Software design for electronic switching systems

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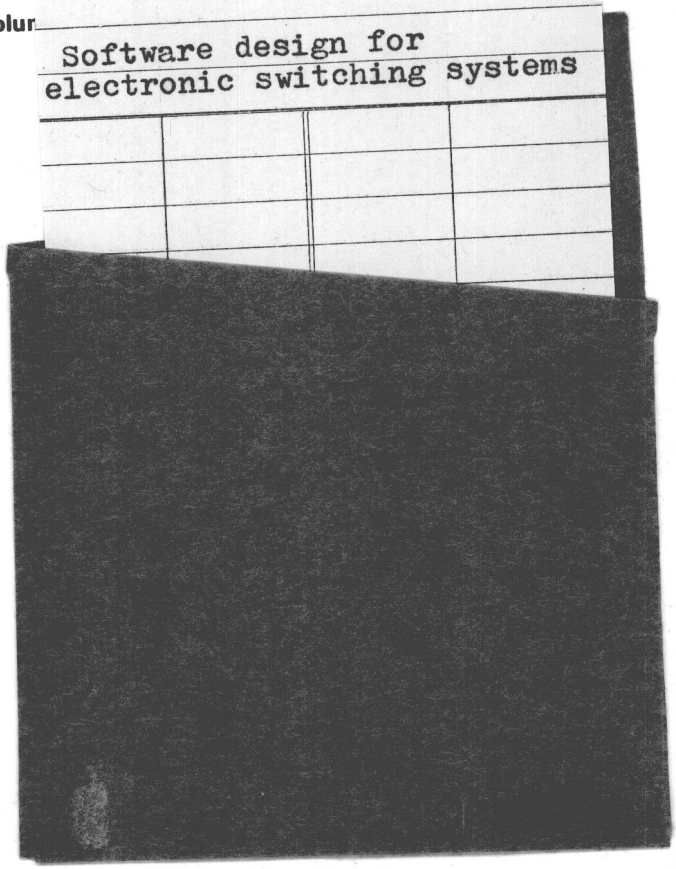

Foreword to the English edition

Among the most important technical innovations made in our times in the field of telecommunications is the recent development of electronic switching systems. It has opened a new possibility of providing an intelligent telecommunications network, which will meet the varying needs of modern societies in a flexible and economical manner, taking advantage of the fast-developing computer and electronic technologies. The development of electronic switching systems has many facets, one of the most important of which is no doubt that of an efficient and flexible software, not only for the online control of the switching systems, but also for the smooth and efficient running of offline software maintenance and administrative functions.

The present book, originally entitled 'Denshi Khokan Program Nyumon' (Introduction to the programming of electronic switching systems) published from the Institute of Electronics and Communication Engineers of Japan in March 1976, was produced, by Messrs. S. Takamura, H. Kawashima and H. Nakajima, as a result of the development work carried out in Japan since 1964. It describes the art of software design for electronic switching systems in a fairly comprehensive and detailed manner. It is a great pleasure for me to see that the book has been translated into English and thus presented in a more universal form, so that people not familiar with the Japanese language can read it.

The present translation is a product of marvellous international co-operation among those involved, both in the United Kingdom and in Japan. Among them, my special thanks go to Dr. M. T. Hills, who advocated initially that the translation would be a useful task and then devoted much time and effort to its editing by providing introductory and supplementary chapters, improving English wherever appropriate and editing some of the chapters.

All the goodwill and effort of those involved in the translation as well as the development work itself will be greatly rewarded if this English edition is widely read and makes some contribution, however small it may be, to the advancement of the art of software design for electronic switching systems, to be shared by interested people all over the world.

Dr. Bunichi Oguchi

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Former Chairman of the Publishing Committee, The Institute of Electronics and Communication Engineers of Japan

7 December, 1978

Preface

Computer control of telephone and data-switching systems has now reached maturity as an established engineering endeavor. The software design for such systems uses many of the techniques of real-time programming developed in the online computing field but has also introduced a large number of its own techniques. These techniques are required to meet the special characteristics associated with electronic switching systems, the major characteristics of which include:

(*a*) complex functional specification
(*b*) need to interface to an enormous input/output subsystem with 10 000 or more terminals with response time requirements well below 1 s
(*c*) automatic provision of uninterrupted service in the presence of hardware and software faults and malfunctions
(*d*) need for a large number of sites each with individual variations
(*e*) complete support system to permit online modification and enhancement over a 20 or more years life

One example of a successful switching system is the Japanese D-10 family of systems which by 1978 had over 200 units in service. The Japanese have been credited with the pioneering of several software engineering techniques which can help satisfy the exacting requirements of modern switching systems. The more prominent example is their development of the state-transition diagram as an integral engineering tool for system specification and production.

The Japanese have always published English language articles on their techniques in their own publications and at International conferences. In 1976 the Institute of Electronic and Telecommunications Engineers of Japan published a book on the D-10 software entitled 'Programming electronic switching systems.' This book was intended

for use only within Japan but it brought together a unified description of all the online and offline software components required in switching systems. This made it a unique publication and of interest to the whole of the electronic switching community rather than those interested only in the specific D-10 system. All the techniques described can be applied in one form or another to other switching systems. For this reason the book has been translated into English and supplemented with more recently published material. The resulting book has been edited to make it of interest to anybody involved in the production or procurement of electronic switching systems, as for the first time in book form a complete and detailed description has been provided of switching system software.

As a general background to the book, the editor has added a brief chapter describing the essential features of the Japanese telephone network together with an overview of the D-10 system.

After a general introduction to ESS programming the book first deals with the techniques used for online processing; the executive, call processing, input programs, analysis and translation and output programs. Next, it deals with the fault processing methods which maintain service in the presence of faults. The software requirements for the day-to-day administration of the system has a chapter.

The online portion is completed by a chapter describing how some specific services are programmed.

The latter part of the book deals with the offline support programs required to generate and maintain the online software. In particular, the techniques developed for system modularisation and management are described in the last chapter.

The level of treatment of the book assumes a basic knowledge of computers and programming techniques together with a knowledge of the requirements of a telephone switching system. The latter may be obtained, for instance, from 'Telecommunications switching principles' by M.T. Hills and published by Allen & Unwin and MIT Press in 1979.

The D-10 system was developed as a joint venture between the operating authority of the Nippon Telegraph and Telephone Public Corporation and the manufacturing companies of NEC, Hitachi, Oki Electronic Industries, and Fujitsu Ltd. This book has been possible by the work of engineers in all these organisations and in particular, by the authors of the original book, S. Takamura, H. Kawashima and H. Nakajima.

The costs of the translation were provided by the Japanese companies and the translation was mainly performed by Y. Shimizu (NEC), K. Wakizaka (Hitachi), K. Kondo (Oki) and K. Awaji (Fujitsu).

The editor is grateful to all these and many other unnamed partici-

pants for their efforts and, in particular, to Dr. B. Oguchi for his encouragement and support. He hopes that his editing has not performed any modification of their intent. He is grateful to the Institute of Electronic and Telecommunications Engineers of Japan for permission to use the material. The hope of everybody concerned in this project is that the result will be of assistance to those working in the field and maybe more importantly, those entering the field for the first time.

M.T. Hills
Virgina, USA
June 1979

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Examples of state-transition diagrams

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Chapter 1

Introduction to the D-10

1.1 The Japanese telephone network

Public telecommunications within Japan are the sole responsibility of the Nippon Telegraph and Telephone Public Corporation (NTT). This is a body which was created in 1952, and took over from the Government the furnishing of telephone, telegraph and related telecommunication services. In Japanese, NTT is 'Nihon Denshin Denwa Kosha' and is usually referred to as 'Denden Kosha'.

International telecommunications are the responsibility of a private company called the Kokusai Denshin Denwa Co. Ltd., (KDD). This company was created in 1953 out of NTT.

The present Japanese telephone network has been created predominantly since 1945 and has many similarities to the North American System. In their publications on switching systems, the Japanese refer to the switching system by their North American names, in particular, *office*, for the local centre. In this book both office and local exchange are used interchangeably. Also the first stage in the trunk switching network is referred to as a *toll* exchange.

The network is arranged as a 4-level hierarchy. There are about 7000 *local exchanges* which are grouped into about 600 toll areas each served by *Toll Centre*. The toll centre areas are arranged into 79 groups each served by a *District Centre*. The top level of the hierarchy consists of 8 *Regional Centres*. These are nearly fully interconnected, but all are connected to the regional centres in Tokyo and in Osaka which can act as *National Centres* for switching between the remote district centres of Japan.

Multistage alternative routing is used from all levels of the hierarchy using conventional 'far-to-near' choice of routes. Four-wire switching is used for the District Centres, Regional Centres and almost all the toll centres.

Toll charging is performed at the toll centre for crossbar and step-by-step local exchanges. Periodic meter pulses are fed back to the local exchange by means of meter-pulse signals. The electronic systems perform their own charging for all national calls.

Switching machines in use

Functions of switching machine
The functions of a switching machine are classified as follows:

LS Local (i.e. subscriber) switching
MS Local tandem switch
TS Toll switching
TTS Toll transit switching

Thus district and regional centres must have the TTS function and these are now all 4-wire switched. The toll centres must have the TS functions and these are mostly 4-wire switched.

Until the introduction of D-10, the majority of the traffic was carried by crossbar.

Signalling systems
Between the subscriber and the local exchange normal 20 i.p.s. dial pulse signalling is standard but with an increasing number of m.f. push-button phones being installed on crossbar and electronic exchanges. The pushbutton phones conform to the CCITT standard.

Dial pulse signalling is used between step-by-step exchanges and between the earlier versions of smaller crossbar exchanges. The normal signalling though is m.f. (2 out of 5) on a link-by-link en-block basis (forward direction only). All crossbar systems can determine the correct number length by examining the initial one to four digits of the toll code. The district and regional centres can perform overlap receiving and sending of digital information. Separate channel signalling between electronic toll exchanges is installed in a number of cases.

A variety of line signalling systems are in use depending on the transmission media.

International calls
The international calls are handled by a separate company, KDD. They maintain the cable and satellite links with the rest of the world and also the gateway exchanges and international operator services. At the present time there is only limited subscriber dialling of outgoing calls.

To make an international call from Japan it is necessary to dial the KDD exchange and request the call. In an area served by D-10, a direct connection is possible, but outside this area it is necessary for the KDD to call the subscriber back. The charge for a call is accounted by KDD separately from a domestic call.

The introduction of the D-10 system is permitting international subscriber dialling, since these systems are capable of sending the calling line identity to the KDD equipment for the purposes of billing. The procedure for setting up an international call is to set up a path to the international exchange by the normal sequence of link-by-link signalling. Once the path is connected to the international exchange the calling number, a service required digit and the called numbers are transmitted end-to-end from the D-10 direct to the international exchange. The service required digit, dialled by the subscriber, indicates whether the call is

(*a*) fully automatic (access code '001').
(*b*) charge information required (access code '002'). This is provided automatically, once the call has finished the originating subscriber is called back and a synthesised message tells him the number dialled and the computed charge.

1.2 History of electronic switching development in Japan

What is now the D-10 project was started in 1964 when the Nippon Telegraph and Telephone Public Corporation (NTT) decided to establish a joint team with the four telephone equipment manufacturers of NEC, Hitachi, Oki Electric Industries and Fujitsu. The team was under the direction of the Electrical Communications Laboratories of the NTT.

Two projects were started, DEX-1 and DEX-T1, which were computer-controlled space and time-division speech networks, respectively. DEX stands for Dendenkosha Electronic Exchange. DEX-1 used duplicated, special-purpose computers for the control and an eight-stage network of 8×8 matrices for switching network, based on the Bell Laboratories ferreed switch. Also ferrods were used for line scanning.

The DEX-T1 system was based on a central p.c.m. switch which served remote units consisting of (autonomous) analogue line concentrators which connected subscriber lines to a p.c.m. modem. DEX-1 was put into experimental service within the ECL Musashino Laboratory in 1965 and DEX-T1 in 1966.