Protocol Conformance Testing

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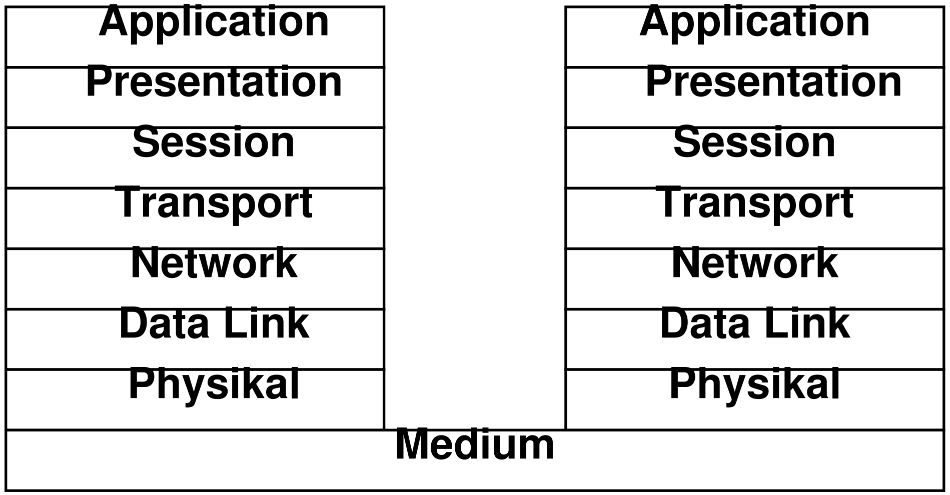
- State of the Art of Protocol Conformance Testing (PCT)
- Introduction to Conformance Testing Methodology and Framework
- Survey of further Activities

ISO - Open Systems Interconnection (OSI)

- Seven layered Model
- Modularization
- Specification of observable Behaviour



ISO-OSI / ITU-T Applicationen

- Layer 7 : X.400 (MH), X.500 (Directory)
- Layer 6 : T.100 (Videotext)
- Layer 5 : ISO/IEC 8327 (Basic Connection Oriented Session)
- Layer 4 : ISO/IEC 8073 (TP4)
- Layer 3,2 : X.25
- Layer 1 : V.24

Conformance Testing Methodology and Framework

- Abbr.: CTMF, ISO/IEC 9646-(1-7), ITU-T (former CCITT) X.290-296 Series
- Needs for Tests for particular protocols
- Description of Tests
- Preparation of Tests
- Realization of Tests
- Assessment of Tests

Fields of CTMF

- Definition of a terminology for testing
- Specification of Abstract Test Suites (ATS) for OSI protocols
- Development of proformas for testing
- Realization and execution of test suites
- Definition of the Conformance Assessment Process
- Definition of the protocol conformance test report
- ...

Not covered by CTMF

- interoperability testing
- performance testing
- robustness
- internal aspects of the system implementation
- the system environment
- test certificates
- accreditation of test labs
- testing tools
- test case generation
- ...

CTMF Standard

1. General Concepts
2. ATS Specification
3. Tree and Tabular Combined Notation (TTCN)
4. Test Realization
5. Test Laboratory Requirements

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6. Protocol Profile Testing Specification
7. Implementation Conformance Statements (ICS)

General Concepts

- Definitions
- Conformance Requirements
- Protocol Implementation Conformance Statement
- Protocol Implementation eXtra Information for Testing
- Abstract Test Methods
- Abstract Test Suites
- Analysis of Test Results

Relationshps between Parts, Concepts, and Activities

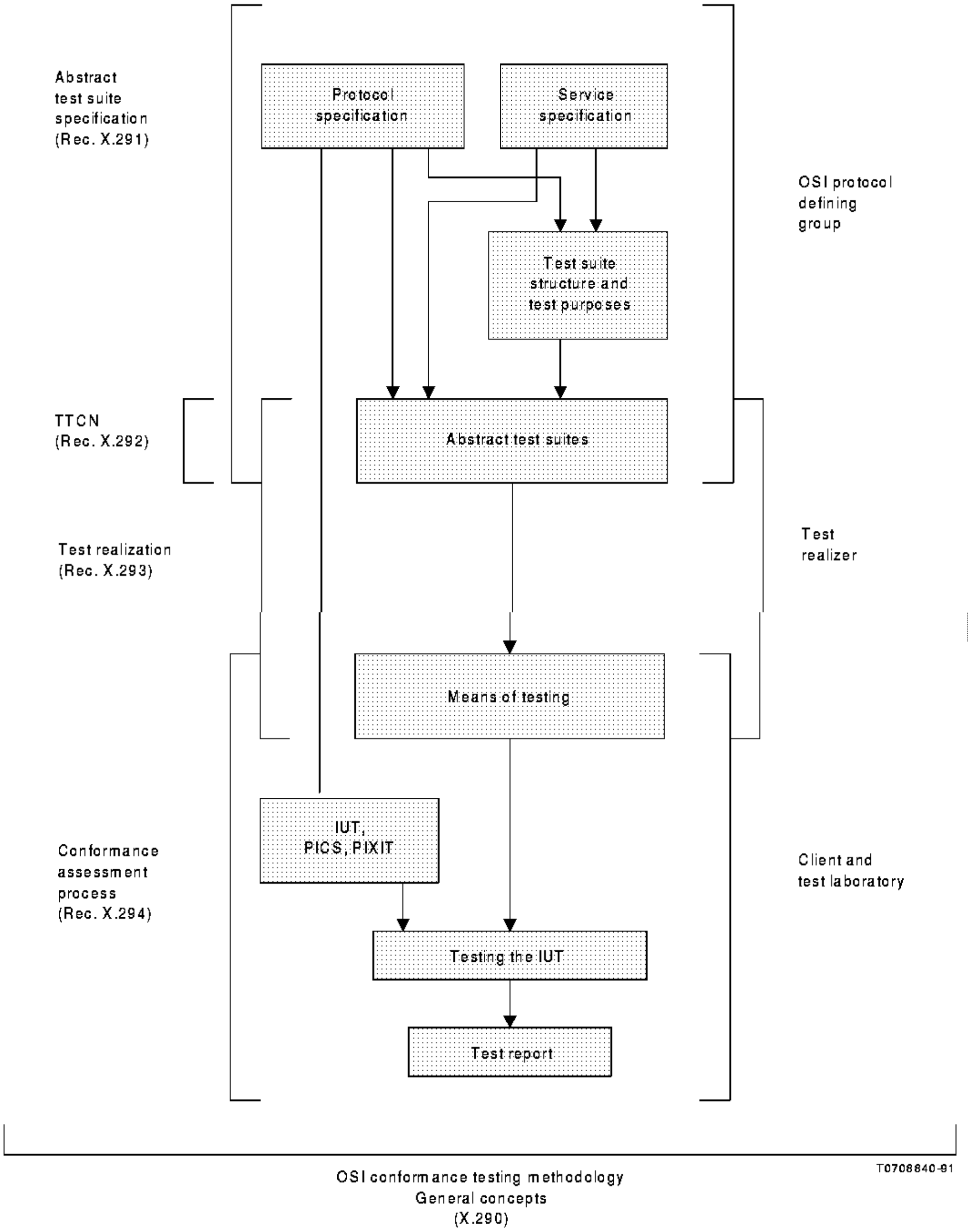


FIGURE 10/X.290

Basic Terms

- Implementation under Test (IUT)
- System under Test (SUT)
- Static and Dynamic Conformance Requirements
- Capabilty (of an Implementation)
- Protocol Implementation Conformance Statement (PICS)
- Protocol Implementation eXtra Information for Testing (PIXIT)
- Conforming Implementation
- System Conformance Statement (SCS)
- Client & Test Laboratory
- ...

Types of Testing

- Basic Interconnection Tests
  - test connection set-up
- Capability Test
  - validation of static conformance requirements and PICS
- Behaviour Test
  - main part of testing, including invalid protocol behaviour by the tester
- Conformance Resolution Tests
  - beyound Behaviour Tests, in case of undefined test cases, in order to fulfil a test putpose

Types of Result (Verdict)

- Pass
  - The observered behaviour gives evidence of conformance
- Inconclusive
  - Neither a pass nor a fail can be given
- Fail
  - The observered behaviour demonstrates non-conformance
- Final Verdict
  - Summary of verdicts, lowest result (pass > inconclusive > fail) determines the final verdict

Conformance Assessment Process Overview

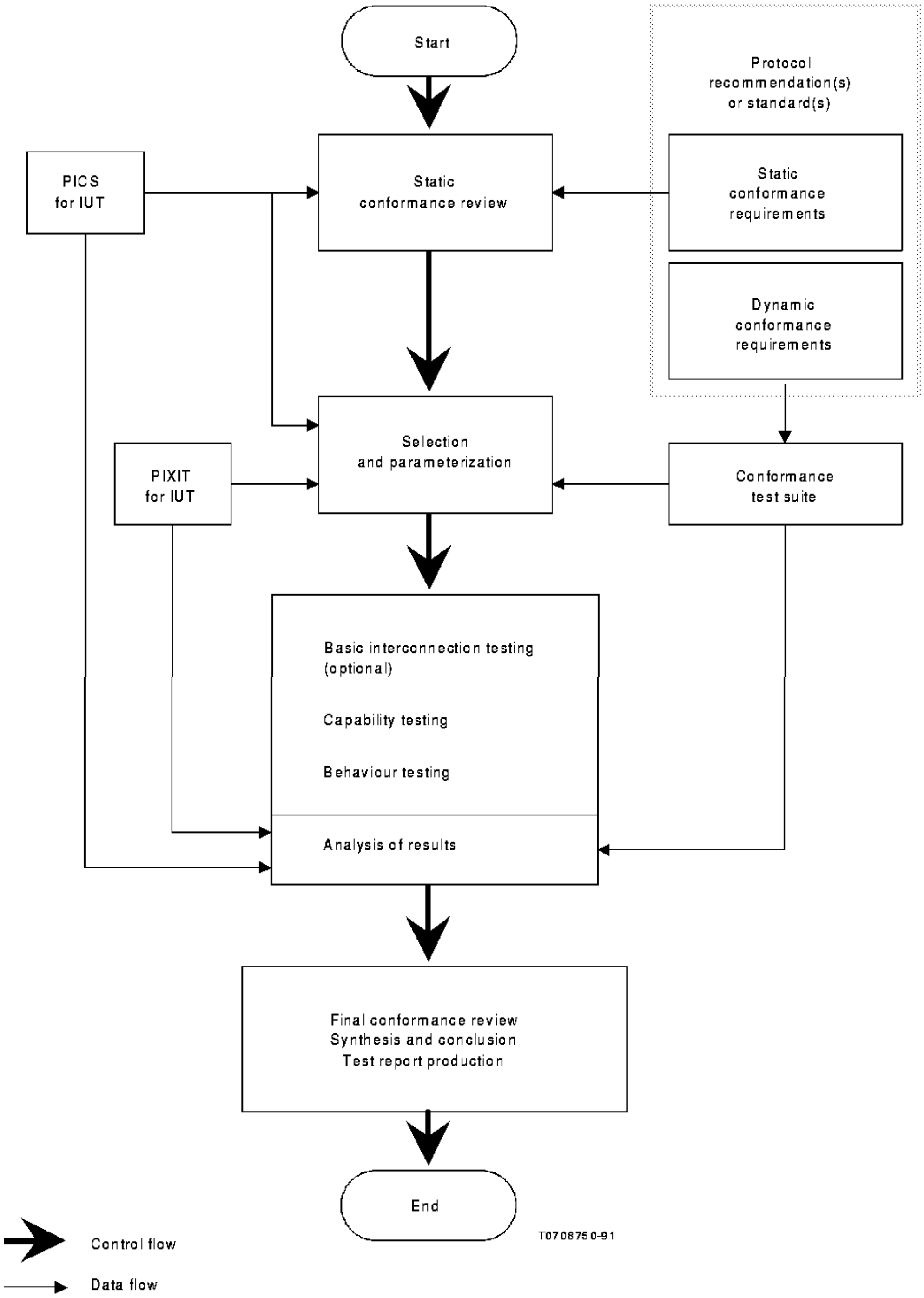


FIGURE 1/X.290

Conceptual Testing Architecture

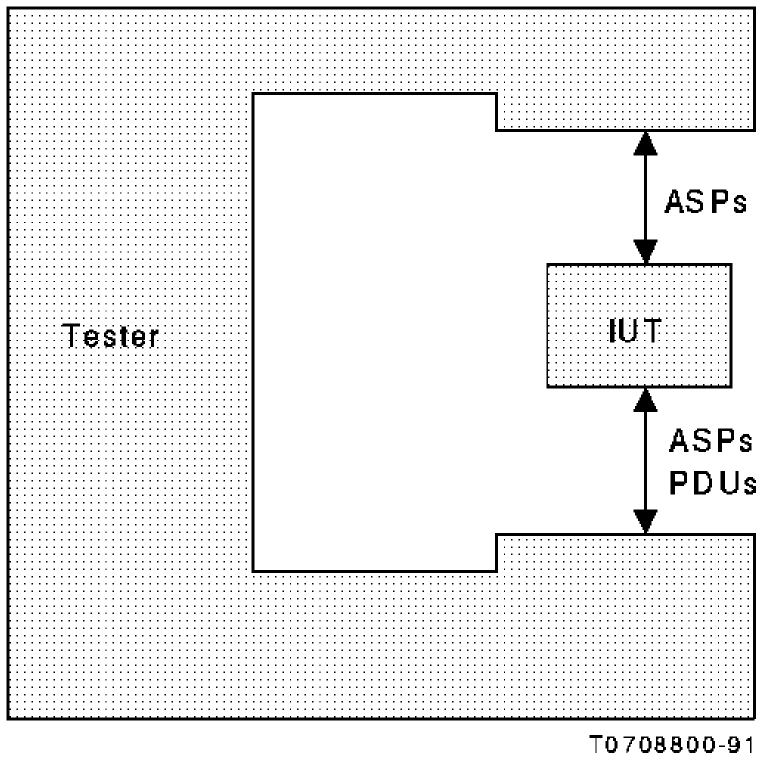


FIGURE 6/X.290

Possible PCOs for Testing

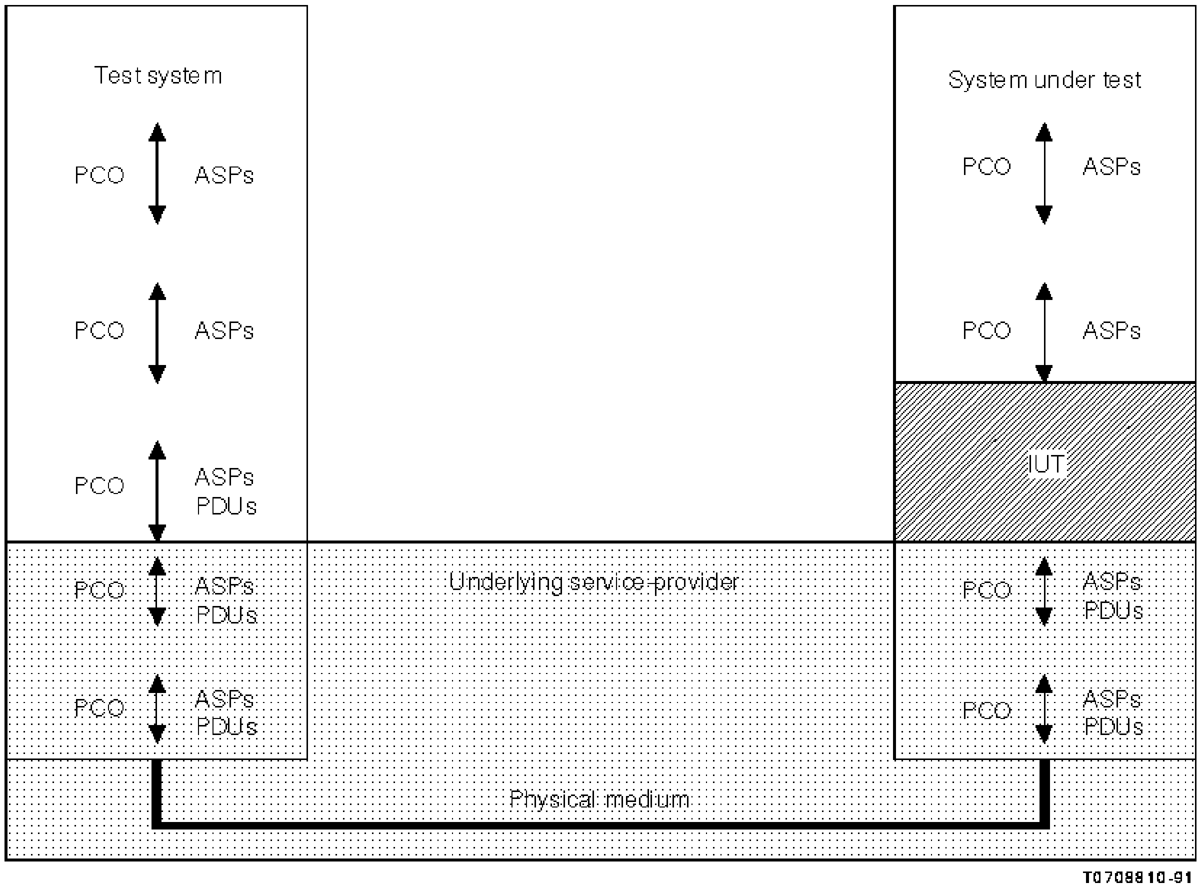
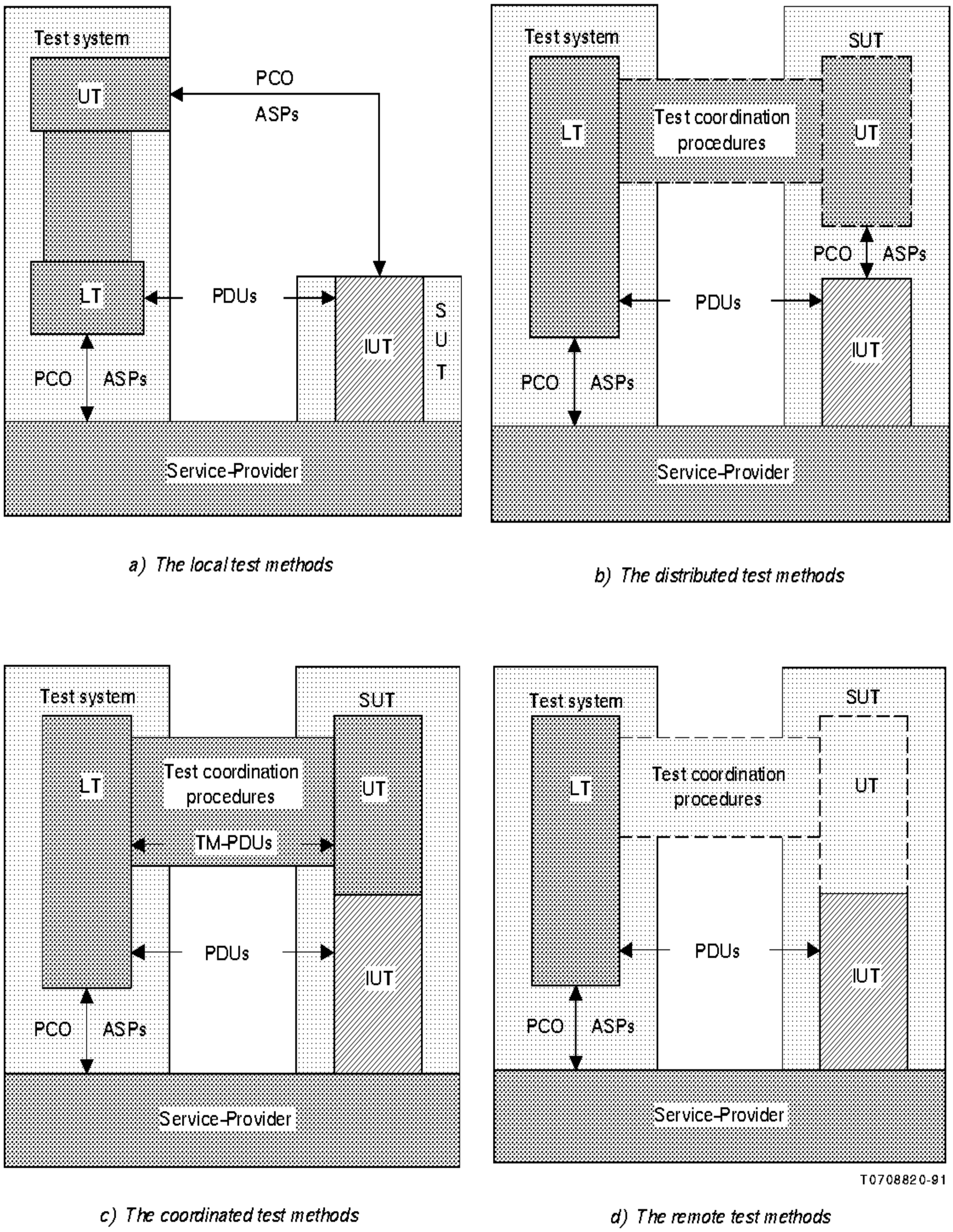


FIGURE 7/X.290

Abstract Test Methods (End-Systems)



Abstract Test Methods (Relay Systems)

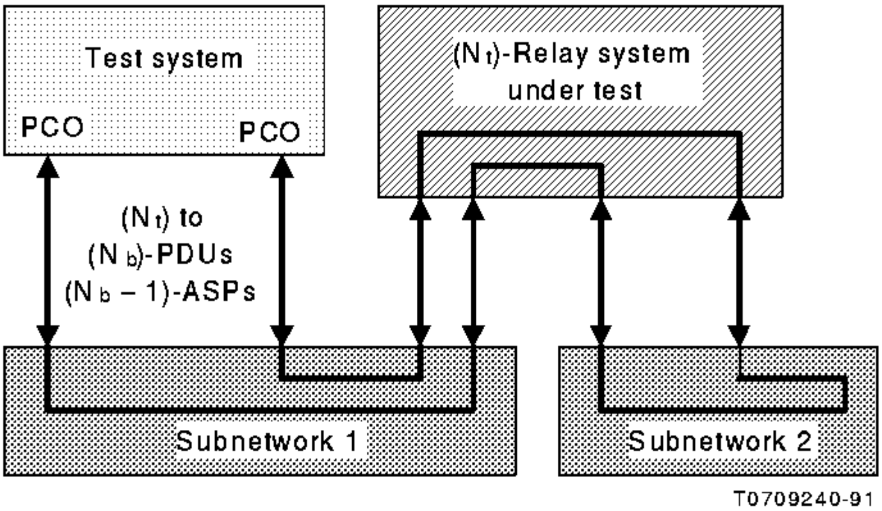


FIGURE 13/X.291

Loop-back test method (YL)

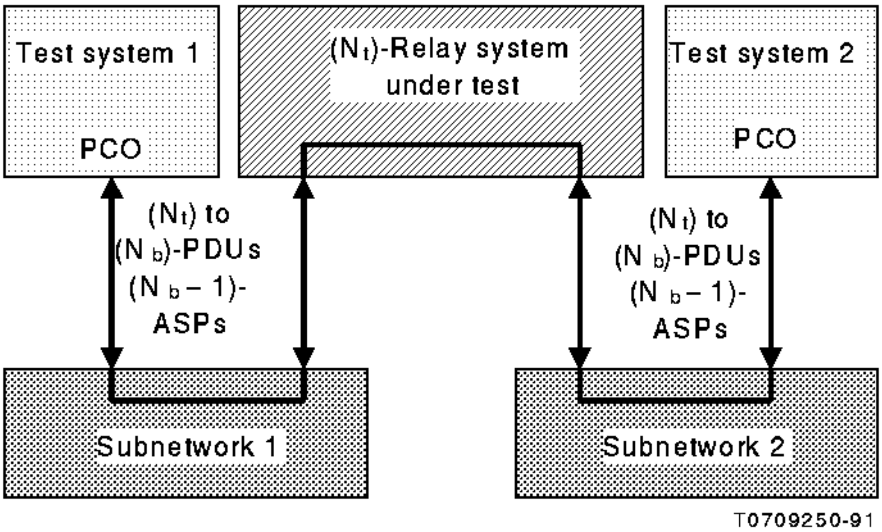
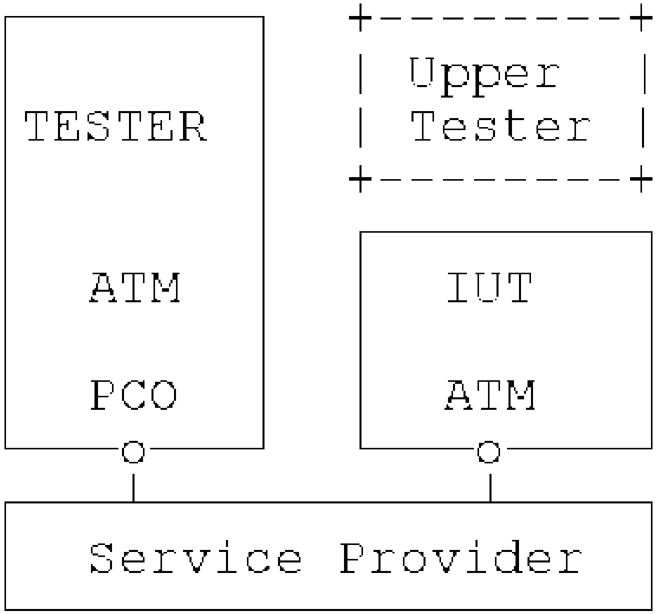


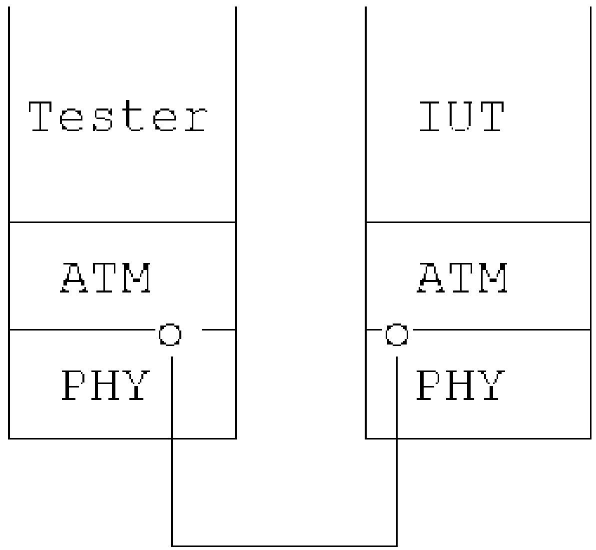
FIGURE 14/X.291

Transverse test method (YT)

Example: ATM Test Configuration



9646 point of view



Protocol Stack

Abstract Test Suite Specification

- Test Suite Structure (TSS)
- Test Purpose (TP) and Test Case
- Test Step
- Test Event
- Preamble, Body, Postamble
- Abstract Test Method (ATM)
  - End-Systems IUT
    - Single Protocol
    - Multi Protocol
  - Relay Systems IUT
- Standardized Test Notation (TTCN)

Test Suite Structure

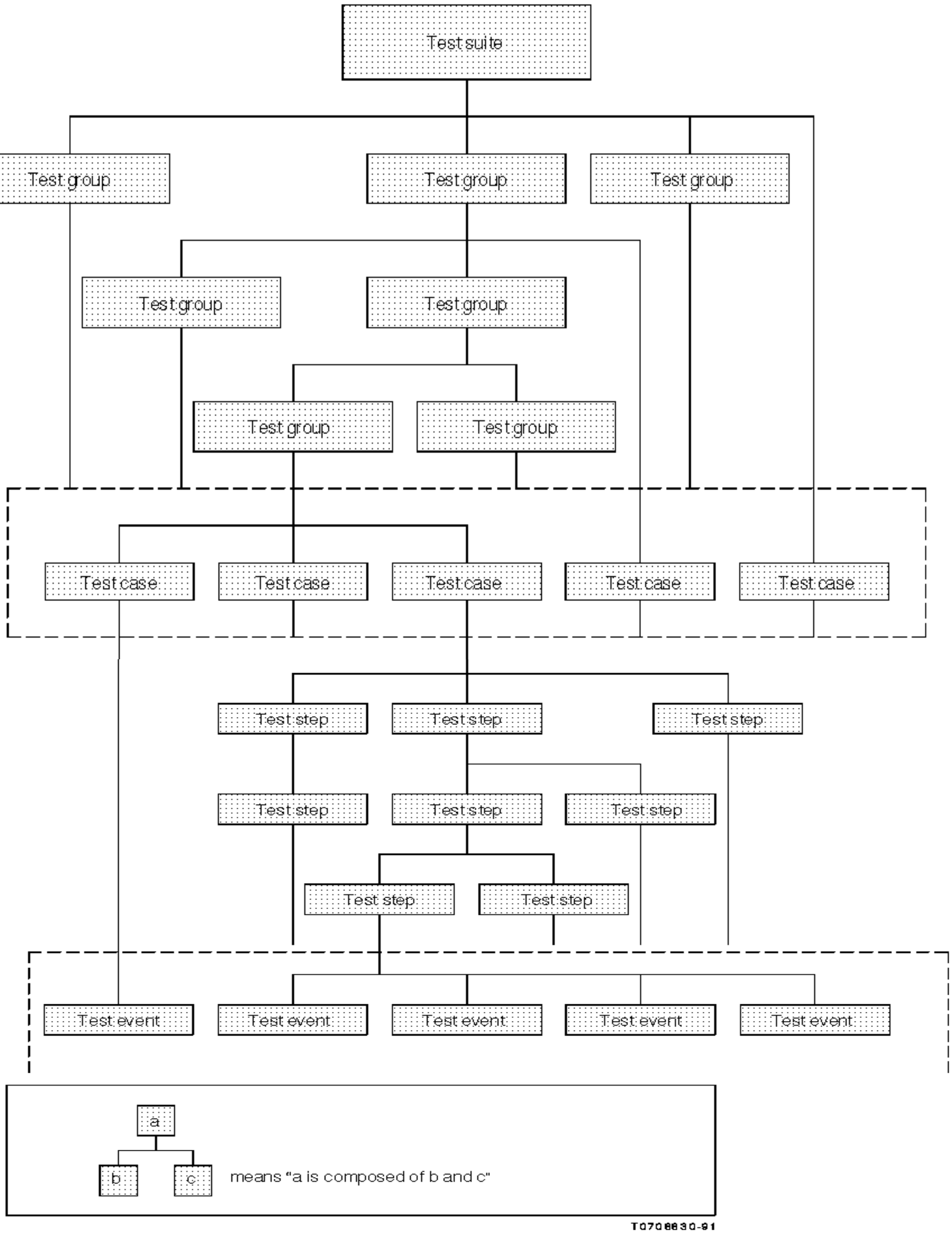


FIGURE 9/X.290

Test suite structure

Example: ATM Test Suite Structure

- ATM Layer Services

- ATM Cell Structure and -------- Encoding at the UNI (General)
  - GFC
  - VPI/VCI
  - PTI
  - CLP
  - HEC

- ATM Layer Functions at ------- the UNI (U-plane)
  - Multiplexing among different ATM connections
  - Cell Rate Decoupling (unassigned cells)
  - Cell discrimination based on pre-defined header field values
  - ATM cell discrimination for the VCI
  - Payload type discrimination
  - Loss priority indication and Selective cell discarding
  - Traffic shaping

- ATM Layer Management - Specification (M-plane)
  - Information Flows
  - ATM OAM Cell Format
  - Fault Management -----
    - Alarm Surveillance
    - Connectivity verification
      - End-to-End Loopback
      - UNI Loopback

Tree and Tabular Combined Notation (TTCN)

- Defined by Part 3
- Graphical Presentation of Test Suites
- Definition of Graphical and Machine Processable (MP) Formats
- Interpretation of TTCN Test Cases
- Formalization of Execution Concepts
- Integration of ASN.1 (ISO/IEC 8824, ITU-T X.208)

Features of TTCN

- Formalized definition of Abstract Test Cases
- Structuring of Test Cases and Steps
- Recording of Test Group Assignment and Test Purpose Reference
- Dynamic Test Behaviour Description
  - Sequence of and choice between Events
  - Special Events (Timer, OTHERWISE, IMPLICIT_SEND, Pseudo Events)
  - Attached and default Behaviour; Preamble and Postamble
- Constarints Description
  - Parametrization and Variables
  - Conditions on Events
- Operation Definition on data Types
- Verdict Assignment
- ...

A TTCN Behaviour Tree

Test Step Dynamic Behaviour

Test Step Name : TREE_EX_1(L:NSAP)
Group : TTCN_EXAMPLES/TREE_EXAMPLE_1/
Objective : To illustrate the use of trees
Default :
Comments : *Note* – This example can be simplified by using Defaults

No.	Label	Behaviour Description	Constraints Reference	Verdict	Comments
1		L! CONNECTrequest	CR1		Request ...
2		L? CONNECTconfirm	CC1		... Confirm
3		L! DATArequest	DTR1		Send Data
4		L? DATAindication	DTI1		Receive Data
5		L! DISCONNECTrequest	DSCR1	PASS	Accept
6		L? DISCONNECTindication	DSCI1	INCONC	Premature
7		L? DISCONNECTindication	DSCR1	INCONC	Premature

An ATM Test Case

Test Case Dynamic Behaviour				
Test Case Name : Disc_OAM_Seg_F5_LB0				
Group : ATM_UNI_ESR1/M_plane/Fault_Management/Connectivity_Verification/ UNI_Loopback/				
Purpose : Verify that if the IUT receives a Segment OAM F5 cell with a Loopback Indication field as '0'B, it will remove that OAM cell.				
Default :				
Comments : Requires a VC connection. Ref. 3.5.3.2.2				
Label	**Behaviour Description**	**Constraints Ref**	**V**	**Comments**
	LT!OAM_LB	OAM_SEG_F5_LB0 (VPIvcc, VCIvcc)		
	START T_NoResp			
LB1	?TIMEOUT T_NoResp		P	
	LT?CELL	CELL_UNASSIGNED		
	GOTO LB1			
	LT?OTHERWISE		F	
Detailed Comments : Selection Ref: VC_SERV				

An ATM PDU Constraint Definition

PDU Constraint Declaration

Constraint Name : OAM_SEG_F5_LB0(VPI_val,VCI_val:BITSTRING)
PDU Type : OAM_LB
Derivation Path :
Comments :

Field Name	Field Value	Comments
GFC	'0000'B	
VPI	VPI_val	
VCI	VCI_val	
PTI	'100'B	
CLP	'?'B	
HEC	Valid_HEC('0000'B, VPI_val,VCI_val,'100'B, OAM_LB.CLP)	
OAM_Cell_Type	'0001'B	
Function_Type	'1000'B	
Reserved	?	
Loopback_ID	'0'B	
Correlation_Tag	?	
Loopback_Location	?	
Source_ID	?	
Unused	?	
CRC_10	Valid_CRC	

Detailed Comments : Reception segment F5 loopback cell

An ATM PDU Definition

PDU Type Definition		
PDU Name : OAM_LB		
PCO Type : PHYSAP		
Comments : Loopback Cell		
Field Name	**Field Type**	**Comments**
GFC	BITSTRING[4]	Generic Flow Control
VPI	BITSTRING[8]	Virtual Path ID
VCI	BITSTRING[16]	Virtual Channel ID
PTI	BITSTRING[3]	Payload Type ID
CLP	BITSTRING[1]	Cell Loss Priority
HEC	OCTETSTRING[1]	Header Error Check
OAM_Cell_Type	BITSTRING[4]	
Function_Type	BITSTRING[4]	
Reserved	BITSTRING[7]	
Loopback_ID	BITSTRING[1]	
Correlation_Tag	OCTETSTRING[4]	
Loopback_Location	OCTETSTRING[12]	
Source_ID	OCTETSTRING[12]	
Unused	OCTETSTRING[16]	
CRC_10	OCTETSTRING[2]	

An Operation Definition for ATM PDUs

Test Suite Operation Definition	
Operation Name	: Valid_HEC(GFC_val,VPI_val,VCI_val,PTI_val,CLP_val:BITSTRING)
Result Type	: OCTETSTRING
Comments	:
Description	
Valid_HEC calculates the proper value for the HEC field of a PDU based on the first four octets of the header and returns a valid HEC value.	

Test Suite Operation Definition	
Operation Name	: Valid_CRC
Result Type	: OCTETSTRING
Comments	:
Description	
Valid_CRC calculates the proper value for the CRC field of an OAM cell. The value used to compute a valid CRC is the text of the OAM cell of the PDU constraint from where this operation is called.	

Parameter Declaration of anATM Test Suite

Test Suite Parameter Declarations			
Name	**Type**	**PICS/PIXIT Ref**	**Comments**
PHY_SYNCH	BOOLEAN	PIXIT 1	Does the physical interface used for testing require synchronous cell timeslot (e.g., SONET, DS3)?
VP_SERVpar	BOOLEAN	PICS	Does the IUT support VP service?
VC_SERVpar	BOOLEAN	PICS	Does the IUT support VC service?
VC_ALARMpar	BOOLEAN	PIXIT 4	Does the IUT support VC alarm signalling on the tested VCC?
VC_F4_SUPpar	BOOLEAN	PIXIT 5	Does the IUT support F4 flows while offering VC service only?
NORESPtime	INTEGER	PIXIT 2	Enter the maximum time it can take for a cell to be forwarded by the IUT.
TESTtime	INTEGER	PIXIT	Enter a sufficient amount of time to complete each test.
TOPRtime	INTEGER		Enter a sufficient amount of time for test operator to initiate some test action. (recommend 180 seconds)
VPIvpc	BITSTRING	PIXIT 6	The VPI value for the VPC for testing.
VPIvcc	BITSTRING	PIXIT 7	The VPI value for the VCC for testing.
VCIvcc	BITSTRING	PIXIT 7	The VCI value for the VCC for testing.
Detailed Comments :			

Further Declarations of an ATM Test Suite

Test Suite Constant Declarations			
Constant Name	**Type**	**Value**	**Comments**
SEG_OAM_F4	BITSTRING	'0000000000000011'B	VCI = 3
END_OAM_F4	BITSTRING	'0000000000000100'B	VCI = 4
Invalid_OCT	BITSTRING	'1111'B	Invalid OAM Cell Type Field value
Invalid_OFT	BITSTRING	'1111'B	Invalid OAM Function Type Field value
Detailed Comments :			

Test Case Variable Declarations			
Variable Name	**Type**	**Value**	**Comments**
Detailed Comments :			

PCO Declarations			
PCO Name	**Type**	**Role**	**Comments**
LT	PHYSAP	Lower Tester	PHY Layer service access point (PHYSAP) on the lower tester
Detailed Comments :			

PIXIT for ATM Test Suite

IUT

Name:

Version:

Machine Configuration:

Operating System Identification:

IUT Identification:

PICS Reference for IUT:

Limitations of the IUT:

General Information

1 Does the physical interface used for testing require synchronous cell time slots (e.g., SONET, DS3) ?

2 Give the maximum time it can take for a cell to be forwarded by the IUT. (2 seconds recommended) (NORESPtime)

3 Enter a sufficient amount of time to complete each test. (2 seconds recommended) (TESTtime)

4 Does the IUT generate a VP/VC-AIS after N consecutive HEC errors cell ? (Due to loss of cell delineation): (HEC_AISpar)

4.1 Number of consecutive HEC errors needed for VP/VC-AIS generation (default value is 6). (HES_AISnum)

OAM specific features

5 Does the IUT support VC alarm signalling on any VCC? (VC_ALARMpar)

6 Does the IUT process the OAM F4 flows while offering VC service only? (VC_F4_SUPpar)

The following PIXIT questions are specific to the Virtual Path Connections (VPCs) by the IUT and only have to be answered if the VPCs are supported, see PICS.

7 Configure the IUT, setup a VPC and enter the VPI value here:

VPIvpc

The following PIXIT questions are specific to the Virtual Circuit Connections (VCCs) by the IUT and only have to be answered if the VCCs are supported, see PICS.

8 Configure the IUT, setup a VCC and enter the VPI/VCI values here:

VPIvcc

VCIvcc

PICS Performa

- To be provided as a Standard
- Definition of a Set of Questions
  - Supplier or Client
  - Relationship to Protocol Specification
  - Major Capability of the IUT
  - Role
  - PDUs and PDU Parameters
  - Timers
  - Error Handling
  - Dependencies
  - ...

An ATM PICS Perfoma Entry

3.3 Cell Relay Function

Index	Text	Status	Reference	Values	Support
3.3.1	Does the IUT support point-to-point VPCs?	O	1.5	Yes, No	__Yes__No
3.3.2	Does the IUT support point-to-point VCCs?	M (Note 1)	1.5	Yes, No	__Yes__No
3.3.3	Does the IUT support point-to-multipoint VPCs?	O	1.5	Yes, No	__Yes__No
3.3.4	Does the IUT support point-to-multipoint VCCs, SVC ?	M (Note 1)	1.5	Yes,No	__Yes__No
3.3.5	Does the IUT support point-to-multipoint VCCs, PVC?	O	1.5	Yes,No	__Yes__No
3.3.6	Does the IUT support PVC?	O.1	1.5	Yes, No	__Yes__No
3.3.7	Does the IUT support SVC?	O.1	1.5	Yes, No	__Yes__No
3.3.8	Does the IUT relay cells within a VPC/VCC while preserving their cell sequence integrity from a single source?	M	3.1	Yes, No	__Yes__No
Comment(s) O.1 = One of these options must be supported. *Editor's note: The Note below does not make sense in relationship to items 3.3.2 and 3.3.4. Discuss.*					

Note: Public ATM network equipment shall be capable of providing with either a VPC service, or a VCC service, or combined VPC/VCC service.

Parameterized Executable Test Suite (PTES)

Reference ATS	—— Derivation ——→	ETS (Executable Test Suite)
↓		↓
Selection, with PICS (and PIXIT)		Selection, with PICS (and PIXIT)
↓		↓
SATS (selected ATS)	—— Derivation ——→	SETS (selected ETS)
↓		↓
Parameterization, with PIXIT (or PICS)		Parameterization, with PIXIT (or PICS)
↓		↓
PATS (parameterized SATS)	—— Derivation ——→	PETS (parameterized SETS)
↓		↓
Derivation/Execution of a PETS		Execution of the PETS

Preparation for Testing

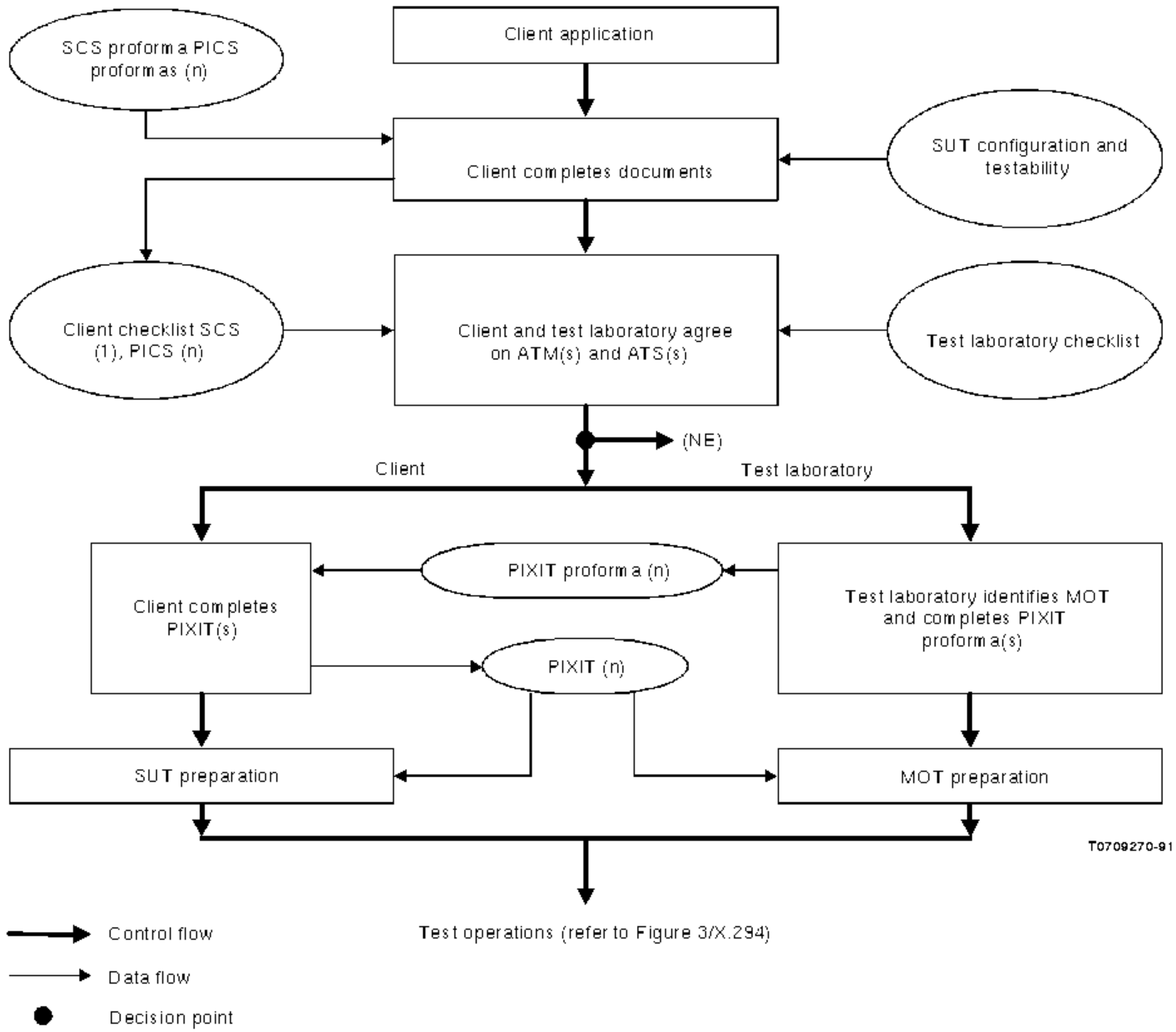


FIGURE 2/X.294

Test Operation

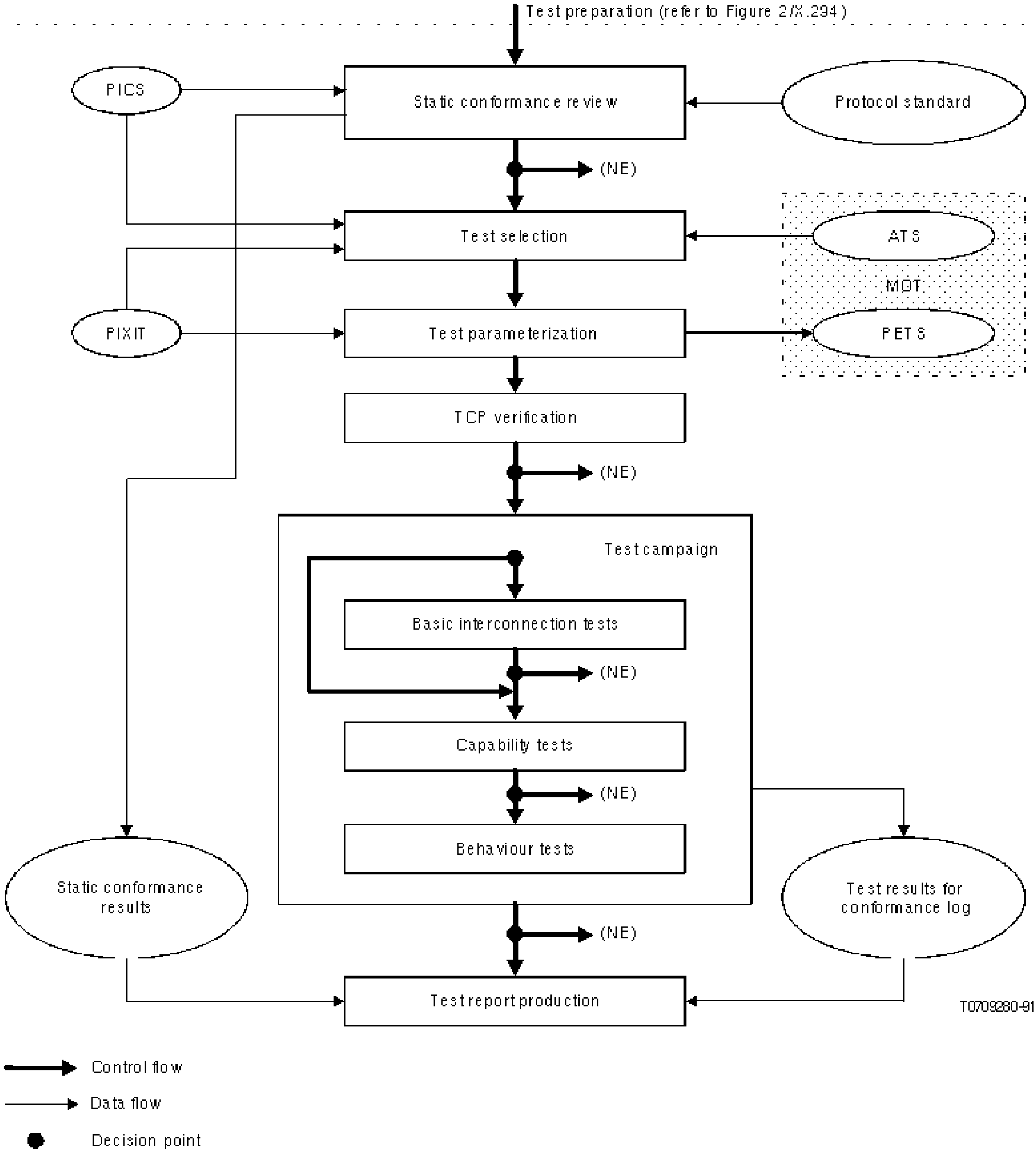


FIGURE 3/X.294

More related testing Issues

- ODP and Managed Objects
- Concurrent TTCN
- Multi Party Testing
- Multi Layer Testing
- Formal Methods in Conformance Testing (FMCT, ISO/IEC P.54, ITU-T Q.10)
- Quality of Service Testing