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Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)

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Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)

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The text of this standard is based on the following documents:

IEEE Std	FDIS	Report on voting
IEEE Std 1232-2010	93/320/FDIS	93/327/RVD

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IEEE Std 1232™-2010
(Revision of
IEEE Std 1232-2002)

IEEE Standard for Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)

Sponsor

IEEE Standards Coordinating Committee 20 on Test and Diagnosis for Electronic Systems

Approved 8 December 2010

IEEE-SA Standards Board

Abstract: Data interchange and standard software services for test and diagnostic environments are defined by Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE). The purpose of AI-ESTATE is to standardize interfaces for functional elements of an intelligent diagnostic reasoner and representations of diagnostic knowledge and data for use by such diagnostic reasoners. Formal information models are defined to form the basis for a format to facilitate exchange of persistent diagnostic information between two reasoners and also to provide a formal typing system for diagnostic services. The services to control a diagnostic reasoned are defined by this standard.

Keywords: AI-ESTATE, Bayesian Network, diagnosis, diagnostic inference, diagnostic model, diagnostic services, D-matrix, fault tree, IEEE 1232, knowledge exchange, system test

IEEE Introduction

This introduction is not part of IEEE Std 1232-2010, IEEE Standard for Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE).

The AI-ESTATE standard provides a formal framework for exchanging diagnostic knowledge and communicating with diagnostic reasoners. The intent is to provide a standard framework for identifying required information for diagnosis and defining the diagnostic information in a machine-processable way. In addition, software interfaces are defined whereby applications can be developed to communicate with diagnostic reasoners in a consistent and reliable way.

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Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE)

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1. Overview

The Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) standard was developed by the Diagnostic and Maintenance Control Subcommittee of the IEEE Standards Coordinating Committee 20 (SCC20) on Test and Diagnosis for Electronic Systems to serve as a standard for defining interfaces among diagnostic reasoners and users, test information knowledge bases, and more conventional databases. In addition to interface standards, the AI-ESTATE standard includes a set of formal data specifications to facilitate the exchange of system under test related diagnostic information.

One approach to defining the interfaces for a component of a larger system is to model, formally, the information being passed across the system's interfaces. Such a model is known as an "information model." The purpose of an information model is to identify clearly the objects in a domain of discourse (e.g., diagnostics) to enable precise communication about that domain. Such a model comprises objects or entities, relationships between those objects, and constraints on the objects and their relationships. When taken together, elements provide a complete, unambiguous, formal representation of the domain of discourse. In other words, they provide a formal language for communicating about the domain.

Using information models, information exchange can be facilitated in two ways. The first is through a set of exchange files. Specifically, information can be stored by one application in a file and read by a second application. The file format is derived directly from the information model and defines the syntax of the message contained within it. The semantics of the message (i.e., the legal content of the file) is defined by the semantics of the model. The second means of information exchange is through a set of services defined for a system component as accessed via the communications backbone. The interface definition for the component is derived from the information model and defines the syntax of the message. Once again, the legal content of the message is defined by the semantics of the model.

The semantics of information models are provided in two ways. First, the model itself defines a machine-readable semantic structure and associated constraints that ensure consistent exchange and processing of the concepts and relationships of the model elements. Second, human-readable definitions specify the correct interpretation of the model elements.

This standard describes a set of formal data and knowledge specifications consisting of the logical representation of devices, their constituents, the failure modes of those constituents, and tests of those constituents. The data and knowledge specification provides a standard representation of the common data elements required for system test and diagnosis. This will facilitate portability of test related knowledge bases for intelligent system test and diagnosis.

The goals of this standard are summarized as follows:

— Incorporate domain specific terminology

— Facilitate portability of diagnostic knowledge

— Enable the consistent exchange and integration of diagnostic capabilities

AI-ESTATE defines key data and knowledge specification formats. No host computer dependence is contained in the AI-ESTATE standard. Systems that use only these specification formats will be portable. This does not preclude use of AI-ESTATE interfaces with nonconformant specification formats; however, such systems may not be portable. A diagnostic model can be moved from one AI-ESTATE implementation to another by translating it into one of two interchange formats described in the specification. Another AI-ESTATE implementation can then utilize this information as a complete package by translating the data and knowledge from the interchange format to its own internal form. The translation step is not a requirement; an AI-ESTATE implementation may use the interchange format or its own internal form.

Software specifications defined in this standard provide a consistent means of communicating with diagnostic reasoners through a well-defined set of services. This supports interoperability of diagnostic reasoner with other elements of a test environment with no effect on the other elements of the system.

This standard also provides an extension mechanism to allow the inclusion of new diagnostic technology outside the scope of the Al-ESTATE specification.

An overview of EXPRESS can be found in Annex B. Overviews of the ISO 10303-28:2007[1] and ISO 10303-21:1994 exchange formats can be found in Annex C and Annex D, respectively.

1.1 Scope

The AI-ESTATE standard defines formal specifications for supporting system diagnosis. These specifications support the exchange and processing of diagnostic information and the control of diagnostic processes. Diagnostic processes include, but are not limited to, testability analysis, diagnosability assessment, diagnostic reasoning, maintenance support, and diagnostic maturation.

1.2 Purpose

The AI-ESTATE standard provides formal models of diagnostic information to ensure unambiguous access to an understanding of the information supporting system testing and diagnosis. The standard defines formal information models and software services specific to several different types of diagnostic reasoners.

[1]Information on references can be found in Clause 2.

The purpose is to provide semantically sound definitions of diagnostic knowledge and to specify software exchange and service interfaces that are consistent with the state of the practice in modern test and diagnostic systems (e.g., the use of eXtensible Markup Language [XML] and web services).

1.3 Conventions used in this document

This standard specifies information models, exchange formats, and services using the EXPRESS language and uses the following conventions in their presentation.

Information models are provided in the form of EXPRESS schemas. Exchange files provide the instances of those schemas for a particular diagnostic model. Note that "information model" and "diagnostic model" use the word "model" in subtly different ways. In an attempt to resolve this confusion, in this document, information models will be referred to as EXPRESS schemas and instances of a schema corresponding to a diagnostic model will be referred to as instances (e.g., Dynamic Context Part 21 instance).

All specifications in the EXPRESS and XML languages are given in the `Courier New` type font. The EXPRESS schemas include comment delimiters "(*" and "*)".

Each entity of each EXPRESS schema is presented in a separate subclause. Within a schema, subclauses are listed in alphabetical order by constants, types, enumerated types, select types, entities, and then functions. The subclause structure begins with the actual EXPRESS specification; then, each attribute of the entity is described below the attribute definition heading. If any constraints have been specified, these are described below the formal propositions heading.

This standard uses the vocabulary and definitions of relevant IEEE standards. In the event of conflict between this standard and a related standard such as IEEE Std 1636™-2009 [B5],[2] the standard as it applies to the information being produced shall take precedence. In the event of any conflict between the models and AI-ESTATE definitions (Clause 3), the models' lexical definitions shall take precedence

1.4 IEEE download site

The schemas and examples that accompany this standard are available on the Internet at http://standards.ieee.org/downloads/1232/1232-2010.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

Internet Engineering Task Force (IETF) RFC 2396 (August 1998), Uniform Resource Identifiers (URI): Generic Syntax. [cited 2004-03-15].[3,4]

[2] The numbers in brackets correspond to those of the bibliography in Annex A.
[3] IETF publications are available from the Internet Engineering Task Force, IETF Secretariat, c/o Association Management Solutions, LLC (AMS), 48377 Fremont Boulevard, Suite 117, Fremont, CA 94538, USA (http://www.ietf.org).
[4] This reference can be downloaded at http://www.ietf.org/rfc/rfc2396.txt.

ISO 10303-11:1994 Industrial Automation Systems and Integration—Product Data Representation and Exchange—Part 11: The EXPRESS Language Reference Manual.[5]

ISO 10303-21:1994 Industrial Automation Systems and Integration—Product Data Representation and Exchange—Part 21: Clear Text Encoding of the Exchange Structure.

ISO 10303-21:1994 Technical Corrigendum 1.

ISO 10303-28:2007 Industrial Automation Systems and Integraion—Product Data Representation and Exchange—Part 28: XML Representation of EXPRESS Schemas and Data using XML Schemas.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be consulted for terms not defined in this clause.[6]

ambiguity group: A set of diagnoses that cannot be distinguished with the given set of test outcomes.

diagnostic reasoner: A system that uses a knowledge base to infer conclusions.

diagnostic strategy: (**A**) An approach taken to combine factors including constraints, goals and other considerations to be applied to the localization of faults in a system. (**B**) The approach taken to evaluate a system in order to obtain a diagnostic result.

EXPRESS schema: A specification of data types, structural constraints, and algorithmic rules corresponding to some domain of interest.

eXtensible Markup Language (XML) schema: A specification of a type of XML document typically expressed in terms of constraints of structure and content of documents of that type, above and beyond the basic syntactical constraints imposed by XML itself.

fault isolation: The process of reducing the set of diagnoses in ambiguity to a degree sufficient to undertake an appropriate corrective action.

information model: A specification of a set of objects in a domain of discourse to enable precise and unambiguous communication about that domain. Such a model consists of one or more schemata, each of which comprise objects or entities, relationships between those objects, and constraints on the objects and their relationships.

instance: An occurrence of a realized schema or schema element.

interoperability: The ability of two or more systems or elements to exchange information and to use the information that has been exchanged.

[5]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, 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, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).
[6] *The IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at http://shop.ieee.org/.

knowledge base: A set of data, data semantics and relationships, and functions used by diagnostic reasoners.

native format: Data that exist in a format either produced or consumed by some non–AI-ESTATE diagnostic reasoner.

UOS document: A document that conforms to a single governing EXPRESS schema and follows Part 28's default mapping from EXPRESS to eXtensible Markup Language (XML).

3.2 Acronyms and abbreviations

AI-ESTATE	Artificial Intelligence Exchange and Service Tie to All Test Environments
BNM	Bayesian Network Model
CDF	cumulative distrubution function
CEM	Common Element Model
DAG	directed acyclic graph
DCM	Dynamic Context Model
DIM	Dmatrix Inference Model
DLM	Diagnostic Logic Model
FTM	Fault Tree Model
PDF	probability distribution function
SCC20	Standards Coordinating Committee 20
UOS	unit of serialization
UUT	unit under test
W3C®	World Wide Web Consortium
XML	eXtensible Markup Language

4. Description of AI-ESTATE

4.1 AI-ESTATE architecture

This standard provides the following:

— An overview of the AI-ESTATE architecture

— A formal definition of diagnostic models for systems under test

— Formal definitions of interchange formats for exchange of diagnostic models

— A formal definition of software services for diagnostic reasoners

AI-ESTATE focuses on two distinct aspects of the stated purpose. The first aspect concerns the need to exchange data and knowledge between conformant diagnostic reasoners. The approach taken to address this need is by providing interchangeable files. The second aspect concerns the need for an AI-ESTATE conformant diagnostic reasoner to interact and interoperate with other elements in a test environment (see Figure 1).