
**Information technology — Smart
transducer interface for sensors and
actuators —**

Part 1:
**Network Capable Application Processor
(NCAP) information model**

*Technologies de l'information — Interface de transducteurs intelligente
pour capteurs et actionneurs —*

*Partie 1: Modèle d'information de processeur d'application utilisable en
réseau (NCAP)*



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat, the IEC Central Office and IEEE do not accept any liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies and IEEE members. In the unlikely event that a problem relating to it is found, please inform the ISO Central Secretariat or IEEE at the address given below.

**COPYRIGHT PROTECTED DOCUMENT**

© IEEE 2000

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO or IEEE at the respective address below.

ISO copyright office
Case postale 56 CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York NY 10016-5997, USA
E-mail stds.ipr@ieee.org
Web www.ieee.org

ISO version published 2010
Published in Switzerland

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

The main task of ISO/IEC JTC 1 is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is called to the possibility that implementation of this standard may require the use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. ISO/IEEE is not responsible for identifying essential patents or patent claims for which a license may be required, for conducting inquiries into the legal validity or scope of patents or patent claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance or a Patent Statement and Licensing Declaration Form, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from ISO or the IEEE Standards Association.

ISO/IEC/IEEE 21451-1 was prepared by the Technical Committee on Sensor Technology of the IEEE Instrumentation and Measurement Society of the IEEE (as IEEE Std 1451.1-1999). It was adopted by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*, in parallel with its approval by the ISO/IEC national bodies, under the “fast-track procedure” defined in the Partner Standards Development Organization cooperation agreement between ISO and IEEE. IEEE is responsible for the maintenance of this document with participation and input from ISO/IEC national bodies.

IEEE Std 1451.1-1999

IEEE Standard for a Smart Transducer Interface for Sensors and Actuators— Network Capable Application Processor (NCAP) Information Model

Sponsor

TC-9 Committee on Sensor Technology
of the
IEEE Instrumentation and Measurement Society

Approved 26 June 1999

IEEE-SA Standards Board

Abstract: This standard defines an object model with a network-neutral interface for connecting processors to communication networks, sensors, and actuators. The object model containing blocks, services, and components specifies interactions with sensors and actuators and forms the basis for implementing application code executing in the processor.

Keywords: actuators, communication network, object model, sensors

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2000 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 18 April 2000. Printed in the United States of America.

Print: ISBN 0-7381-1767-6 SH94767
PDF: ISBN 0-7381-1768-4 SS94767

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

IEEE is the sole entity that may authorize the use of certification marks, trademarks, or other designations to indicate compliance with the materials set forth herein.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

[This introduction is not part of IEEE Std 1451.1-1999, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Network Capable Application Processor (NCAP) Information Model.]

The objective of the IEEE/NIST Working Group on transducer interface standards is to utilize existing control networking technology and develop standardized connection methods for Smart Transducers to control networks. Little or no changes would be required to use different methods of analog-to-digital (A/D) conversion, different microprocessors, or different network protocols and transceivers.

This objective is achieved through the definition of a common object model for the components of a Networked Smart Transducer, together with interface specifications to these components.

The Networked Smart Transducer model shows two key views of a smart transducer:

- Physical view
- Logical view

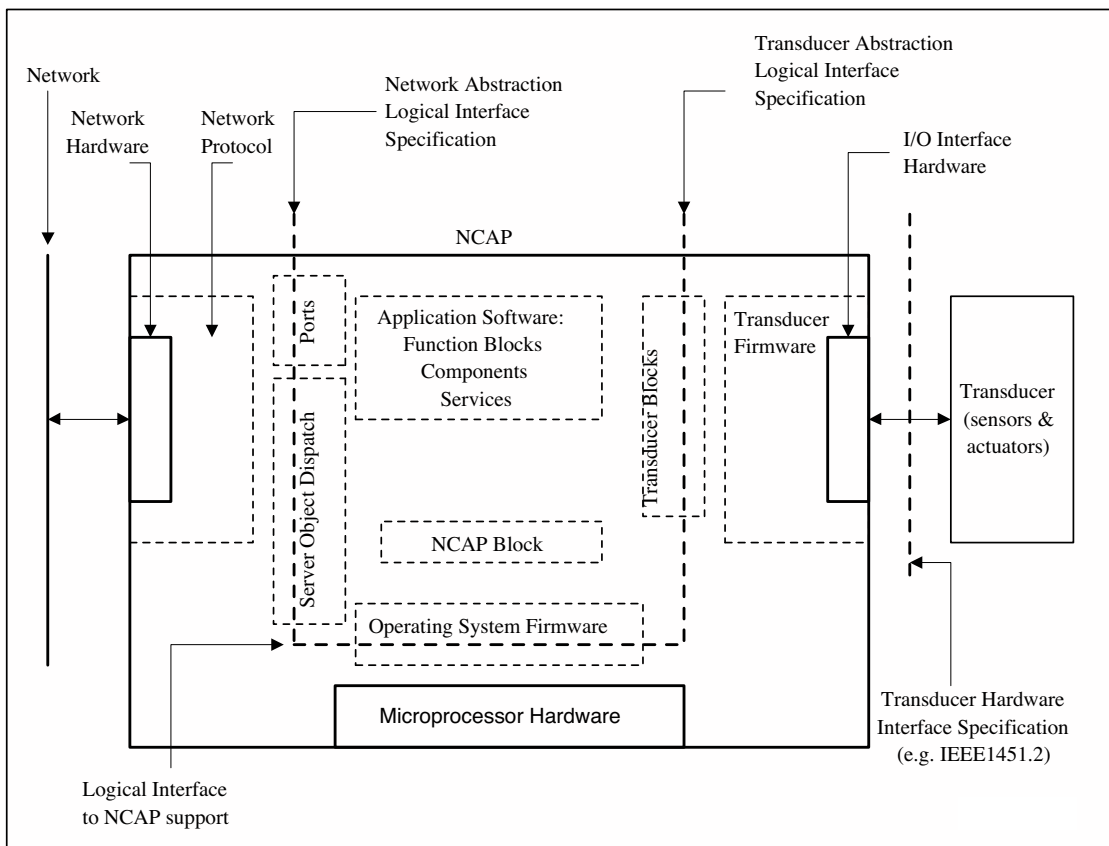


Figure 1—Networked Smart Transducer model

Physical view

The first view shows the physical components of the system. This view is indicated by components drawn in solid lines in Figure 1.

Figure 1 shows a model composed of sensors and actuators connected to form a transducer. The transducer is connected over an interface to a microprocessor or controller that is in turn interfaced to the network. The Hardware Interface Specification between the sensor/actuator and the rest of the device hardware, known as the network capable application processor (NCAP), is indicated by the rightmost thick, dashed line in the figure. A typical specification is described in the companion standard [IEEE Std 1451.2-1997].

The NCAP hardware consists of the microprocessor and its supporting circuitry as well as hardware implementing the physical layer of the attached network and the input/output (I/O) interface to the transducer, as shown in Figure 1.

Logical view

The second view is the logical view of the system and is indicated by components shown in dotted lines in Figure 1.

The logical components may be grouped into application and support components. The support components are the operating system, the network protocol, and transducer firmware components shown. The operating system provides an interface to applications, indicated by the dashed line labeled “Logical Interface to NCAP support.”

A second logical interface, labeled “Network Abstraction Logical Interface Specification,” consists of Port and Server Object Dispatch components defined in this standard. This interface provides an abstraction to hide communication details specific to a given network within a small set of communication methods. The details of this interface are defined by this standard.

The third logical interface, labeled “Transducer Abstraction Logical Interface Specification” performs the same abstraction function for the specifics of the transducer I/O hardware and firmware. In effect, this interface makes all such transducer interfaces look like I/O drivers. The details of this interface are defined by this standard.

Applications are modeled as Function Blocks in combination with Components and Services. The NCAP block provides application organization and support for the other blocks. All of these Blocks, Components, and Services are defined by this standard.

These interfaces are optional in the sense that not all must be exposed in an implementation.

NOTE—If support for interoperable transducers is not required, it is permissible to not use the IEEE1451.2 Interface Specification, or a similar transducer interface standard, but to still use the IEEE1451.1 object model. Similarly, if networking is not supported, or if the networking implementation is closed, it is not necessary to use IEEE1451.1 to still get the benefits of using IEEE1451.2 or a similar transducer interface standard.

Contents

1.	Overview.....	1
1.1	Scope.....	2
1.2	Purpose.....	2
1.3	Benefits	2
2.	References.....	3
2.1	General references	3
2.2	References pertaining to String representation.....	3
2.3	References pertaining to uncertainty	5
3.	Definitions.....	5
4.	Conventions	14
4.1	Class naming.....	14
4.2	Descriptive syntax.....	14
4.3	Word usage	15
4.4	Class definitions.....	16
4.5	Operation signature datatypes.....	17
4.6	Behavioral specification notation	18
5.	Information model	19
5.1	Object model specifications.....	20
5.2	Data model specifications.....	27
5.3	Network communication models.....	28
5.4	IEEE 1451.1 users.....	32
6.	Datatypes in an IEEE 1451.1 system.....	33
6.1	Primitive datatypes.....	33
6.2	Derived datatypes.....	37
7.	Common properties.....	51
7.1	Class designator properties	51
7.2	Object operation properties.....	53
7.3	Block Cookie properties	66
7.4	Value uncertainty specification.....	68
8.	Top-level class definitions	69
8.1	Root abstract class.....	69
8.2	Entity abstract class.....	70
9.	Block classes.....	81
9.1	Block abstract class.....	81
9.2	NCAP Block class.....	90

- 9.3 Function Block class 108
- 9.4 Base Transducer Block abstract class 111
- 9.5 Transducer Block abstract class 114
- 9.6 Dot2 Transducer Block class 123
- 9.7 Dot3 Transducer Block class 123
- 9.8 Dot4 Transducer Block class 124
- 10. Component classes 124
 - 10.1 Component abstract class 124
 - 10.2 Parameter class 126
 - 10.3 Parameter With Update class 128
 - 10.4 Physical Parameter abstract class 133
 - 10.5 Scalar Parameter class 147
 - 10.6 Scalar Series Parameter class 149
 - 10.7 Vector Parameter class 154
 - 10.8 Vector Series Parameter class 159
 - 10.9 Time Parameter class 164
 - 10.10 Action class 168
 - 10.11 File class 171
 - 10.12 Partitioned File class 177
 - 10.13 Component Group class 181
- 11. Service classes 187
 - 11.1 Service abstract class 187
 - 11.2 Base Port abstract class 189
 - 11.3 Base Client Port abstract class 191
 - 11.4 Client Port class 193
 - 11.5 Asynchronous Client Port class 198
 - 11.6 Base Publisher Port abstract class 208
 - 11.7 Publisher Port class 211
 - 11.8 Self Identifying Publisher Port class 213
 - 11.9 Event Generator Publisher Port class 219
 - 11.10 Subscriber Port class 225
 - 11.11 Mutex Service class 229
 - 11.12 Condition Variable Service class 233
- 12. Publication semantics 239
 - 12.1 Overview 239
 - 12.2 Publishing operational behavior 240
 - 12.3 Structure of publications 241
- 13. Defined publications 246
 - 13.1 Publication Timer_Tick specification 246
 - 13.2 Publication Timer_Properties specification 247
 - 13.3 Publication Request_Timer_Properties specification 249
 - 13.4 Publication Physical_Parametric_Data specification 249
 - 13.5 Publication Physical_Parametric_Data_Publisher_Identifying specification 252
- 14. Encode and decode rules 253

14.1	Argument encoding and decoding	253
14.2	Client-server argument encoding and decoding	254
14.3	Publish-side argument encoding	256
14.4	Subscriber-side argument decoding	260
15.	Memory management rules.....	263
15.1	Applicability of memory management ruler.....	263
15.2	In process memory management	263
15.3	Simple datatype memory management.....	263
15.4	Nonsimple datatype memory management.....	263
16.	Conformance.....	266
16.1	Conformance objective	266
16.2	Definition of conformance terms	267
16.3	Conformance requirements.....	269
Annex A	(informative) Using the object model.....	275
Annex B	(informative) Client-server example.....	284
Annex C	(informative) Publish-subscribe example	292
Annex D	(informative) System configuration and operation examples.....	298
Annex E	(informative) NCAP interoperation and network-independent code.....	310
Annex F	(normative) IEEE 1451.1 String character set	312
Annex G	(normative) Assignment of enumeration values to ISO 639 language codes.....	315
Annex H	(normative) IEEE1451.2 Transducer Block definition.....	320
Annex I	(informative) Bibliography	341
Annex J	(informative) IEEE list of participants.....	342

IEEE Standard for a Smart Transducer Interface for Sensors and Actuators— Network Capable Application Processor (NCAP) Information Model

1. Overview

This standard is divided into 16 clauses:

Clause	Purpose
1.	Provides the scope, purpose, and benefits of this standard
2.	Lists references to other standards that are referenced by this standard
3.	Provides definitions that are either not found in other standards or have been modified for use with this standard
4.	Provides conventions for the notation used in this standard
5.	Provides an overview of the information model specified by the standard
6.	Defines the datatypes used in this standard
7.	Defines object properties common to all objects specified in this standard
8.	Defines the top-level objects of an IEEE 1451.1 system
9.	Defines the Block classes
10.	Defines the Component classes
11.	Defines the Service classes
12.	Defines the properties of publications
13.	Defines standard publications
14.	Defines the encoding and decoding rules
15.	Defines the rules for memory management
16.	Defines requirements for conformance

Annexes are provided as follows:

Annex	Purpose
A	Provides an overview of the use of the object model
B	Provides a detailed explanation of client-server interactions
C	Provides a detailed explanation of publish-subscribe interactions
D	Provides detailed examples of the configuration of systems
E	Provides detailed considerations of interoperability
F	Defines a string character set required for certain strings
G	Defines a string language enumeration
H	Defines a Transducer Block for IEEE 1451.2 transducers
I	Bibliography

1.1 Scope

This standard defines an interface for connecting network-capable processors to control networks through the development of a common control network information object model for smart sensors and actuators.

The object model includes definitions of

- Transducer Blocks
- Function Blocks
- NCAP Blocks

This standard will not define individual device algorithms or specifics on what is implemented by using the model.

1.2 Purpose

Many control network implementations are currently available that allow transducers to be accessed over a network. The purpose of this standard is to provide a network-neutral application model that will reduce the effort in interfacing smart sensors and actuators to a network.

1.3 Benefits

A system designed and built in conformance to this standard is expected to provide the following benefits:

- A uniform design model for system implementation
- A uniform and network-independent set of operations for system configuration
- Defined network-independent models for communication
- Interoperability of all communications
- Defined network-independent models for implementing application functionality
- Portable application models

- A network-independent abstraction layer and encode-decode rules that isolate applications from the details of network communications
- A uniform information model for representing physical parametric data
- Uniform models for managing and representing event data, parametric data, and bulk data
- Uniform models for managing and representing time
- Uniform models for intranode concurrency management and components to manage internode concurrency
- Uniform models for memory management

2. References

This standard shall be used in conjunction with the publications and standards listed in this clause. The notation [document-designator] in this standard is a reference to the document in this clause denoted [document-designator].

2.1 General references

[IEEE 754]: IEEE Std 754-1985 (Reaff 1990), IEEE Standard for Binary Floating-Point Arithmetic.¹

[IEEE 1451.2]: IEEE Std 1451.2-1997, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats.

2.2 References pertaining to String representation

The following standards shall be used in conjunction with the `StringCharacterSet` and `StringLanguage` enumerations (see 6.1.2).

ANSI X3.4 1986, Coded Character Set—7-bit American National Standard Code for Information Interchange.²

CNS 11643-1992, (Taiwan) Standard Interchange Code for Generally Used Chinese Characters.³

FSS-UTF, File System Safe Universal Transformation Format (FSS_UTF). X/Open CAE Specification C501 ISBN 1-85912-082.⁴

GB 2312-80 (PRC), China State Bureau of Standards. Coded Chinese Graphic Character Set for Information Interchange.⁵

[ISO 639]: ISO 639:1988-04-01 (E/F), Code for the Representation of Names of languages. Later editions of this standard shall not be used.⁶

¹IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://www.standards.ieee.org/>).

²ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

³This document is available on the World Wide Web at the following site: <http://www.imc.org/rfc1922>.

⁴This document is available by contacting X/Open company, Ltd.—USA, 3141 Fairview Park Drive., Suite 670, Falls Church, VA 22042-4501, USA.

⁵CSBS documents are available from the China State Bureau of Standards, P.O. Box 8010, 42 Hi Chun Road, Haidian District, Beijing 100088, China.

ISO/IEC 646:1991, Information technology—ISO 7-bit coded character set for information interchange.

ISO/IEC 2022: 1994, Information technology—Character code structure and extension techniques.

ISO/IEC 6429: 1992, Information technology—Control functions for coded character sets.

ISO/IEC 8859-1: 1998, Information technology—8-bit single-byte coded graphic character sets—Part 1: Latin alphabet No. 1.

ISO/IEC 8859-2: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 2: Latin alphabet No. 2.

ISO/IEC 8859-3: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 3: Latin alphabet No. 3.

ISO/IEC 8859-4: 1998, Information technology—8-bit single-byte coded graphic character sets—Part 4: Latin alphabet No. 4.

ISO/IEC 8859-5: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 5: Latin/Cyrillic alphabet.

ISO/IEC 8859-6: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 6: Latin/Arabic alphabet.

ISO/IEC 8859-7: 1987, Information processing—8-bit single-byte coded graphic character sets—Part 7: Latin/Greek alphabet.

ISO/IEC 8859-8: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 8: Latin/Hebrew alphabet.

ISO/IEC 8859-9: 1999, Information technology—8-bit single-byte coded graphic character sets—Part 9: Latin alphabet No. 5.

ISO/IEC 8859-10: 1998, Information technology—8-bit single-byte coded graphic character sets—Part 10: Latin alphabet No. 6.

ISO/IEC 10646-1: 1993, Information technology—Universal multiple-octet coded character set (UCS)—Part 1: Architecture and basic multilingual plane.

ISO/IEC DIS 10646-2, Information technology—Universal multiple-octet coded character set (UCS)—Part 2: Ideographic character sets.

JIS X 0208:1997, Japanese Standards Association. Code of the Japanese Graphic Character Set for Information Interchange.⁷

JIS X 0212-1990, Japanese Standards Association. Code of Supplementary Japanese Graphic Character Set for Information Interchange.

KS X 1001:1992, Korea Bureau of Standards. Korean Graphic Character Set for Information Interchange.⁸

⁶ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

⁷JIS documents are available from the Japanese Standards Association, 1-24, Akasaka 4-chome, Minato-Ka, Tokyo, Japan 107.

KS X 1002:1991, Korea Bureau of Standards. Korean Graphic Character Set for Information Interchange. (supplemental character set).

TIS 620-2533 1990, Character Codes for Computers.⁹

⁸KS documents are available from the Korean Bureau of Standards, 2 Chung-ang-dong Kwach'on-city, Kyonggi-do 171-11, Korea.

⁹TIS documents are available from the Thai Industrial Standards Institute, Rama 6 Street, Bangkok 10400, Thailand, (tel. 202-3348; fax 247-8739).