COMPUTER SOFTWARE

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Charles H. Fleer
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PREFACE

The concept of technology has existed from the beginning of recorded time. The idea of technology has taken on new meaning with the advent of modern war and the rapid technological advancements that have resulted from the development of computers.

In the 1960s and 1970s the U.S. Congress became keenly aware of the need to improve the United States position in both international economic affairs and technology security. The 1976 Defense Science Board report, "An Analysis of Export Control of U.S. Technology—DOD Perspective," stated conclusively that the control of design and manufacturing know-how is absolutely vital for the maintenance of U.S. technological superiority. In 1979 Congress passed the Export Administration Act to implement the provisions of the report, and the Department of Defense (DOD) has worked ever since to implement specific provisions. Specifically, the DOD has developed a list of critical technologies to be used to control licensing. The Critical Technologies List is continually reviewed and updated by an international panel.

The Critical Technologies List gives primary emphasis to:

1. Arrays of design and manufacturing know-how
2. Keystone manufacturing, inspection, and test equipment
3. Keystone materials
4. Goods accompanied by sophisticated operations, application, and maintenance know-how

With the commercial success of the computer and worldwide recognition of its capacity to aid in the development of other technologies, it seems inevitable in the next few decades that industry will generate an explosion of advanced technologies which are still unheard of today.

Computer technology is presently advancing at the rate of a new generation of computer capabilities every six months. Government, industry, academia, and consumers are all unable to keep abreast of these rapid developments. As a result, Advanced and Emerging Technologies, Inc., located at 350 Wesley Street, Suite 201, Myrtle Beach, South Carolina 29577, will publish updated supplements to this book every six months. The supplements will discuss new products, trends, ongoing research efforts, and changes in national policy.

During the coming decades the use of computer simulation in the design and manufacturing sectors of the world economy will be driven by heightened international economic competition and rapid increases in computer capability. An understanding of key technological disciplines such as those outlined in this book will be useful, if not essential.

The dual concerns of economic competition and national security have provided the main impetus for increased support of research and development by both government and industry. The nation's technological development efforts have contributed extensively to the economy and to our ability to compete effectively in international

markets. Credit for these contributors can be shared by all sectors of the U.S. economy—government, industry, academia, and other institutions.

This nation's technological lead is threatened by countries that have established a national resolve to excel in all phases of technological development, including education and training, product development, knowledge engineering, and the application of existing advanced technologies.

Computer Software describes the use of Artificial Intelligence, Expert System—an existing advanced technological computer software system for the development of computer software, its technology, and technology knowledge engineering. This book also reports on the nation's technology policies, as well as efforts to fund development, control exports, and promote the transfer of technology. The charts used in this book contain the most current information available.

The lack of general knowledge of internationally recognized definitions and descriptions of computer software technology, rapid advances in computer software technology, and the intense competition for the computer market created a serious need for a single volume with supplements that would introduce an integrated approach to the development of computer software technology. This book describes an advanced computer program, Artificial Intelligence, Expert System, which is designed to do just that.

This book consists of seven chapters. Chapter 1 offers an overview of the internationally recognized definitions and relationships of 18 critical advancing and emerging technologies. These technologies are grouped into five general categories. The chapter thus defines the scope of today's technology.

Chapter 2 reports on the U.S. government's technology policy positions, from the Executive Office of the President to other major departments of the government. The policy areas addressed are technology development policy, technology control policy, and technology transfer policy.

Chapter 3 addresses trends in development, discussing trends in technology development today and the people and the institutions that are the principal drivers of future development.

Chapter 4 looks at emerging computer software technology to primarily identify key computer software technology opportunities for exploiting computer capabilities in new ways.

Chapter 5 looks at advanced computer software on the market today.

Chapter 6 offers direction on how to establish a technology management system, provide guidance on establishing technology goals and objectives, conduct technology assessment, and develop a technology breakdown structure. It also provides the computer software technology database produced as a result of the technology management system.

Chapter 7 encompasses the application of Artificial Intelligence, Expert System, to computer software technology. The computer software technology database developed in Chapter 6 is used in knowledge engineering design. Technology goals and

objectives are established from the engineering model; heuristic facts and expert system rules are developed and then inserted into an expert system computer shell to provide assistance in developing new technology, aiding the assessment of current levels of capability and helping to solve technical problems.

In summary, technology development throughout the world is moving like a speeding train, and governments, industry, and consumers are being left behind. International competition for technological leadership has never been greater. The United States today is considered a leader in the development of supercomputers and other advanced computer technologies. Other Western countries and Japan are underwriting development of new products, their goal being to capture the U.S., Western, European, and Japanese markets, which are the largest consumers of technology.

To maintain U.S. leadership, the federal government needs to focus on technology advancement. Establishment of a President's Cabinet Council on Technology Management (CCTM) is a necessary first step. The government needs to establish, by setting a coordinated sense of direction, a national policy that could adapt to the rapidly changing world of the technology revolution. The CCTM should follow the internationally adopted Critical Technologies List in pursuing U.S. technology development.

Charles H. Fleer

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We wish to acknowledge the gift from our Father who gives us the freedom to pursue knowledge that we may gain wisdom.

"HAPPY IS THE MAN THAT FINDETH WISDOM, AND THE MAN THAT GETTETH UNDERSTANDING." (*Proverbs*, 3–13)

A great many people have contributed to the writing of this book—far too many to name here. This book has been made possible by the creative work of hundreds of individual U.S. and foreign engineers, scientists, U.S. government management experts, industry research and development organizations, and educational institutions.

During the past several years the U.S. government has worked with engineers and scientists from throughout the Western world and Japan to develop the Critical Technologies List. We wish to recognize their contribution to the knowledge base included in this book.

Other materials have been obtained from various U.S. government departments and agencies, from industries, and from individuals. We would like to express our appreciation to the following organizations for their contributions and cooperation: the United States Congress, Office of Technology Assessment; Executive Office of the President, Office of Science and Technology Policy, Department of Defense, Office of the Secretary; Department of Energy, Office of the Secretary; National Science Foundation.

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Texas Instruments' Knowledge Engineering Consultation

Chapter 1
An Overview of Technology

INTRODUCTION

It is the advance of technology rather than new products that has generated the computer revolution of the past 20 years. Today technology is moving forward so rapidly that keeping up with advances and developments is a monumental task for anyone in the field as well as for educational institutions. Advanced new technologies are arising from efforts of governments, industries, and research and development institutions around the world. Everyone in the world today is participating to a greater or lesser extent in this technology revolution. The involvement of individual countries and the benefits they will derive from the technology revolution will depend on their ability to acquire technical information rapidly, and their capacity to act on this information or be passed by others in this highly competitive world.

The 1976 Defense Science Board report, *An Analysis of Export Control of U.S. Technology---A DOD Perspective*, advocated control of technology rather than products as a means of improving the position of the United States in terms of both international security and economic affairs. The report, also called the "Bucy Report," concluded that the control of design and manufacturing know-how is absolutely vital to the maintenance of U.S. technological superiority.

The Export Administration Act of 1979 was passed by Congress to implement the key provisions of that report. The Department of Defense (DOD) has worked since 1979 to implement specific provisions of the Export Administration Act. Specifically, the DOD developed a list of critical technologies to be used in controlling the licensing of those technologies. This list, the Militarily Critical Technologies List (MCTL), emphasized development rather than control. Accordingly, the sorting and priority setting process offered aim at a program to use the Critical Technologies List (CTL) as a development document.

The purpose of this chapter is to outline for the first time the internationally approved technologies in book form with their classifications, definition, and technology groupings. This series of books will use the Critical Technologies List as an outline for the exploration of state-of-the-art technologies, clarifying their interrelatedness to promote an interdisciplinary approach to planning, design, development, production, and application. Advanced and emerging technologies, along with current trends, will be included and treated in similar fashion. This book, then, demonstrates the development of computer hardware technology and its application to the artificial intelligence expert system.

DEFINITIONS

Technology may be defined as the knowledge used in the design, production, manufacture, testing, utilization, or maintenance of materials, i.e., the design and

manufacturing knowledge that serves to translate scientific knowledge into end products or services.

Critical technology is the knowledge whose acquisition and use by local, state, and national governments, industries, and consumers would significantly enhance the advanced development and operational capability of the users, irrespective of whether such technology is acquired directly from the United States or other countries.

In order to better understand the CTL as used in this book, the following definitions may be useful. In the CTL, critical elements of technologies are included under three general categories:

1. *Arrays of knowledge* or *know-how (including design and manufacturing know-how)* are the knowledge and related technical information required to achieve a significant development, production, or utilization purpose. Such know-how includes services, processes, procedures, specifications, design data and criteria, and testing techniques.

2. *Keystone equipment* (including manufacturing, inspection, and testing equipment) is the equipment specifically necessary for the effective application of a significant array of technical information and know-how.

3. *Keystone materials* are materials that are specifically necessary for the effective application of a significant array of technical information and know-how.

Other important definitions include the following.

- *Development* is the process of design, fabrication, and experimental work that translates an application concept into a set of specifications, models, and design data necessary for the effective production of product.
- *Production* is the process of product design, manufacture, inspection, and testing that translates specifications and design data into a serially produced product that meets acceptable quality standards.
- *Product utilization* is the process of application, operation, and maintenance (including reconstruction) that translates a product into a useful capability for meeting a need.

TYPES OF TECHNOLOGY

This book will deal with five general categories of technology: computer technology, component technology, systems technology, subsystems technology, and materials technology.

COMPUTER TECHNOLOGY

The computer technology we will discuss can be divided into three general areas: systems and network technology, hardware technology, and software technology (see Fig. 1.1).

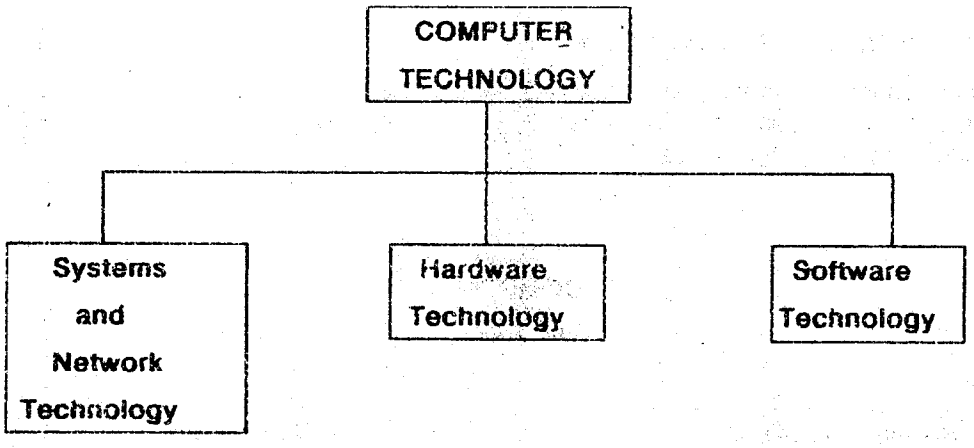

Figure 1.1 Computer Technology

Information Systems and Network Technology

Information systems and network technology encompasses the integration and engineering required to:

- Define the requirements for new systems architectures;
- Select and evaluate the technology for development and implementation of the new computer system;
- Plan, manage, and control its development and production; and
- Determine the distribution and the control technology for its maintenance and support. Also included in this section are information, image, and speech processing; and decision systems technology.

Hardware Technology

Computer hardware technology includes all the basic components and techniques required to develop and produce digital and hybrid computers and their associated peripherals, including integration for greater accuracy and computing speed, and the allocation of resources to both hardware and software to accomplish the specific tasks imposed by complex problems. All types of computers are included, from single-board computers to supercomputers and other high-performance mainframes and parallel processors.

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Software Technology

Software technology includes computer programs, program documentation, descriptions of use and algorithms, program installation, maintenance, life-cycle support, and services related to operations and training.

COMPONENT TECHNOLOGY

Component technology encompasses semiconductor and electronic component technology, optical and low-energy laser technology, microwave technology, and sensor technology (see Fig. 1.2).

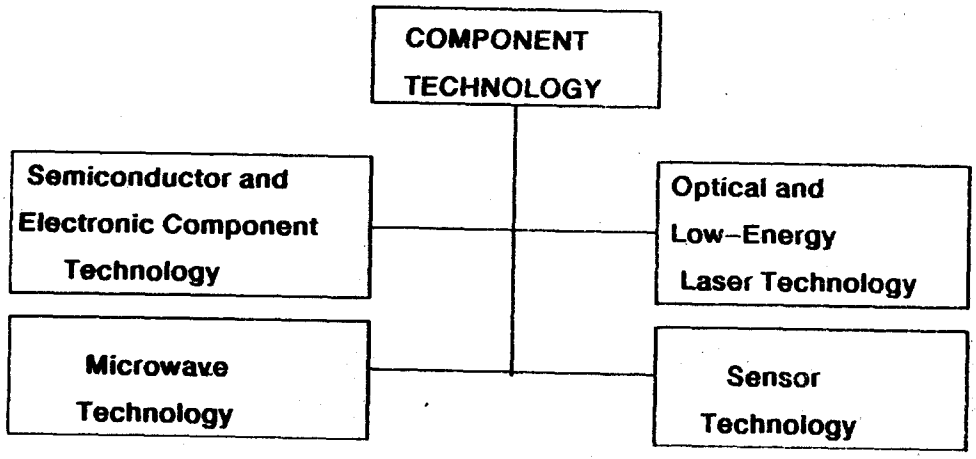

Figure 1.2 Component Technology

Semiconductor and Electronic Component Technology

Semiconductor and electronic component technology includes microcircuits, transistors, thrysistors, diodes, photdsensitive devices, acoustic wave devices, cryogenic and passive components, and electronic materials technologies.

Microwave Technology

Microwave technology includes microwave tubes, microwave solid-state devices, high-power microwave control components, waveguides and components, and millimeter wave devices. Included are both active and passive device technologies.

Optical and Low-Energy Laser Technology

Optical and low-energy laser technology encompasses the development and production of optical and electrooptical components for a variety of commercial