

Recommendation X.290

OSI CONFORMANCE TESTING METHODOLOGY AND FRAMEWORK
FOR PROTOCOL RECOMMENDATIONS FOR CCITT APPLICATIONS

The CCITT,

considering

- (a) that Recommendation X.200 defines the Reference Model of Open Systems for CCITT Applications;
- (b) that the objective of OSI will not be completely achieved until systems dedicated to CCITT applications can be tested to determine whether they conform to the relevant OSI protocol Recommendations;
- (c) that standardized test suites should be developed for each OSI protocol Recommendation as a means to:
 - obtain wide acceptance and confidence in conformance test results produced by different testers,
 - provide confidence in the interoperability of equipments which passed the standardized conformance tests;
- (d) the need for defining an international Recommendation to specify the framework and general principles for the specification of conformance test suites and the testing of protocol implementations,

unanimously declares the view that

- 1. the general principles, definition of terms and concepts of OSI protocol conformance testing shall be in accordance with Part 1 of this Recommendation;
- 2. the test methods, test suites, test notation shall be in accordance with Part 2 of this Recommendation.

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PART 1: GENERAL CONCEPTS

Introduction

The objective of OSI will not be completely achieved until systems can be tested to determine whether they conform to the relevant "OSI or related CCITT X-Series or T-Series" (hereafter abbreviated to "OSI*") protocol "standard(s) or Recommendation(s)" (hereafter abbreviated to "Recommendation(s)*").

Standardized test suites should be developed for each OSI* protocol Recommendation, for use by suppliers or implementors in self-testing, by users of OSI products, by the administrations* or other third party testers. This should lead to comparability and wide acceptance of test results produced by different testers, and thereby minimize the need for repeated conformance testing of the same system.

The standardization of test suites requires international definition and acceptance of a common testing methodology and appropriate testing methods and procedures. It is the purpose of this Recommendation to define the methodology, to provide a framework for specifying conformance test suites and define the procedures to be followed during testing.

Conformance testing involves testing both the capabilities and behaviour of an implementation and checking what is observed against the conformance requirements in the relevant Recommendation(s)* and against what the implementor states the implementation's capabilities are.

Conformance testing does not include assessment of the performance nor the robustness or reliability of an implementation. It cannot give judgements on the physical realization of the abstract service primitives, how a system is implemented, how it provides any requested service, nor the environment of the protocol implementation. It cannot, except in an indirect way, prove anything about the logical design of the protocol itself.

The purpose of conformance testing is to increase the probability that different implementations are able to interwork. This is achieved by verifying them by means of a protocol test suite, thereby increasing the confidence that each implementation conforms to the protocol specification. Confidence in conformance to a protocol specification is particularly important when equipment supplied by different vendors is required to interwork.

However, it should be borne in mind that the complexity of most protocols makes exhaustive testing impractical on both technical and economic grounds. Also, testing cannot guarantee conformance to a specification since it detects errors rather than their absence. Thus conformance to a test suite alone cannot guarantee interworking. What it does do is give confidence that an implementation has the required capabilities and that its behaviour conforms consistently in representative instances of communication.

It should be noted that the OSI reference model for CCITT applications (Recommendation X-200) states (in section 4.3):

"Only the external behaviour of Open Systems is retained as the standard of behaviour of real Open Systems".

This means that although aspects of both internal and external behaviour are described in OSI* Recommendations*, only the requirements on external behaviour have to be met by real open systems. Although some of the methods defined in this Recommendation do impose certain constraints on the implementor, for example that there be some means of realizing control and observation at one or more service access points, it should be noted that other methods defined herein do not impose such constraints.

However, in the case of partial OSI* end-systems which provide OSI* protocols up to a specific layer boundary, it is desirable to test both the external behaviour of the implemented protocol entities and the potential of those entities for

supporting correct external behaviour in higher layers.

Detailed investigation of relative benefits, efficiency and constraints of all methods is addressed in various parts of this Recommendation. However, any organization contemplating the use of test methods defined in this Recommendation in a context such as certification should carefully consider the constraints on applicability and the benefits of the different possible test methods.

Testing is voluntary as far as ISO/CCITT is concerned. Requirements for testing in procurement and other external contracts are not a matter for standardization.

1. Scope and field of application

1.1 This Recommendation specifies a general methodology for testing the conformance to OSI* protocol Recommendation(s)* of products in which the Recommendation(s)* are claimed to be implemented. The methodology also applies to testing conformance to transfer syntax Recommendation(s)* to the extent that can be determined by testing each in combination with a specific OSI* protocol.

1.2 This Recommendation is structured into two separate parts:

Part 1 identifies the different phases of conformance testing process, these phases being characterized by four major roles. These roles are:

- a) the specification of abstract test suites for particular OSI* protocols;
- b) the derivation of executable test suites and associated testing tools;
- c) the role of a client of a test laboratory, having an implementation of OSI* protocols to be tested;
- d) the operation of conformance testing, culminating in the production of a conformance test report which gives the results in terms of the Recommendation(s)* and the test suite(s) used.

Additionally, this Part provides tutorial material, together with definition of concepts and terms.

Part 2 defines the requirements and guidance for the specification of abstract test suites for OSI* protocols.

1.3 In both parts of this Recommendation, the scope is limited to include only such information as is necessary to meet the following objectives:

- a) to achieve an adequate level of confidence in the tests as a guide to conformance;
- b) to achieve comparability between the results of the corresponding tests applied in different places at different times;
- c) to facilitate communication between the parties responsible for the roles described above.

1.4 One such aspect of this scope involves the framework for development of OSI* test suites. For example:

- a) how they should relate to the various types of conformance requirement;
- b) the types of test to be standardized and the types not needing standardization;

- c) the criteria for selecting tests for inclusion in a conformance test suite;
- d) the notation to be used for defining tests;
- e) the structure of a test suite.

1.5 Certification, an administrative procedure which may follow conformance testing, is outside the scope of this Recommendation. Requirements for procurement and contracts are also outside the scope of this Recommendation.

1.6 The Physical layer and Media Access Control protocols are outside the field of application of this Recommendation.

2. References

Recommendation X.200, Reference Model of Open Systems Interconnection for CCITT Applications. (See also ISO 7498)

Recommendation X.210, Open Systems Interconnection Layer Service Definition Conventions. (See also ISO TR 8509)

Recommendation X.209, Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1). (See also ISO 8825)

Section 1: Terminology

3. Definitions

3.1 Reference model definitions

This Recommendation is based upon the concepts developed in Reference Model of Open Systems Interconnection for CCITT Applications (CCITT X.200), and makes use of the following terms defined in that Recommendation:

- a) (N)-entity
- b) (N)-service
- c) (N)-layer
- d) (N)-protocol
- e) (N)-service-access-point
- f) (N)-relay
- g) (N)-protocol-data-unit
- h) (N)-protocol-control-information
- i) (N)-user-data
- j) real open system

- k) subnetwork
- l) application-entity
- m) application-service-element
- n) transfer syntax
- o) Physical layer
- p) Data link layer
- q) Network layer
- r) Transport layer
- s) Session layer
- t) Presentation layer
- u) Application layer
- v) systems-management
- w) application-management
- x) layer-management

3.2 Terms defined in other Recommendations

This Recommendation uses the following terms defined in the OSI Service Conventions (Recommendation X.210):

- a) service-user
- b) service-provider

This Recommendation uses the following term defined in the ASN.1 - Basic Encoding Rules Recommendation (Recommendation X.209):

- c) encoding

3.3 Conformance testing definitions

For the purpose of this Recommendation the definitions in 3.4 to 3.8 apply.

3.4 Basic terms

3.4.1 Implementation under test (IUT)

That part of a real open system which is to be studied by testing, which should be an implementation of one or more

OSI* protocols in an adjacent user/provider relationship.

3.4.2 System under test (SUT)

The real open system in which the IUT resides.

3.4.3 Dynamic conformance requirements

All those requirements (and options) which determine what observable behaviour is permitted by the relevant OSI* Recommendation(s)* in instances of communication.

3.4.4 Static conformance requirements

Constraints which are placed in OSI* Recommendations* to facilitate interworking by defining the requirements for the capabilities of an implementation.

Note - Static conformance requirements may be at a broad level, such as the grouping of functional units and options into protocol classes, or at a detailed level, such as the ranges of values that are to be supported for specific parameters or timers.

3.4.5 Capabilities of an IUT

That set of functions and options in the relevant protocol(s) and, if appropriate, that set of facilities and options of the relevant service definition which are supported by the IUT.

3.4.6 Protocol implementation conformance statement (PICS)

A statement made by the supplier of an OSI* implementation or system, stating the capabilities and options which have been implemented, and any features which have been omitted.

3.4.7 PICS proforma

A document, in the form of a questionnaire, designed by the protocol specifier or conformance test suite specifier, which when completed for an OSI* implementation or system becomes the PICS.

3.4.8 Protocol implementation extra information for testing (PIXIT)

A statement made by a supplier or implementor of an IUT which contains or references all of the information (in addition to that given in the PICS) related to the IUT and its testing environment, which will enable the test laboratory to run the appropriate test suite against the IUT.

3.4.9 PIXIT proforma

A document, in the form of a questionnaire, provided by the test laboratory, which when completed during the preparation for testing becomes a PIXIT.

3.4.10 Conforming implementation

An IUT which is shown to satisfy both static and dynamic conformance requirements, consistent with the capabilities stated in the PICS.

3.4.11 System conformance statement

A document summarizing which OSI* Recommendations* are implemented and to which conformance is claimed.

3.4.12 Client

The organization that submits a system or implementation for conformance testing.

3.4.13 Test laboratory

An organization that carries out conformance testing. This can be a third party, a user organization, an administration*, or an identifiable part of the supplier organization.

3.5 Types of testing

3.5.1 Active testing

The application of a test suite to a SUT, under controlled conditions, with the intention of observing the consequent actions of the IUT.

3.5.2 Passive testing

The observation of PDU activity on a link, and checking whether or not the observed behaviour is allowed by the relevant Recommendation(s)*.

3.5.3 Multi-layer testing

Testing the behaviour of a multi-layer IUT as a whole, rather than testing it layer by layer.

3.5.4 Embedded testing

Testing the behaviour of a single layer within a multi-layer IUT without accessing the layer boundaries for that layer within the IUT.

3.5.5 Basic interconnection testing

Limited testing of an IUT to determine whether or not there is sufficient conformance to the main features of the relevant protocol(s) for interconnection to be possible, without trying to perform thorough testing.

3.5.6 Capability testing

Testing to determine the capabilities of an IUT.

Note - This involves checking all mandatory capabilities and those optional ones that are stated in the PICS as being supported, but not checking those optional ones which are stated in the PICS as not supported by the IUT.

3.5.7 Static conformance review

A review of the extent to which the static conformance requirements are met by the IUT, by comparing the static conformance requirements expressed in the relevant Recommendation(s)* with the PICS and the results of any associated

capability testing.

3.5.8 Behaviour testing

Testing the extent to which the dynamic conformance requirements are met by the IUT.

3.5.9 Conformance testing

Testing the extent to which an IUT is a conforming implementation.

3.5.10 Conformance assessment process

The complete process of accomplishing all conformance testing activities necessary to enable the conformance of an implementation or a system to one or more OSI* Recommendations* to be assessed. It includes the production of the PICS and PIXIT documents, preparation of the real tester and the SUT, the execution of one or more test suites, the analysis of the results and the production of the appropriate system and protocol conformance test reports.

3.6 Terminology of test suites

3.6.1 Abstract test method

The description of how an IUT is to be tested, given at an appropriate level of abstraction to make the description independent of any particular implementation of testing tools, but with enough detail to enable tests to be specified for this method.

3.6.2 Abstract testing methodology

An approach to describing and categorizing abstract test methods.

3.6.3 Abstract test case

A complete and independent specification of the actions required to achieve a specific test purpose, defined at the level of abstraction of a particular abstract test method. It includes a preamble and a postamble to ensure starting and ending in a stable state (i.e., a state which can be maintained almost indefinitely, such as the "idle" state or "data transfer" state) and involves one or more consecutive or concurrent connections.

Note 1 - The specification should be complete in the sense that it is sufficient to enable a verdict to be assigned unambiguously to each potentially observable outcome (i.e., sequence of test events).

Note 2 - The specification should be independent in the sense that it should be possible to execute the derived executable test case in isolation from other such test cases (i.e., the specification should always include the possibility of starting and finishing in the "idle" state - that is without any existing connections except permanent ones). For some test cases, there may be pre-requisites in the sense that execution might require some specific capabilities of the IUT, which should have been confirmed by results of the test cases executed earlier.

3.6.4 Executable test case

A realization of an abstract test case.

Note - In general the use of the word "test" will imply its normal English meaning. Sometimes it may be used as an

abbreviation for abstract test case or executable test case. The context should make the meaning clear.

3.6.5 Test purpose

A description of the objective which an abstract test case is designed to achieve.

3.6.6 Generic test case

A specification of the actions required to achieve a specific test purpose, defined by a test body together with a description of the initial state in which the test body is to start.

3.6.7 Preamble

The test steps needed to define the path from the starting stable state of the test case up to the initial state from which the test body will start.

3.6.8 Test body

The set of test steps that are essential in order to achieve the test purpose and assign verdicts to the possible outcomes.

3.6.9 Postamble

The test steps needed to define the paths from the end of the test body up to the finishing stable state for the test case.

3.6.10 Test step

A named subdivision of a test case, constructed from test events and/or other test steps, and used to modularize abstract test cases.

3.6.11 Test event

An indivisible unit of test specification at the level of abstraction of the specification (e.g., sending or receiving a single PDU).

3.6.12 Test suite

A complete set of test cases, possibly combined into nested test groups, that is necessary to perform conformance testing or basic interconnection testing for an IUT or protocol within an IUT.

3.6.13 Test case

A generic, abstract or executable test case.

3.6.14 Test group

A named set of related test cases.

3.6.15 Generic test suite

A test suite composed of generic test cases, with the same coverage as the complete set of test purposes for the particular protocol, this being the set or a superset of the test purposes of any particular abstract test suite for the same protocol.

3.6.16 Abstract test suite

A test suite composed of abstract test cases.

3.6.17 Executable test suite

A test suite composed of executable test cases.

3.6.18 Conformance test suite

A test suite for conformance testing of one or more OSI* protocols.

Note - It should cover both capability testing and behaviour testing. It may be qualified by the adjectives: abstract, generic or executable, as appropriate. Unless stated otherwise, an "abstract test suite" is meant.

3.6.19 Basic interconnection test suite

A test suite for basic interconnection testing of one or more OSI* protocols.

3.6.20 Selected abstract test suite

The subset of an abstract test suite selected using a specific PICS.

3.6.21 Selected executable test suite

The subset of an executable test suite selected using a specific PICS and corresponding to a selected abstract test suite.

3.6.22 Parameterized abstract test case

An abstract test case in which all appropriate parameters have been supplied with values in accordance with a specific PICS and PIXIT.

3.6.23 Parameterized executable test case

An executable test case in which all appropriate parameters have been supplied with values in accordance with a specific PICS and PIXIT.

3.6.24 Parameterized abstract test suite

A selected abstract test suite in which all test cases have been made parameterized abstract test cases for the appropriate PICS and PIXIT.

3.6.25 Parameterized executable test suite

A selected executable test suite in which all test cases have been made parameterized executable test cases for the

appropriate PICS and PIXIT, and corresponding to a parameterized abstract test suite.

3.7 Terminology of results

3.7.1 Repeatability (of results)

Characteristic of a test case, such that repeated executions on the same IUT lead to the same verdict, and by extension a characteristic of a test suite.

3.7.2 Comparability (of results)

Characteristic of conformance assessment processes, such that their execution on the same IUT, in different test environments, leads to the same overall summary.

3.7.3 Outcome

A sequence of test events together with the associated input/output, either identified by an abstract test case specifier, or observed during test execution.

3.7.4 Foreseen outcome

An outcome identified or categorized in the abstract test case specification.

3.7.5 Unforeseen outcome

An outcome not identified or categorized in the abstract test case specification.

3.7.6 Verdict

Statement of "pass", "fail" or "inconclusive" concerning conformance of an IUT with respect to a test case that has been executed and which is specified in the abstract test suite.

3.7.7 System conformance test report (SCTR)

A document written at the end of the conformance assessment process, giving the overall summary of the conformance of the system to the set of protocols for which conformance testing was carried out.

3.7.8 Protocol conformance test report (PCTR)

A document written at the end of the conformance assessment process, giving the details of the testing carried out for a particular protocol, including the identification of the abstract test cases for which corresponding executable test cases were run and for each test case the test purpose and verdict.

3.7.9 Valid test event

A test event which is allowed by the protocol Recommendation*, being both syntactically correct and occurring or arriving in an allowed context in an observed outcome.

3.7.10 Syntactically invalid test event

A test event which syntactically is not allowed by the protocol Recommendation*.

Note - The use of "invalid test event" is deprecated.

3.7.11 Inopportune test event

A test event which, although syntactically correct, occurs or arrives at a point in an observed outcome when not allowed to do so by the protocol Recommendation*.

3.7.12 "Pass" verdict

A verdict given when the observed outcome satisfies the test purpose and is valid with respect to the relevant Recommendation(s)* and with respect to the PICS.

3.7.13 "Fail" verdict

A verdict given when the observed outcome is syntactically invalid or inopportune with respect to the relevant Recommendation(s)* or the PICS.

3.7.14 "Inconclusive" verdict

A verdict given when the observed outcome is valid with respect to the relevant Recommendation(s)* but prevents the test purpose from being accomplished.

3.7.15 Conformance log

A record of sufficient information necessary to verify verdict assignments as a result of conformance testing.

3.8 Terminology of test methods

3.8.1 Point of control and observation (PCO)

A point at which control and observation is specified in a test case.

3.8.2 Lower tester

The abstraction of the means of providing, during test execution, control and observation at the appropriate PCO either below the IUT or remote from the IUT, as defined by the chosen abstract test method.

3.8.3 Upper tester

The abstraction of the means of providing, during test execution, control and observation of the upper service boundary of the IUT, plus the control and observation of any relevant abstract local primitive.

3.8.4 Abstract (N)-service-primitive ((N)-ASP)

An implementation independent description of an interaction between a service-user and a service-provider at an (N)-service boundary, as defined in an OSI* service definition Recommendation*.

3.8.5 Abstract local primitive (ALP)

An abbreviation for a description of control and/or observation to be performed by the upper tester, which cannot be described in terms of ASPs but which relates to events or states defined within the protocol Recommendation(s)* relevant to the IUT.

Note - The PIXIT will indicate whether or not a particular ALP can be realized within the SUT. The ability of the SUT to support particular ALPs as specified in the PIXIT will be used as a criterion in the test selection process.

3.8.6 Test coordination procedures

The rules for cooperation between the lower and upper testers during testing.

3.8.7 Test management protocol

A protocol which is used as a realization of the test coordination procedures for a particular test suite.

3.8.8 Local test methods

Abstract test methods in which the PCOs are directly at the layer boundaries of the IUT.

3.8.9 External test methods

Abstract test methods in which the lower tester is separate from the SUT and communicates with it via an appropriate lower layer service-provider.

Note - The service-provider is immediately beneath the (lowest layer) protocol which is the focus of the testing, and may involve multiple OSI layers.

3.8.10 Distributed test method

An external test method in which there is a PCO at the layer boundary at the top of the IUT.

3.8.11 Coordinated test method

An external test method for which a standardized test management protocol is defined as the realization of the test coordination procedures, enabling the control and observation to be specified solely in terms of the lower tester activity, including the control and observation of test management PDUs.

3.8.12 Remote test method

An external method in which there is neither a PCO above the IUT nor a standardized test management protocol; some requirements for test coordination procedures may be implied or informally expressed in the abstract test suite but no assumption is made regarding their feasibility or realization.

3.8.13 Real tester

The realization of the lower tester, plus either the definition or the realization of the upper tester, plus the definition of the test coordination procedures, as appropriate to a particular test method.

3.8.14 Test realizer

An organization which takes responsibility for providing, in a form independent of client and IUT, the means of testing IUTs in conformance with the abstract test suite.

4. Abbreviations

For the purposes of this Recommendation the following abbreviations apply.

Administration*: Administration or recognized private operating agency.

ALP: abstract local primitive

ASP: abstract service primitive

DTE: data terminal equipment

IUT: implementation under test

OSI: open systems interconnection

OSI*: OSI or related CCITT X-Series or T-Series Recommendations

PCO: point of control and observation

PCTR: protocol conformance test report

PDU: protocol data unit

PICS: protocol implementation conformance statement

PIXIT: protocol implementation extra information for testing

BBSAP: service access point

SCTR: system conformance test report

Recommendation*: Standard or Recommendation

SUT: system under test

TM-PDU: test management PDU

Section 2: Overview

5. The meaning of conformance in OSI*

5.1 Introduction

In the context of OSI*, a real system is said to exhibit conformance if it complies with the requirements of

applicable OSI* Recommendations* in its communication with other real systems.

Applicable OSI* Recommendations* include protocol Recommendations*, and transfer syntax Recommendations* inasmuch as they are implemented in conjunction with protocols.

OSI* Recommendations* form a set of interrelated Recommendations* which together define behaviour of open systems in their communication. Conformance of a real system will, therefore, be expressed at two levels, conformance to each individual Recommendation*, and conformance to the set.

Note - If the implementation is based on a predefined set of Recommendations*, often referred to as a functional standard or profile, the concept of conformance can be extended to specific requirements expressed in the functional standard or profile, as long as they do not conflict with the requirements of the base Recommendations*.

5.2 Conformance requirements

5.2.1 The conformance requirements in a Recommendation* can be:

- a) mandatory requirements: these are to be observed in all cases;
- b) conditional requirements: these are to be observed if the conditions set out in the Recommendation* apply;
- c) options: these can be selected to suit the implementation, provided that any requirements applicable to the option are observed. More information on options is provided in Annex A.

For example, CCITT essential facilities are mandatory requirements; additional facilities can be either conditional or optional requirements.

Note - The CCITT terms "essential facilities" and "additional facilities" need to be considered in the context of the scope of the CCITT Recommendation concerned; in many cases, essential facilities are mandatory for networks but not for DTEs.

5.2.2 Furthermore, conformance requirements in a Recommendation* can be stated

- a) positively: they state what shall be done;
- b) negatively (prohibitions): they state what shall not be done.

5.2.3 Finally, conformance requirements fall into two groups:

- a) static conformance requirements;
- b) dynamic conformance requirements.

These are discussed in 5.3. and 5.5, respectively.

5.3 Static conformance requirements

Static conformance requirements are those that define the allowed minimum capabilities of an implementation, in order to facilitate interworking. These requirements may be at a broad level, such as the grouping of

functional units and options into protocol classes, or at a detailed level, such as a range of values that have to be supported for specific parameters of timers.

Static conformance requirements and options in OSI* Recommendations* can be of two varieties:

- a) those which determine the capabilities to be included in the implementation of the particular protocol;
- b) those which determine multi-layer dependencies, e.g., those which place constraints on the capabilities of the underlying layers of the system in which the protocol implementation resides. These are likely to be found in upper layer Recommendations*.

All capabilities not explicitly stated as static conformance requirements are to be regarded as optional.

5.4 Protocol implementation conformance statement (PICS)

To evaluate the conformance of a particular implementation, it is necessary to have a statement of the capabilities and options which have been implemented, and any features which have been omitted, so that the implementation can be tested for conformance against relevant requirements, and against those requirements only. Such a statement is called a Protocol Implementation Conformance Statement (PICS).

In a PICS there should be a distinction between the following categories of information which it may contain:

- a) information related to the mandatory, optional and conditional static conformance requirements of the protocol itself;
- b) information related to the mandatory, optional and conditional static conformance requirements for multi-layer dependencies.

If a set of interrelated OSI* protocol Recommendations* has been implemented in a system, a PICS is needed for each protocol. A System Conformance Statement will also be necessary, summarizing all protocols in the system for each of which a distinct PICS is provided.

5.5 Dynamic conformance requirements

Dynamic conformance requirements are all those requirements (and options) which determine what observable behaviour is permitted by the relevant OSI* Recommendation(s)* in instances of communication. They form the bulk of each OSI* protocol Recommendation*. They define the set of allowable behaviours of an implementation or real system. This set defines the maximum capability that a conforming implementation or real system can have within the terms of the OSI* protocol Recommendation*.

A system exhibits dynamic conformance in an instance of communication if its behaviour is a member of the set of all behaviours permitted by the relevant OSI* protocol Recommendation(s)* in a way which is consistent with the PICS.

5.6 A conforming system

A conforming system or implementation is one which is shown to satisfy both static and dynamic conformance requirements, consistent with the capabilities stated in the PICS, for each protocol declared in the System Conformance Statement.

5.7 Interworking and conformance

5.7.1 The primary purpose of conformance testing is to increase the probability that different implementations are able to interwork.

Successful interworking of two or more real open systems is more likely to be achieved if they all conform to the same subset of an OSI* Recommendation*, or to the same selection of OSI* Recommendations*, than if they do not.

In order to prepare two or more systems to interwork successfully, it is recommended that a comparison be made of the System Conformance Statements and PICSs of these systems.

If there is more than one version of a relevant OSI* Recommendation* indicated in the PICSs, the differences between the versions need to be identified and their implications for consideration, including their use in combination with other Recommendations*.

5.7.2 While conformance is a necessary condition, it is not on its own a sufficient condition to guarantee interworking capability. Even if two implementations conform to the same OSI* protocol Recommendation*, they may fail to interwork because of factors outside the scope of that Recommendation.

Trial interworking is recommended in order to detect these factors. Further information to assist interworking between two systems can be obtained by extending the PICS comparison to other relevant information, including test reports and PIXIT (see clause 6.2). The comparison can focus on:

- a) additional mechanisms claimed to work around known ambiguities or deficiencies not yet corrected in the Recommendations* or in peer real systems, e.g., solution of multi-layer problems;
- b) selection of free options which are not taken into account in the static conformance requirements of the Recommendations*;
- c) the existence of timers not specified in the Recommendation* and their associated values.

Note - The comparison can be made between two individual systems, between two or more types of product, or, for the PICS comparison only, between two or more specifications for procurement, permissions to connect, etc.

6. Conformance and testing

6.1 Objectives of conformance testing

6.1.1 Introduction

Conformance testing as discussed in this Recommendation is focused on testing for conformance to OSI* protocol Recommendations*. However, it also applies to testing for conformance to OSI* transfer syntax Recommendations*, to the extent that this can be carried out by testing the transfer syntax in combination with an OSI* protocol.

In principle, the objective of conformance testing is to establish whether the implementation being tested conforms to the specification in the relevant Recommendation*. Practical limitations make it impossible to be exhaustive, and economic considerations may restrict testing still further.

Therefore, this Recommendation distinguishes four types of testing, according to the extent to which they provide an indication of conformance:

- a) basic interconnection tests, which provide prima facie evidence that an IUT conforms;
- b) capability tests, which check that the observable capabilities of the IUT are in accordance with the static conformance requirements and the capabilities claimed in the PICS;
- c) behaviour tests, which endeavour to provide testing which is as comprehensive as possible over the full range of dynamic conformance requirements specified by the Recommendation*, within the capabilities of the IUT;
- d) conformance resolution tests, which probe in depth the conformance of an IUT to particular requirements, to provide a definite yes/no answer and diagnostic information in relation to specific conformance issues, such tests are not standardized.

6.1.2 Basic interconnection tests

6.1.2.1 Basic interconnection tests provide limited testing of an IUT in relation to the main features in a Recommendation*, to establish that there is sufficient conformance for interconnection to be possible, without trying to perform thorough testing.

6.1.2.2 Basic interconnection tests are appropriate:

- a) for detecting severe cases of non-conformance;
- b) as a preliminary filter before undertaking more costly tests;
- c) to give a prima facie indication that an implementation which has passed full conformance tests in one environment still conforms in a new environment (e.g., before testing an (N)-implementation, to check that a tested (N-1)-implementation has not undergone any severe change due to being linked to the (N)-implementation);
- d) for use by users of implementations, to determine whether the implementations appear to be usable for communication with other conforming implementations, e.g., as a preliminary to data interchange.

6.1.2.3 Basic interconnection tests are inappropriate:

- a) as a basis for claims of conformance by the supplier of an implementation;
- b) as a means of arbitration to determine causes for communications failure.

6.1.2.4 Basic interconnection tests should be standardized as either a very small test suite or a subset of a conformance test suite (including capability and behaviour tests). They can be used on their own or together with a conformance test suite. The existence and execution of basic interconnection tests are optional.

6.1.3 Capability tests

6.1.3.1 Capability tests provide limited testing of each of the static conformance requirements in a Recommendation*, to ascertain what capabilities of the IUT can be observed and to check that those observable capabilities are valid with respect to the static conformance requirements and the PICS.

6.1.3.2 Capability tests are appropriate:

- a) to check as far as possible the consistency of the PICS with the IUT;
- b) as a preliminary filter before undertaking more in-depth and costly testing;
- c) to check that the capabilities of the IUT are consistent with the static conformance requirements;
- d) to enable efficient selection of behaviour tests to be made for a particular IUT;
- e) when taken together with behaviour tests, as a basis for claims of conformance.

6.1.3.3 Capability tests are inappropriate:

- a) on their own, as a basis for claims of conformance by the supplier of an implementation;
- b) for testing in detail the behaviour associated with each capability which has been implemented or not implemented;
- c) for resolution of problems experienced during live usage or where other tests indicate possible non-conformance even though the capability tests have been satisfied.

6.1.3.4 Capability tests are standardized within a conformance test suite. They can either be separated into their own test group(s) or merged with the behaviour tests.

6.1.4 Behaviour tests

6.1.4.1 Behaviour tests test an implementation as thoroughly as is practical, over the full range of dynamic conformance requirements specified in a Recommendation*. Since the number of possible combinations of events and timing of events is infinite, such testing cannot be exhaustive. There is a further limitation, namely that these tests are designed to be run collectively in a single test environment, so that any faults which are difficult or impossible to detect in that environment are likely to be missed. Therefore, it is possible that a non-conforming implementation passes the conformance test suite; one aim of the test suite design is to minimize the number of times that this occurs.

6.1.4.2 Behaviour tests are appropriate, when taken together with capability tests, as a basis for the conformance assessment process.

6.1.4.3 Behaviour tests are inappropriate for resolution of problems experienced during live usage or where other tests indicate possible non-conformance even though the behaviour tests have been satisfied.

6.1.4.4 Behaviour tests are standardized as the bulk of a conformance test suite.

Note - Behaviour tests include tests for valid behaviour by the IUT in response to valid, inopportune and syntactically invalid protocol behaviour by the real tester. This includes testing the rejection by the IUT of attempts to use features (capabilities) which are stated in the PICS as being not implemented. Thus, capability tests do not need to include tests for capabilities omitted from the PICS.

6.1.5 Conformance resolution tests

6.1.5.1 Conformance resolution tests provide diagnostic answers, as near to definitive as possible, to the resolution of whether an implementation satisfies particular requirements. Because of the problems of exhaustiveness noted in § 6.1.4.1, the definite answers are gained at the expense of confining tests to a narrow field.

6.1.5.2 The test architecture and test method will normally be chosen specifically for the requirements to be tested, and need not be ones that are generally useful for other requirements. They may even be ones that are regarded as being unacceptable for (standardized) abstract conformance test suites, e.g., involving implementation specific methods using, say, the diagnostic and debugging facilities of the specific operating system.

6.1.5.3 The distinction between behaviour tests and conformance resolution tests may be illustrated by the case of an event such as a Reset. The behaviour tests may include only a representative selection of conditions under which a Reset might occur, and may fail to detect incorrect behaviour in other circumstances. The conformance resolution tests would be confined to conditions under which incorrect behaviour was already suspected to occur, and would confirm whether or not the suspicions were correct.

6.1.5.4 Conformance resolution tests are appropriate:

- a) for providing a yes/no answer in a strictly confined and previously identified situation (e.g., during implementation development, to check whether a particular feature has been correctly implemented, or during operational use, to investigate the cause of problems);
- b) as a means for identifying and offering resolutions for deficiencies in a current conformance test suite.

6.1.5.5 Conformance resolution tests are inappropriate as a basis for judging whether or not an implementation conforms overall.

6.1.5.6 Conformance resolution tests are not standardized.

Note on 6.1 - As a by-product of conformance testing, errors and deficiencies in protocol Recommendations* may be identified.

6.2 Protocol implementation extra information for testing (PIXIT)

In order to test a protocol implementation, the test laboratory will require information relating to the IUT and its testing environment in addition to that provided by the PICS. This "Protocol Implementation eXtra Information for Testing" (PIXIT) will be provided by the client submitting the implementation for testing, as a result of consultation with the test laboratory.

The PIXIT may contain the following information:

- a) information needed by the test laboratory in order to be able to run the appropriate test suite on the specific system (e.g., information related to the test method to be used to run the test cases, addressing information);
- b) information already mentioned in the PICS and which needs to be made precise (e.g., a timer value range which is declared as a parameter in the PICS should be specified in the PIXIT);
- c) information to help determine which capabilities stated in the PICS as being supported are testable and which are untestable;
- d) other administrative matters (e.g., the IUT identifier, reference to the related PICS).

The PIXIT should not conflict with the appropriate PICS.

The abstract test suite specifier, test realizer and test laboratory will all contribute to the development of the PIXIT proforma.

6.3 Conformance assessment process outline

6.3.1 The main feature of the conformance assessment process is a configuration of equipment allowing exchanges of information between the IUT and a real tester. These are controlled and observed by the real tester.

6.3.2 In conceptual outline, conformance testing should include several steps, involving both static conformance reviews and live testing phases, culminating in the production of a test report which is as thorough as is practical.

6.3.3 These steps are:

- a) analysis of the PICS;
- b) test selection and parameterization;
- c) basic interconnection testing (optional);
- d) capability testing;
- e) behaviour testing;
- f) review and analysis of test results;
- g) synthesis, conclusions and conformance test report production.

These are illustrated in Figure 1.

Prior to the execution of any of the tests, the IUT's PICS and PIXIT are input to the test case selection and parameterization process.

6.4 Analysis of results

6.4.1 General

6.4.1.1 Outcomes and verdicts

The observed outcome (of the test execution) is the series of events which occurred during execution of a test case; it includes all input to and output from the IUT at the points of control and observation.

The foreseen outcomes are identified and defined by the abstract test case specification taken in conjunction with the protocol Recommendation*. For each test case, there may be one or more foreseen outcome(s). Foreseen outcomes are defined primarily in abstract terms.

A verdict is a statement of pass, fail or inconclusive to be associated with every foreseen outcome in the abstract test suite specification.

The analysis of results is performed by comparing the observed outcomes with foreseen outcomes.

The verdict assigned to an observed outcome is that associated with the matching foreseen outcome. If the observed outcome is unforeseen then the abstract test suite specification will state what default verdict shall be assigned.

The means by which the comparison of the observed outcomes with the foreseen outcomes is made is outside the scope of this Recommendation.

Note - Amongst the possibilities are:

- a) manual or automated comparison (or a mixture);
- b) comparison at or after execution time;
- c) translating the observed outcomes into abstract terms for comparison with the foreseen outcomes or translating the foreseen outcomes into the terms used to record the observed outcomes.

The verdict will be pass, fail or inconclusive:

- a) pass means that the observed outcome satisfies the test purpose and is valid with respect to the relevant Recommendation(s)* and with respect to the PICS;
- b) fail means that the observed outcome is syntactically invalid or inopportune with respect to the relevant Recommendation(s)* or the PICS;
- c) inconclusive means that the observed outcome is valid with respect to the relevant Recommendation(s)* but prevents the test purpose from being accomplished.

The verdict assigned to a particular outcome will depend on the test purpose and the validity of the observed protocol behaviour.

The verdicts made in respect of individual test cases will be synthesized into an overall summary for the IUT based on the test cases executed.

6.4.1.2 Conformance test reports

The results of conformance testing will be documented in a set of conformance test reports. These reports will be of two types: a System Conformance Test Report (SCTR), and a Protocol Conformance Test Report (PCTR).

The SCTR, which will always be provided, gives an overall summary of the conformance status of the SUT, with respect to its single or multi-layer IUT. A standard proforma for the SCTR is for further study.

The PCTR, one of which will be issued for each protocol tested in the SUT, documents all of the results of the test

cases giving references to the conformance logs which contain the observed outcomes. The PCTR also gives reference to all necessary documents relating to the conduct of the conformance assessment process for that protocol.

A standard proforma for the PCTR is for further study. The ordered list of test cases to be used in the PCTR will be specified in the conformance test suite Recommendation*.

6.4.2 Repeatability of results

In order to achieve the objective of credible conformance testing, it is clear that the result of executing a test case on an IUT should be the same whenever it is performed. Statistically, it may not be possible to perform a complete conformance test suite and observe outcomes which are completely identical to those obtained on another occasion: unforeseen events do occur, and this is a feature of the environments involved. Nevertheless, at the test case level, it is very important that every effort is made by the test specifiers and test laboratories to minimize the possibility that a test case produces different outcomes on different occasions.

6.4.3 Comparability of results

In order to achieve the ultimate objectives of conformance testing, the overall summary concerning conformance of an IUT has to be independent of the test environment in which the testing takes place. That is to say, the standardization of all of the procedures concerned with conformance testing should result in a comparable overall summary being accorded to the IUT, whether the testing is done by the supplier, a user, or by any third party test house. There are a large number of factors to be studied to achieve this, of which some of the more important are:

- a) careful design of the abstract test case specification to give flexibility where appropriate, but show which requirements have to be met; (which is the subject of this Recommendation);
- b) careful specification of the real tester which should be used to run the test suite; again this specification should give flexibility where appropriate, but show which requirements have to be met, including all test coordination procedures (if any);

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- c) careful specification of the procedure to be followed in determining how the contents of the PICS are to be used in the analysis of outcomes of test cases; there should be no room for "optimistic" interpretation;
- d) careful specification of the procedures to be followed by test laboratories as regards the repetition of a test case before making a final verdict for that test purpose;
- e) a proforma for a conformance test report;
- f) careful specification of the procedures necessary when synthesizing an overall summary.

6.4.4 Auditability of results

For legal reasons, as well as others, it may be necessary to review the observed outcomes from the execution of a conformance test suite in order to make sure that all procedures have been correctly followed. Whether or not analysis has been carried out in a manual or automatic mode, it is essential that all inputs, outputs, and other test events are carefully logged, and the analysis of the results recorded. In some cases this may be the responsibility of the test realizer, who may elect to include the test criteria in the conformance log, as well as all outcomes. In others, it may be the responsibility of the test laboratory, which might be required to follow all standard procedures concerning the recording of results.

Note - As far as auditability is concerned, some automatic procedures would be preferred, but in the event it should be appreciated that from a legal standpoint such automatic procedures would have to be accredited themselves, if they are to be credible.