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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ARTIFICIAL INTELLIGENCE EXCHANGE AND SERVICE TIE TO ALL TEST ENVIRONMENTS (AI-ESTATE)

FOREWORD

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International Standard IEC/IEEE 62243 has been processed through IEC technical committee 93: Design automation.

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

IEEE Std	FDIS	Report on voting
1232 (2002)	93/214/FDIS	93/220/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

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The committee has decided that the contents of this publication will remain unchanged until 2007.

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

Sponsor

IEEE Standards Coordinating Committee 20

Approved 13 November 2002

American National Standards Institute

Approved 13 June 2002

IEEE-SA Standards Board

Abstract: AI-ESTATE is a set of specifications for data interchange and for standard services for the test and diagnostic environment. The purpose of AI-ESTATE is to standardize interfaces between 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. This standard then defines the services to manipulate diagnostic information and to control a diagnostic reasoner.
Keywords: AI-ESTATE, diagnosis, diagnostic interference, diagnostic model, diagnostic services, dynamic content, fault tree, knowledge exchange, system test

IEEE Introduction

This AI-ESTATE standard provides a formal framework for exchanging diagnostic knowledge and constructing 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 diagnostic tools can be developed to process the diagnostic information in a consistent and reliable way.

Artificial intelligence exchange and service tie to all test environments (AI-ESTATE)

1. Overview

The Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) standard was developed by the Diagnostic and Maintenance Control (D & MC) Subcommittee of the IEEE Standards Coordinating Committee 20 (SCC 20) on Test and Diagnosis for Electronic Systems to serve as a standard for the application of artificial intelligence to system test and diagnosis. This AI-ESTATE standard defines interfaces among reasoners and reasoning system 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.

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
- Permit extensibility of diagnostic knowledge
- Enable the consistent exchange and integration of diagnostic capabilities

This standard provides a controlled extension mechanism to allow inclusion of new diagnostic technology outside the scope of the AI-ESTATE specification.

One of the purposes of this standard is to define information models for knowledge bases to be used in the context of test and diagnosis and, from these models, to derive a data interchange format. The specifications in this standard shall support fully portable diagnostic knowledge. No host computer dependence is contained in the AI-ESTATE standard.

AI-ESTATE defines key data and knowledge specification formats. Implementations that use only these specification formats will be portable. This does not preclude use of AI-ESTATE interfaces with nonconformant specification formats; however, such implementations may not be portable. As shown in Figure 1, a diagnostic model can be moved from one AI-ESTATE implementation to another by translating it into the interchange format. 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.

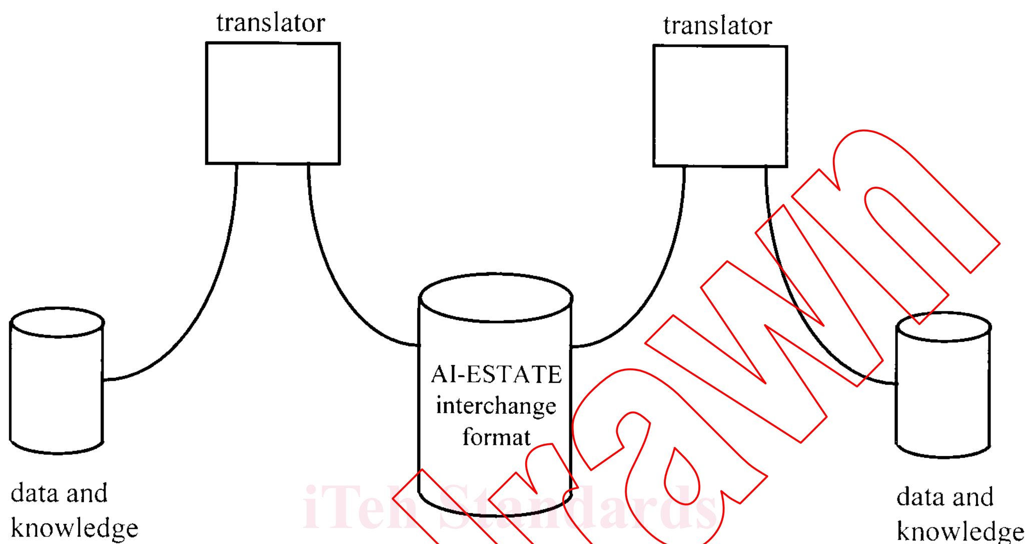

Figure 1—An example of AI-ESTATE's portability mechanism for data and knowledge

The translation step is not a requirement; an AI-ESTATE implementation may use the interchange format for its own internal form.

Software specifications defined in this standard will ensure the interchangeability of diagnostic reasoners through the definition of encapsulated services. This will allow diagnostic reasoners to be interchanged within an AI-ESTATE conformant system with no effect on the other elements of the system.

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 test and diagnosis. The standard unifies and expands on the specifications published in IEEE Std 1232™-1995 [B3],[1] IEEE Std 1232.1™-1997 [B4], and IEEE Std 1232.2™-1998 [B5].

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

1.3 Conventions used in this standard

This standard specifies information models using the EXPRESS language and uses the following conventions in their presentation:

All specifications in the EXPRESS language are given in the `Courier` type font. This includes references to entity and attribute names in the supporting text. The EXPRESS models found in Clause 5 include comment delimiters "(*" and "*)," thus allowing extraction of the models from an electronic version of the standard for direct use.

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 case of conflict of definitions, the following precedence shall be observed: 1) AI-ESTATE definitions (Clause 3); 2) SCC20 documentation and standards; and 3) IEEE 100™, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B2].

Clause 6 of this standard presents the formal specification of the encapsulated services of this standard. EXPRESS is used to represent the interface of each individual service defining the semantics and type of the required value to be returned.

2. References

This standard shall be used in conjunction with the following publications.

ISO 10303-11:1994, Industrial Automation Systems and Integration—Product Data Representation and Exchange—Part 11: Description Methods: The EXPRESS Language Reference Manual.[2]

ISO 10303-21:2002, Industrial Automation Systems and Integration—Product Data Representation and Exchange—Part 21: Implementation Methods: Clear Text Encoding of the Exchange Structure.

3. Definitions and acronyms

For the purposes of this standard, the following terms and definitions apply. IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B2], should be referenced for terms not defined in this clause.

3.1 Definitions

3.1.1 ambiguity: In fault isolation, the inability to localize to a single diagnosis for a repair level, given a set of test results, observations, or other information.

3.1.2 ambiguity group: The collection of all diagnoses that are in ambiguity.

[2]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genéve 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/).

3.1.3 application executive: A software component (or the role of a software component) that administers, and coordinates services to other components within a test system.

3.1.4 diagnosis: The conclusion(s) inferred from tests, observations, or other information.

3.1.5 diagnostic procedure: A structured sequence of tests, observations, and other information used to localize a fault or faults.

3.1.6 element: The smallest entity of an Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) model. For example, in a particular model, the smallest test, the smallest diagnosis, and the no-fault conclusion are all elements.

3.1.7 failure: The loss of ability of a repair item, equipment, or system to perform a required function. The manifestation of a fault. Within AI-ESTATE models, a manifestation is given by the outcome of a test.

3.1.8 false alarm: An indicated fault where no fault exists.

3.1.9 fault: A defect or flaw in a hardware or software component.

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

3.1.11 fault localization: The reduction of ambiguity by the application of tests, observations, or other information.

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

3.1.13 knowledge base: A combination of structure, data, and function used by reasoning systems.

3.1.14 level of maintenance: A level at which test, diagnosis, and repair operates (e.g., maintenance depot, factory, in the field).

3.1.15 portability: The capability of being moved between systems.

3.1.16 protocol: A set of conventions or rules that govern the interactions of processes or applications within a computer system or network.

3.1.17 reasoning system: A system that can combine elements of information and knowledge to draw conclusions.

3.1.18 replaceable unit: A collection of one or more parts considered as a single part for the purposes of replacement and repair due.

3.1.19 resource: Any capability that is to be scheduled, assigned, or controlled by the underlying implementation to assure nonconflicting usage by processes.

3.1.20 service: A software interface providing a means for communicating information between two applications. An action or response initiated by a process (i.e., server) at the request of some other process (i.e., client).

3.1.21 system: 1) A collection of interacting, interrelated, or interdependent elements forming a collective, functioning entity; 2) a set of objects or phenomena grouped together for classification or analysis; 3) a collection of hardware or software components necessary for performing a high-level function.

3.1.22 test: A set of stimuli, either applied or known, combined with a set of observed responses and criteria for comparing these responses to a known standard.

3.1.23 test strategy: An approach taken to combine factors including constraints, goals, and other considerations to be applied to the testing of a system under test.

3.2 Acronyms

AI-ESTATE	Artificial Intelligence Exchange and Service Tie to All Test Environments
BIT	Built-In Test
CEM	Common Element Model
DCM	Dynamic Context Model
DIM	Diagnostic Inference Model
EDIM	Enhanced Diagnostic Inference Model
FTM	Fault Tree Model
SNMP	Simple Network Management Protocol
UTC	Coordinated Universal Time

4. Description of AI-ESTATE

4.1 AI-ESTATE architecture

This standard provides the following:

- Overview of the AI-ESTATE architecture
- Formal definition of diagnostic models for systems under test
- Formal definition of encapsulated 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 systems. Two approaches can be taken to address this need: providing interchangeable files and providing services for retrieving the required data or knowledge through an information management system. AI-ESTATE is structured such that either approach can be used. The second aspect concerns the need for functional elements of an AI-ESTATE conformant system to interact and interoperate. The AI-ESTATE architectural concept provides for the functional elements to communicate with one another via a ‘‘communication pathway’’ as depicted in Figure 2. Essentially, this pathway is an abstraction of the services provided by the functional elements to one another. Thus, the implemented services provide a communication pathway between the reasoner and the rest of the test system.

Services are provided by reasoners to the other functional elements of an AI-ESTATE conformant system. Reasoners can include (but are not necessarily limited to) diagnostic systems, test sequencers, maintenance data feedback analyzers, intelligent user interfaces, and intelligent test programs. AI-ESTATE will not specify services between functional elements that do not incorporate artificial intelligence capabilities. Thus, services are provided by a reasoner to the test system, the human presentation system, a maintenance data/knowledge collection system, and possibly the system under test. The reasoner shall use services provided by these other systems as required. Note that these services shall not be specified by the AI-ESTATE standard.

Data interchange formats are specified to provide a means for exchanging knowledge bases between conformant systems without the need to apply an information management system. Recognizing that

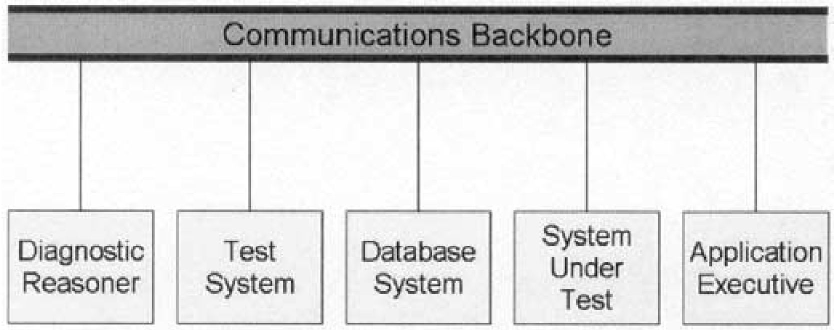

Figure 2—AI-ESTATE architectural concept

some applications may provide services for extracting required data or knowledge, services are specified to permit an application to query the diagnostic system for this purpose.

This standard facilitates the use of standard representations of diagnostic data and knowledge within the context of an AI-ESTATE implementation. In specifying data and knowledge for these domains, a structure has been constructed, as shown in Figure 3. At the top level is the Common Element Model that specifies elements common to the AI-ESTATE domain of equipment test and diagnosis in its entirety. Examples of common element constructs are `diagnosis` (diagnostic conclusions about the system under test), `repair_item` (the physical entity being repaired), `resource`, and `test`. These constructs are characterized by attributes such as costs and failure rates, which are also specified in the Common Element Model.

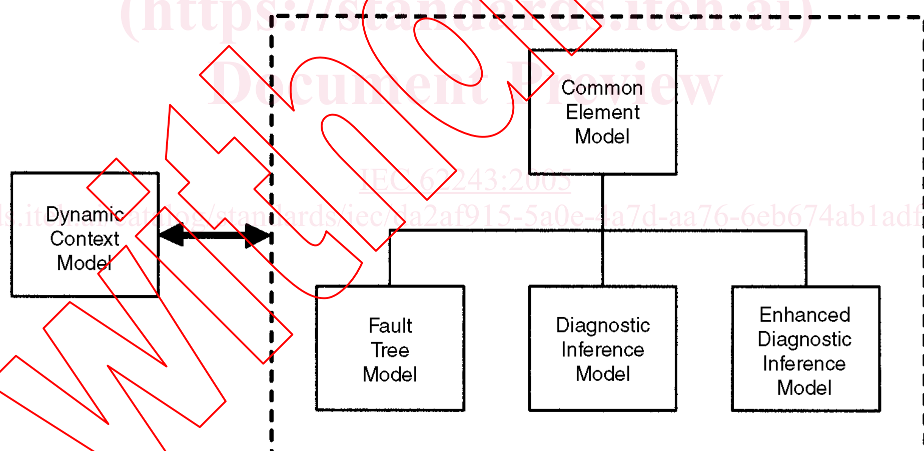

Figure 3—Hierarchical structure of AI-ESTATE models

Below this top layer is a layer of application-specific data and knowledge formats (i.e., the Diagnostic Inference Model, the Enhanced Diagnostic Inference Model, and the Fault Tree Model). These models take advantage of the constructs in the Common Element Model and tailor the constructs to the application's particular reasoning requirements.

Other data and knowledge specification formats are envisioned and will be included in future revisions of this standard. Examples include a constraint-based model, a Bayesian network model, and a neural network model. The Common Element Model has been specified such that other data and knowledge specification formats can also utilize its constructs as base elements that are tailored to the particular application's needs.