years, driven by huge increases in transmission capacity and plunging communications prices, other trading blocs and the developing world will react. It will be tempting to try to slow down leaders, but the real corrective will be a new type of convergence – the convergence of global electronic development. Finding a path to this type of convergence will become a major research and policy issue in the future.

5. BEYOND CONVERGENCE – RESEARCH OUTLOOKS

5.1 General

What are the critical issues beyond convergence? Certainly, the effects of technical convergence upon markets, strategies and policy will remain, but what will be dominant policy and research issues beyond convergence? The various chapters bring, in effect, future issues as well, not only convergence, such as:

- electronic commerce
- cyber-trade and international frameworks
- virtualisation
- network economy

As illustrated in this volume, convergence can be pursued from a number of different perspectives and approaches. Similarly, we would like to suggest four areas of development in future research on convergence and beyond:[8]

- deepening disciplinary perspectives
- broadening disciplinary perspectives
- broadening the framework of issues; and
- new concepts

One central disciplinary perspective in the research on convergence and change in telecommunications is economics. We should expect more novel applications of economic theory, and we should expect that not only mainstream economics research would grow. Indeed, it is surprising that, given the high rate of technology change, there are not more contributions based upon the economics of technology, including evolutionary economics.

[8] See also Bohlin et al (1999a).

Second, we can expect that researchers from more and more disciplines will be attracted to move into issues beyond convergence. Previously, the whole area of telecommunications was the domain of specialists, but it has grown into a wide phenomenon that is considered important and of high interest to the general public. As this book has shown, there is much research on issues such as business strategy and management research, but other perspectives including inter-disciplinary efforts can be expected. In particular, it is of interest to develop ever-deeper ties between social sciences on the one hand and on the other hand technology analysis and assessment, in view of the high technology intensity and dynamics of the field of inquiry.

Third, we should expect that the research will become even broader due to convergence. The term increasingly used today to reflect the corresponding broader set of issues is *information society*. Having such an encompassing perspective calls for broader frames of reference and broader research agendas. From a policy point of view, the growing information society likewise calls for co-ordination of several policy areas, previously separated. *Globalization* and the increasing international interdependence, moreover, call for broader approaches, including perspectives on the information society in security analysis and geopolitical considerations.

Fourth, future research will be stimulated and developed by new concepts that are used in the policy arena. Suffice to mention two: self-regulation and sustainability. *Self-regulation* has been actively promoted by certain business groups in the electronic commerce debate, but important research tasks remain. What is the extent of self-regulation? What are the relationships between self-regulation and anti-competitive behaviour? What are important lessons from other sectors (e.g., lawyers, doctors, etc.). *Sustainability*, on the other hand, has been rising as one of the most central issues for the future of mankind. Starting from environmental issues, the sustainability debate has broadened to include social aspects and culture. Furthermore, sustainability is now more viewed as a question of informed self-interest. The information society in turn holds both promises and threats for sustainable development (in its broad sense), and there has been a growing interest in policy circles to find ways to bridge the two policy concerns.

5.2 An Example Issue Beyond Convergence

As an example of a future issue beyond convergence, we would like to elaborate upon the notion of *sustainable information societies in a global context*.[9] The central issue here is to capture the linkages and bridges between the three elements as shown in Figure 4 – Sustainability, Information Society and Global/Regional Interests.

[9] This section builds upon material presented in Bohlin et al (1999b), Bohlin (2000a), Bohlin (2000b) and Thorngren (2000). For a wide treatment on the issue of Sustainable Information Socities, see European Commission (2000).

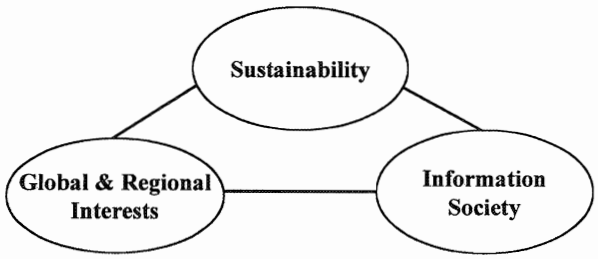

Figure 3. Sustainable Information Societies in a Global Context

Concern for sustainability has been rising on the world scene as one of the most important issues for the future of mankind. Concurrently, it is generally recognised that the Information Society will be instrumental to growth and well-being in the 21st century. The Information Society has moved to become a central organising principle for the future society, and a long-term, strategic concern. Not surprisingly, then, there has been a growing desire to find ways in which the Information Society will promote sustainability, and where sustainability will reinforce the uptake of the Information Society. Thus, research on strategies and policies that will support a *Sustainable Information Society* is what we are looking for. This interest reflects a belief we have a viable concept here and not a juxtaposition of terms in vogue.

To see this, consider that sustainability is now viewed less as a purely ethical and redistributive question but more as a question of informed self-interest. Competitiveness and sustainability have previously been portrayed as opposites, but there is a growing recognition that these two issues are mutually reinforcing. Industrialisation and growth without attention to sustainability may not only be problematic for some ill-fated groups of society but may seriously limit any region's aspiration to prosperity, as the dynamic repercussions of unsustainability on its citizens may be significant and take unexpected turns.

While sustainability was initially formulated in terms of environmental preservation, the sustainability debate has broadened in scope to include social, economic and cultural aspects. What sustainability is all about has also changed – from static views that emphasise the preservation of current resources for future generations toward more dynamic views which emphasise the development of greater opportunities for future generations. Likewise, it was initially held that the Information Society would contribute only to environmental sustainability, being driven by immaterialisation and dematerialisation of the economy, enabled by information and communication technologies (ICT). However, policies to support an Information Society for every segment of society may serve to infuse social sustainability, and likewise support cultural identities, notwithstanding the threats of cultural homogenisation through the Internet.

A broad and dynamic agenda of sustainability fits well with the wide policy ambitions of the Information Society, especially against the backdrop that the Information Society is increasingly viewed as the engine of future growth for our economies. This notion of sustainable Information Societies can serve as an organising principle for much of the policy-relevant discourse on future strategies and development paths for the Information Society.

Additional leverage is gained from the new globalised context that is emerging, involving several centres of power and growth – such as the United States, China, Japan, India, Russia and Europe, to mention just a few. There will be a corresponding need to develop strategies

that enhance and sustain the respective regions, as well as to develop strategies for mutual consensus and collaboration. In this context, a Sustainable Information Society becomes a strategic concern, fundamental to long-term prosperity and security for any nation or region of the world seeking to have influence in the 21st century.

What are then some important research agendas in this context? One important issue is to focus on the various *goal-conflicts*. Here it is of particular interest not only to consider sustainability from a wide point of view, but to consider the *dynamic* perspective on sustainability. A number of possible goal-conflicts may arise in this context, and internal inconsistencies in the sustainability debate need to be clarified. For instance, does sustainability mean the conservation of culture (if we are addressing cultural sustainability), or is it more sustainable to change the culture? Should we resist the possibilities of cultural impact and possible cultural homogenisation through the Internet or go with the change? If we go with the change, which changes are then sustainable? Likewise, what variables are important in the context of social sustainability? Certainly we would want to consider social inclusion and various forms of equity, but should we then pursue sustainability from a perspective which allows for uneven economic growth with the prospect that the whole society will gain in the end? Put differently, we will find here traditional goal-conflicts, such as those between equity and efficiency.

Another important research task is to develop a better understanding of the future development and impact of *life styles*. Arguably, changed life styles are a necessary condition for sustainability, as human opportunism always can undermine a legal framework, regardless of how well it is designed. On the other hand, legal frameworks will certainly serve to influence life styles and behaviour in the long run. As an example of changed life styles and mind-sets, we could consider the possible development of an Eco-Cyber Life Style which is based upon the opportunities in cyberspace to share, to interact, to learn and to grow by sharing. Explorations in cyberspace have suggested some important issues of growth: innovation is based on sharing, and resources can be re-used at low cost (cf. 'information recycling'). By implication, we should be more open to the prospects of finding a life style where we enjoy a rich and dignified life without compromising future generations. There are opportunities for positive feedback between the evolution of the information society, with its impact on the mind, and the evolution towards a more sustainable society. Research on these linkages would be useful and promising, although such research must concurrently address threats, crime, constraints and security issues, not only opportunities for change in a positive direction.

Other concerns relate to the *international dimensions* of the evolution of a sustainable information society. In what way will the notion of sustainable information societies contribute to the debate on geopolitical evolution and security concerns? Over the past years, many scholars and analysts have addressed security concerns and international relations relevant to the information age in a number of publications, for instance in the prestigious journal *Foreign Affairs*.[10] However, bringing the dimension of sustainability into this discourse remains an unexploited topic. As both sustainability and the information society are issues that know no borders and are strategic for our future, it is likely that we will see research and intellectual discourse on the coupled geopolitical ramifications. It is in this context that informed self-interest will become particularly acute – it will be in any nation's or region's long-term interest to develop a society which is sustainable, and which builds an information society that enhances the potential of every citizen.

[10] See for instance Nye (1999).

The inherent momentum of the Information Society will carry us further, however. As the Information Society permeates our way of life there will be a corresponding need to process information and make judicious use of the knowledge obtained. Leadership in the Information Society will be less about timely information ("Information Advantage") and will instead move into knowledge. However, enlightenment will not necessarily lead to sustainability: there will be a corresponding need to temper the powers of knowledge against individual and collective opportunism – with *wisdom*. Regions that will allow and empower their peoples to participate in the search for wisdom – in its broad, ethical sense – will benefit by growth and fulfillment among citizens. Research and intellectual debate that supports such action is a prize to be seized.

REFERENCES

Bohlin, E. (1995), *Economics and Management of Investments: An International Investigation of New Technology Decision-Making in Telecommunications*, published Ph.D. Dissertation, Chalmers University of Technology, Bibliotekets Reproservice CTHB, Göteborg.

Bohlin, E., Levin, S., Leite, A.N. (1999a) "Political Economy of Telecom Regulation: Editorial", *Telecommunications Policy*, Special Issue on Political Economy, Vol. 23, pp. 603-606.

Bohlin, E., with Frotschnig, A. and Pestel, R. (1999b). "Information Society and Sustainability: Editorial", *IPTS Report*, Special Issue on Information Society and Sustainability, No. 32, March, pp. 4-9, also available at <http://www.jrc.es>.

Bohlin, E. (2000a), "Sustainable Information Societies for the 21st Century – The Conference Agenda", in European Commission (2000), pp. 1-7.

Bohlin, E. (2000b), "Future Research Strategies for Sustainable Information Societies", in European Commission (2000), pp. 119-121.

Chaffee, C.D. (1988), *The Rewiring of America: The Fiber Optics Revolution*, Academic Press, Boston.

Chapuis, R.J. and Joel, A.E. (1990), *Electronics, Computers and Telephone Switching. Volume 2 of 100 Years of Telephone Switching (1960-1985)*, North-Holland Publishing Company.

Clements, B. (1998), The Impact of Convergence on Regulatory Policy in Europe, *Telecommunications Policy*, Vol. 21, No. 6, pp. 513-532.

Ducatel, K. (1999), Ubiquitous Computing: A New Convergence Debate? *Communications and Strategies*, No. 36, pp. 185-206.

European Commission (1997), *Green Paper on the Convergence of the Telecommunications, Media and Information Technology Sectors, and the Implications for Regulation*, COM (97)623, European Commission, Brussels.

European Commission (2000), *Towards a Sustainable Information Society – Report of the Conference on February 21-22, 2000*, Directorate General Information Society, Unit C1 (New Methods of Work), European Commission.

Nora, S. and Minc, A. (1978), *L'informatisation de la Société*, La Documentation Française, Paris.

Nye, J. (1999), "Redefining the National Interest", *Foreign Affairs*, Vol. 78, No. 4, pp. 22-35.

OECD (1992), *Telecommunications and Broadcasting: Convergence or Collision?,* Committee on Information Computer Communications Policy, Report No. 29, Organization for Economic Development, Paris.

OTA (1990), *Critical Connections: Communications for the Future*, Office of Technology Assessment, U.S. Department of Commerce, Washington D.C.

Thorngren, B. (2000), "The Relevance of the Sustainability Concept in Information Society Debate and Research", in European Commission (2000), pp. 117-118.

Vaughan, H.E. (1959), Research Model for Time-Separation Integrated Communication, *Bell System Technical Journal*, Vol. 38, No. 4, pp. 909-932.

Zakon, R.H. (1999), "Hobbes' Internet Timeline Version 4.0", <http://info.isoc.org/guest/zakon /internet/history/hit.html>.

APPENDIX: A CHRONOLOGY OF DIGITIZATION AND CONVERGENCE

As a summary chronology of some early events leading to the digitized network and convergence, see Table 1. It would take us too far to go into detailed comment and elaboration of the table, except for a few remarks. First, a striking aspect of the history of digitization and convergence is the length of gestation periods and the long development cycle. For instance, although the pulse code modulation concept (PCM) was invented in 1938, it was not fit for large-scale production until 1962. The concept was before its time, since it turned out to necessitate integrated circuits. Moreover, the PCM concept, translating analog signals into digital, builds on three theoretical pillars: sampling, quantizing and encoding, the latter systematized only in 1948 by C. Shannon (i.e. the bits concept and theory of binary digits). For the Internet, early papers on packet switching appeared in the early 1960s but the Internet protocol was adopted in 1982. Convergence was likewise merely intimated in 1959 while engineering solutions took longer.

Another striking element of chronology is the parallel development in several fields, where technical advances in different fields were critical for new progress. For instance, the digitization of transmission and switching, and the emergence of computer communication, resulted in the standardization discussions on the Integrated Services Digital Network (ISDN) in the late 1960s and early 1970s. Moreover, the development of a common channel signal system in the 1960s, and the increasing use of software, suggested intelligent networking and a new network architecture with network (service) control points and signal transfer points in 1978. Further, fiber optics with its favorable price/performance ratio is one of the factors that allowed a fast digitization rate in the late 1980s, also pointing to this important complementarity of events. For the Internet, the development of distributed intelligence (in e.g. PCs) has been critical to achieve the mass adoption of the electronic mail systems based on Internet. Many more examples of this complementarity and parallel development could be given from the table.

Table 1. Chronology of Selected Early Digitization and Convergence Events

Year	Event	Descriptor
1924	Sampling theorem	N. Nyqvist demonstrated that signals could be reconstructed by an appropriate sampling rate, providing a first building block for digital multiplexing
1926	Pulse code modulation (PCM) concept	PCM invented by P.M. Rainey, Bell System, as a means to send facsimiles over telegraph channels – an invention soon forgotten, though
1928	Quantizing	R.V.L. Harvey demonstrated that information can be measured on a scale of messages, with the amplitude range divided into fixed amplitude levels – a building block to digital transmission
1938	PCM concept again	A.A. Reeves discovered, independently of P.M. Rainey's PCM, a method for converting analog signs to digital, and also a building block for time-division multiplexing
1945	Time division concept	First time-division switching concept – switching by pulse displacement – discovered by M. Deloraine, ITT
1947	Transistors	Transistor technology discovered at Bell Labs by a team led by W. Shockley
1948	Binary coding	Theory for binary encoding of information with digits (BITS) formulated by the mathematician C. Shannon, Bell Labs
1949	Electronic switching concept	First electronic switching development project, ECO, launched at Bell Labs
1957	Stored program control (SPC) concept	At the first ISS (International Switching Symposium) in New Jersey, Bell Laboratories announced the SPC concept – a switch controlled electronically
1957	Digital time-division switching concept	First digital time-division switch development project, ESSEX, launched at Bell Labs
1958	The integrated circuit	First integrated circuit developed by J. Kilby, Texas Instruments
1959	Integrated communications	H.E. Vaughan was one of the first to envisage integrated digital communications
1960	First electronic switch trial	The first SPC (space-division) switch in use was opened in Morris, November 1960, by AT&T
1961	First packet-switching theory paper	Leonard Kleinrock, MIT, presents his paper "Information Flow in Large Communication Networks"
1962	First electronic time-division switch trial	At Highgate Wood, UK, the first time-division (but analog) switch was tried
1962	First trial of PCM PCM in production	First trial in Chicago. The Bell System starts to produce PCM equipment (so-called T1)
1964	Common channel signal concept	CCITT starts to standardize SS6 (Signal System 6), the first signal system to separate signaling into a signal network
1965	ARPA sponsors Internet predecessor study	The U.S. Defense Department's Advanced Research Project Agency (ARPA) sponsors study on "cooperative network of time-sharing computers"

Table 1. Chronology of Selected Early Digitization and Convergence Events (cont.)

Year	Event	Descriptor
1965	Widespread division of PCM	More than 100,000 channels of PCM capacity installed in the Bell System
1965	First electronic switch in mass production	The Bell System's 1ESS was the first SPC switch in mass production, although with space division (analog)
1966	Fiber optics concepts	K.C. Kao and G.A. Hackman propose that glass can transmit laser signals for use in telecommunications
1967	First design spec. of Internet predecessor	First design paper on ARPANET published by Larry Roberts: Multiple Computer Networks and Intercomputer Communication
1967	Signal transfer point (STP) concept	STP concept advanced in CCITT's work on SS6, a switch for the common channel signal network
1968	First common channel signal system	Signal System 6 standardized by CCITT as the first common signaling system, although only for international telecommunications
1969	First Internet packets sent	First packets sent by Charley Kline at UCLA as he tried to log into Stanford Research Institute. First attempt resulted in the system crashing as the letter G of LOGIN was entered
1970	First digital time-division local switch tried	First digital local switch of time division mode tested in Lannion, France (to become E10)
1971	First e-mail program	Ray Tomlinson of BBN invents e-mail program to send messages across a distributed network
1972	The microprocessor	First large-scale integrated circuit (LSI) by INTEL, i.e. the first microprocessor
1972	First demonstration of ARPANET	Demonstration of ARPANET between 40 machines and the Terminal Interface Processor (TIP) organized by Bob Kahn during the International Conference on Computer Communications (ICCC)
1972	PCM standardized	The PCM hierarchy standardized in CCITT, with two dialects, the European vs. the North American (and Japanese), characterized by a primary multiplex of 32 vs. 24 channels
1972	ISDN concept first advanced	CCITT Special Study Group D formulates first vision of integrated services digital network (ISDN)
1974	Internet protocol published	Vint Cerf and Bob Kahn publish "A Protocol for Packet Network Interconnection" which specified in detail the design of a Transmission Control Program (TCP) in IEEE Transactions on Communications
1976	First domestic common channel signaling system implemented	AT&T implements first nationwide common channel system developed from SS6, the so-called CCIS (common channel interoffice signaling)
1976	Second common channel system to be developed	Signal System 7 begins development at CCITT – a system for domestic use, to be complementary to digital networks and ISDN
1976	First fiber optics field trial	Bell Labs tries the first fiber optics system in Atlanta, carrying more than 50,000 telephone calls

Table 1. Chronology of Selected Early Digitization and Convergence Events (cont.)

Year	Event	Descriptor
1976	First digital time-division toll switch	AT&T launches its 4ESS, the first digital time-division toll switch capable of handling 550,000 busy-hour call attempts
1976	First modular (distributed) SPC switch	The AXE system, developed jointly by Ericsson and Televerket, utilized a modular (distributed) program structure which came to signify the second-generation digital switching (the first generation relied on centralized SPC control)
1977	C&C concept advanced	Dr. Kobayashi, NEC, presents his widely promoted vision of computer and communications (C&C) integration
1978	Database network concept	Network control points (NCP) and action control points (ACP) invented by R. Weber, Bell Labs, separating (by the use of CCIS) database and software nodes from the traditional switched network. (Note that NCP and ACP are separate nodes from STP.)
1979	Prototype of Internet between universities	Meeting between Univ. of Wisconsin, DARPA, NSF and computer scientists from many universities to establish a Computer Science Department research computer network
1982	Internet protocol adopted by ARPANET	Advanced Research Project Agency adopt the Transmission Control Protocol (TCP) and Internet Protocol (IP) as the protocol suite for ARPANET
1982	Single-mode fiber	Single-mode fiber commercialized by Siecor and Northern Telecom, chosen by MCI for its network
1984	ISDN standard proposed	First comprehensive draft of ISDN agreed upon by CCITT
1984	SS7	Signal System 7 standardized by CCITT
1985	First domestic full-scale SS7 implementation	Televerket implements, within a few months, a nationwide SS7 network connecting all its AXEs
1985	First nationwide fiber backbone network installed	NTT completes its nationwide fiber-optic backbone network for long distance
1985	Intelligent network concept	Bellcore announces its design for an intelligent network architecture in local telecommunications related to AT&T's NCP and ACP concepts
1986	NSFNET created	NSFNET backbone network of 56 kbit/s established and 5 super-computing centers interconnected with the network
1986	First U.S. coast-to-coast fiber-optic network	AT&T completes first commercial coast-to-coast call on December 6, 1986, transmitted by fiber optics
1987	First national digital overlay network	Televerket inaugurates in Nov. 1987 the first digital (overlay) network with national coverage, integrating previously local digital islands
1989	Commercial electronic mail through Internet	First relays between a commercial electronic mail carrier and the Internet: MCI Mail through the Corporation for the National Research Initiative (CNRI), and Compuserve through Ohio State University

Sources: Adapted and revised from Bohlin (1995), building on Chapuis and Joel (1990), Chaffee (1988), Zakon (1999), interviews, and corporate documents.