Conformance and Interoperability Testing Principles and Supporting Standards

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Purpose of this presentation

For this Workshop

- achieve a common understanding of the key CIT terms, concepts and language
- identify some of the existing CIT standards and some additional standards that may be needed

Outline

- **Overview**
- **CIT Basics**
- **Existing CIT Standards**
- **Needed New CIT Standards**
- **Accreditation and Certification**
- **Conclusions**

Kinds of Testing

Considered here:

Conformance Interoperability

CIT techniques may apply to testing:

Performance
Stress
Robustness
Reliability
Configuration

Scalability
Degraded mode
Load tolerance
Fault tolerance
Interface
Integration

Why Conformance to Standards is important?

- Conforming implementations of the same standard have a higher degree of interoperability
- Different vendors can independently implement standards with a high degree of assurance of product interoperability
- Promotes market share rather than a single-vendor market
- Buyer can shop around for best-buy products and not loose his previous investment

Why Interoperability is important?

- The ultimate objective is that independent implementations of the same standard interoperate
- Conformance improves the chances of interoperability while interoperability testing checks if interoperability has been achieved

Conformance and Interoperability

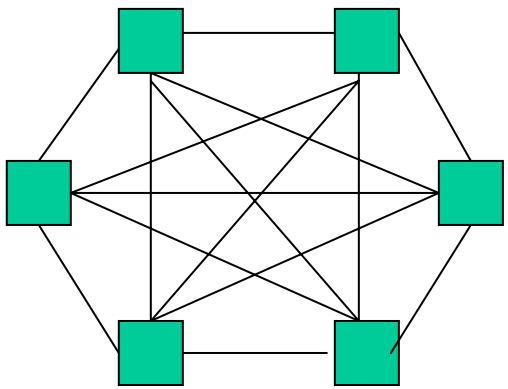
- Conformance should be maintained during Interoperability testing
- Without conformance, two implementations can be forced to interoperate during testing by destroying interoperation with all other implementations

Causes of Interoperability Problems

- **Standards**
  - Errors and ambiguities in standards
  - Incompatible standards (standards with different QoS, traffic priorities)
- **Implementations**
  - Human errors, e.g. programmer errors
  - Different interpretations of the standard
  - Different choice of options allowed by the standard
- **Technology**
  - networks use different traffic queuing techniques
  - device compatibility
  - host system configuration

Nature of Interoperability Testing

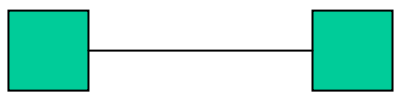
- Interoperability testing is meaningful only in pair-wise combinations of implementations
- Interoperability Testing of N products requires that $(N^2 - N)/2$ product pair combinations are tested



N = 6
Each product is tested 15 times (Pairs = 15)

Nature of Conformance Testing

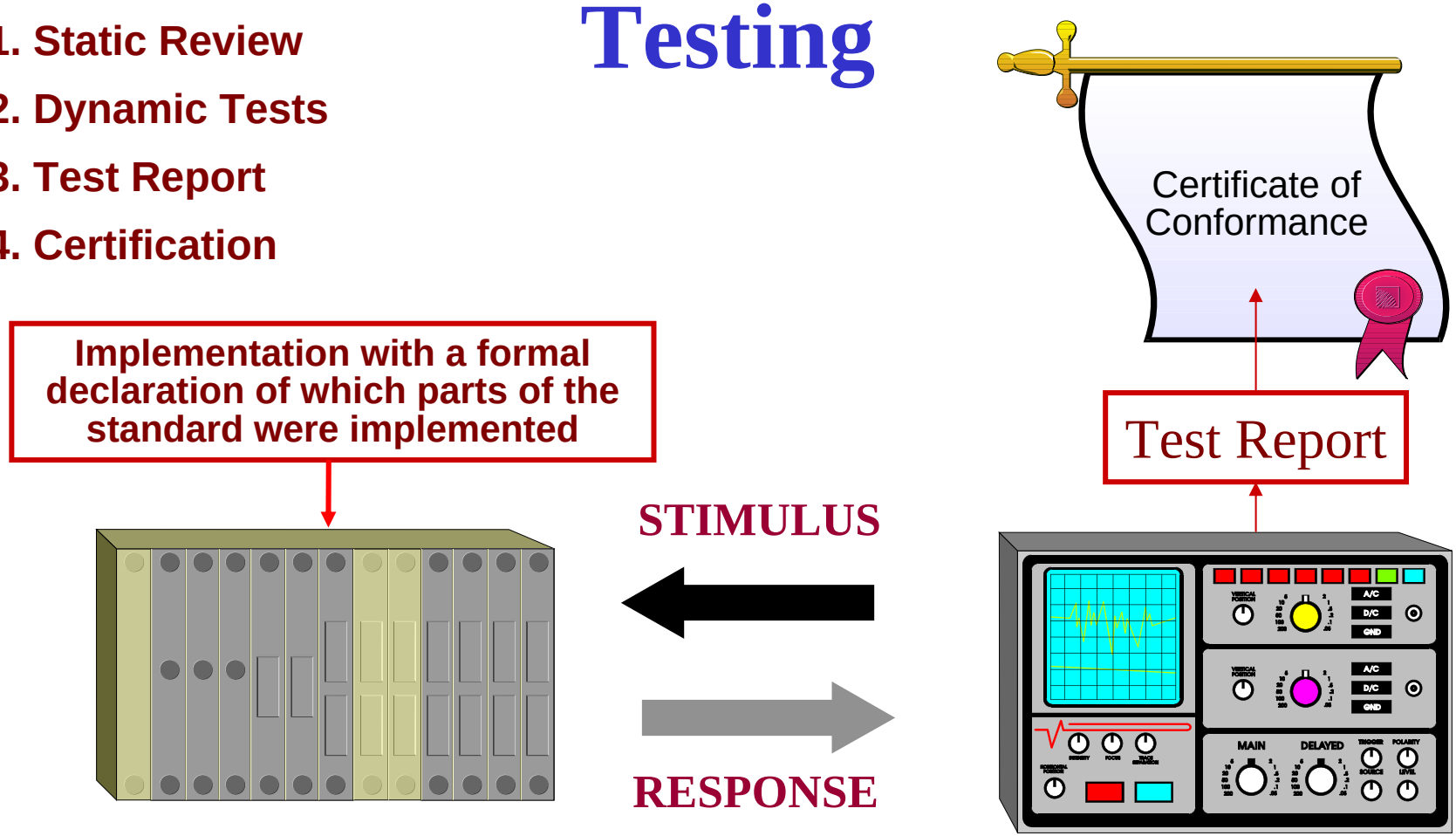
- Testing to determine if the product does what the standard or specification says it is supposed to do - meet a set of stated requirements
- Each product is tested only once, against the standard (represented by the test suite) and not against multiple products



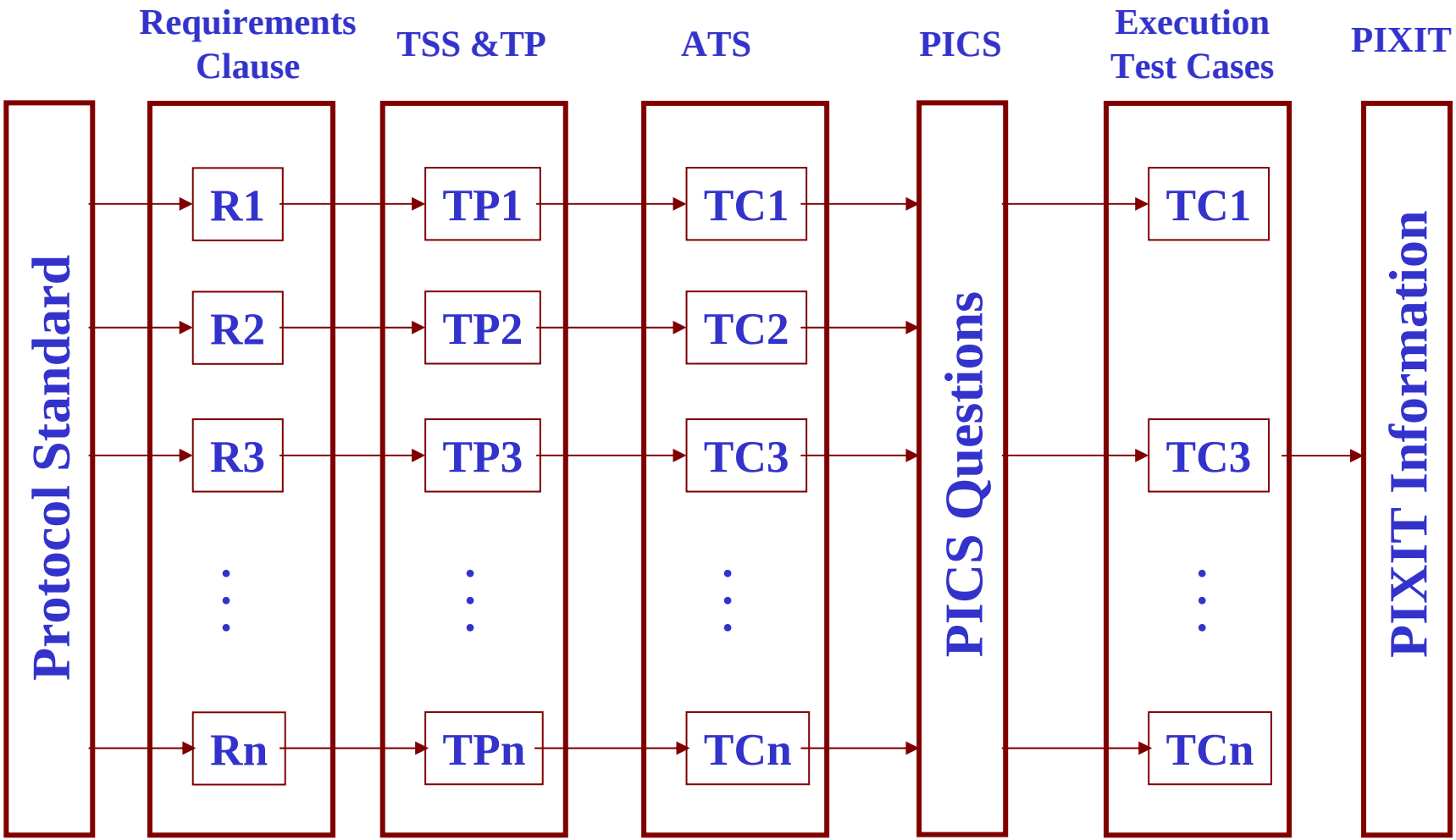
Product Test Suite

Overview of Conformance Testing

1. Static Review
2. Dynamic Tests
3. Test Report
4. Certification



Standards that Facilitate Testing



TSS & TP - Test Suite Structure and Test Puprposes
ATS: - Abstract Test Suite
PICS: - Protocol Implementation Conformance Statement

TP - Test Purpose
TC - Test Case
R - Requirement

Static vs Dynamic Testing

- **Static (PICS review)**
  - what mandatory, optional or conditional features of the protocol were implemented - declared in the PICS proforma by the supplier
  - PICS becomes a shopping list for finding compatible products
  - a car PICS analogy:
    - does the car have an ignition system?
    - does the car have a steering wheel?
- **Dynamic (execution of the ATS)**
  - behaviour of mandatory, optional or conditional features
  - a car ATS analogy
    - turn the ignition key, does the engine turn over? Pass, Fail, Inconclusive
    - turn the steering wheel, do the front wheels turn? Pass, Fail, Inconclusive

A Requirements Clause from a Standard

Extract from the User-Network Interface (UNI) Specification 3.1

3.3 ATM Cell Structure and Encoding at the UNI

(R) CPE at the UNI shall encode the GFC value to all zeros (0000).

(R) Public network equipment at the public UNI shall encode the GFC value to all zeros (0000).

(O) CPE shall inform Layer Management if a count of the non-zero GFC fields measured for non-overlapping intervals of 30,000 +/- 10,000 cell times reached ten (10) or more.

(O) Public network equipment shall inform Layer Management if a count of non-zero GFC fields measured for non-overlapping intervals of 30,000 +/- 10,000 cell times reaches ten (10) or more.

Protocol Implementation Conformance Statement (PICS) Proforma

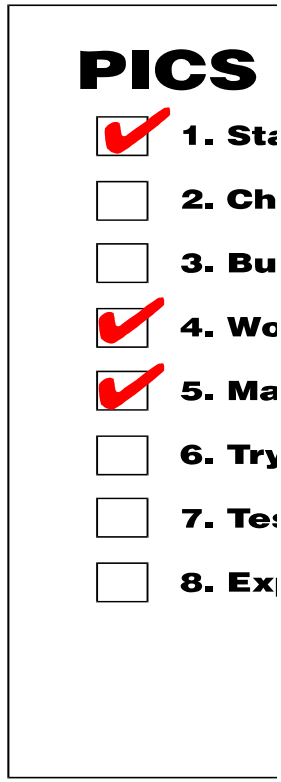
Extracted from af-test-0059.000: PICS Proforma for the UNI 3.1 ATM Layer

3.5 Generic Flow Control (GFC) Field

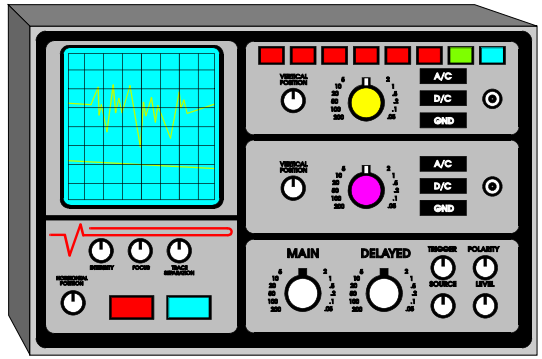
Index	Text	Status	Ref.	Values	Support
3.5.1	Does the IUT operate the GFC protocol in "uncontrolled access" mode, encoding the GFC field to be all zeros?	M	3.3		__Yes__No
3.5.2	If the IUT is an intermediate node, does the IUT overwrite any non-zero GFC field received before sending it into the network?	M	3.3		__Yes__No
3.5.3	Does the IUT, on receipt of 10 or more non-zero GFC fields measured for non-overlapping intervals over 30000+/-10000 cell times, generate an error to layer management?	O	3.3		__Yes__No

Static Review

- **ICS Proforma - Implementation Conformance Statement Proforma**
  - formatted questionnaire for declaring what optional features have been implemented
  - part of the specification or standard
- **ICS**
  - Filled-out ICS Proforma
  - A list of requirements and options claimed to have been implemented
- **Used for**
  - Shopping list for matching products for interoperability
  - Test case selection (from test suite) for execution



Dynamic Tests



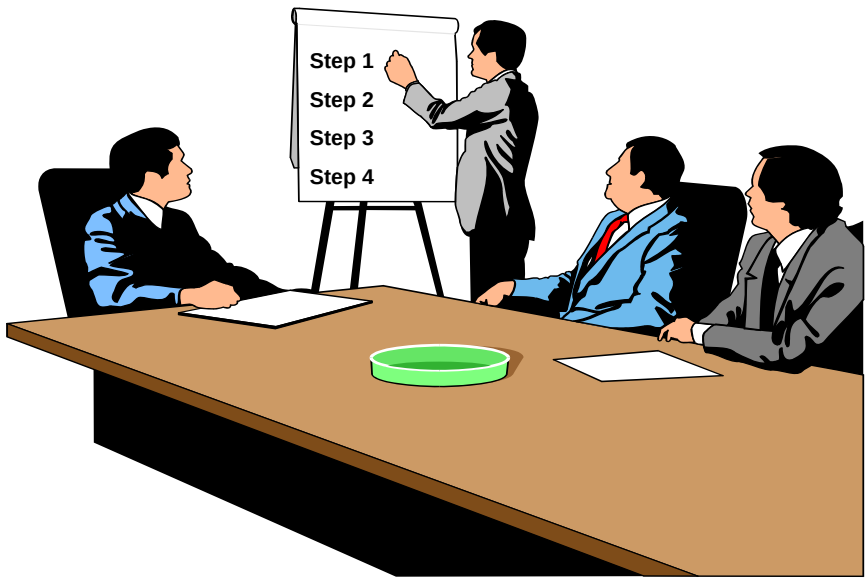
- **Abstract Test Suite (ATS)**
  - Defined by a standards organization, written in an abstract language like
    - **Tree and Tabular Combined Notation (TTCN-1, TTCN-2), ISO/IEC 9646, ITU-T X.292**
    - **Testing and Test Control Notation (TTCN-3), ITU-T Rec. Z.140**
- **Executable Test Suite (ETS)**
  - AT .mp file “compiled” to run on specific test equipment
  - creation of the ETS is proprietary to the test equipment vendor

Extra Information for Testing

- **IXIT - Implementation eXtra Information for Testing**
  - Additional information required before testing can proceed
    - administrative: identification of client, laboratory staff, IUT, protocol, test suite
    - technical: address of the IUT, timer values, configuration, parameters, procedures, test cases that cannot be executed
- **IXIT Proforma**
  - Standardized template to be completed by the client and the test laboratory to produce the IXIT
- **PIXIT - Protocol IXIT**
  - A special case of IXIT, widely used

What is a Test Suite?

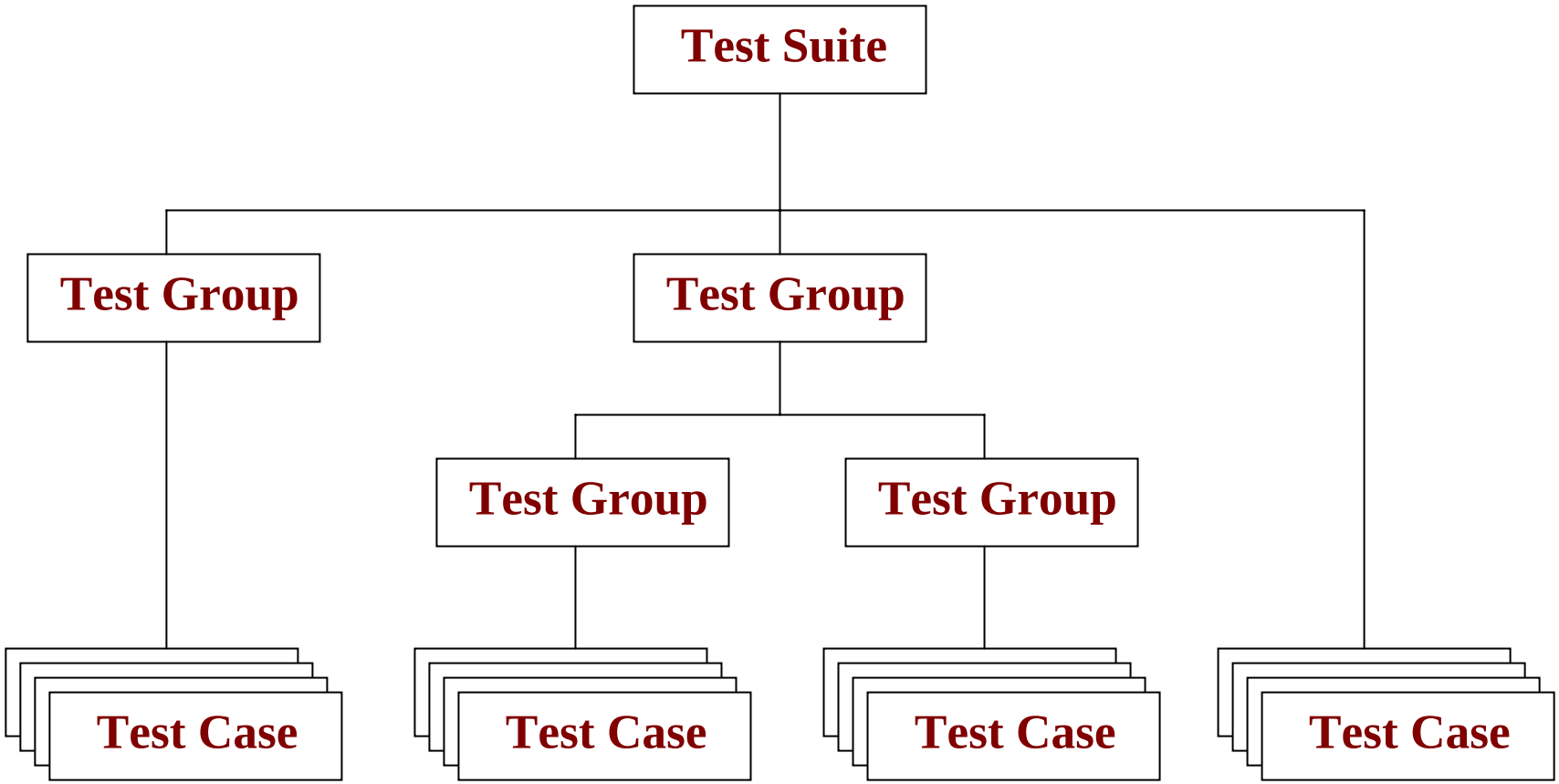
- A *test suite* is a collection of *test cases* which, in turn, may comprise a number of *test steps*
- A test case is designed to verify *conformance* or *interoperability* of a particular requirement or option according to the *test purpose* defined for it



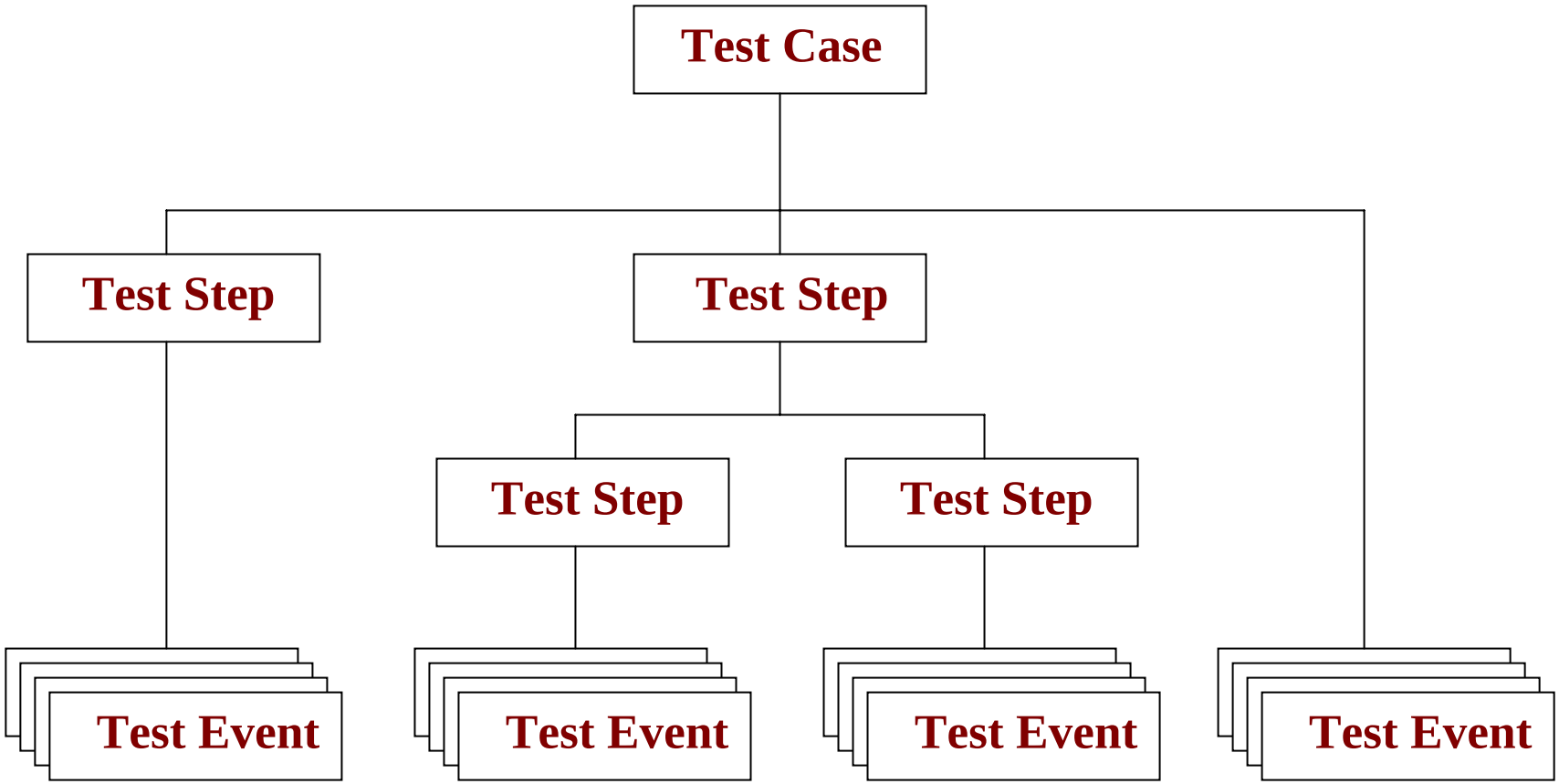
Test Suite Development

- **Start with a *PICS***
  - This ensures that complete coverage is obtained
- **Develop *Test Suite Structure***
  - This logically groups the test cases
- **Develop *Test Purposes***
  - This defines the objectives of the *test cases*
- **Write a *Test Case* for each Test Purpose**
  - The *test purpose* is then included with its test case in the test suite

Test Suite Structure



Test Case Structure



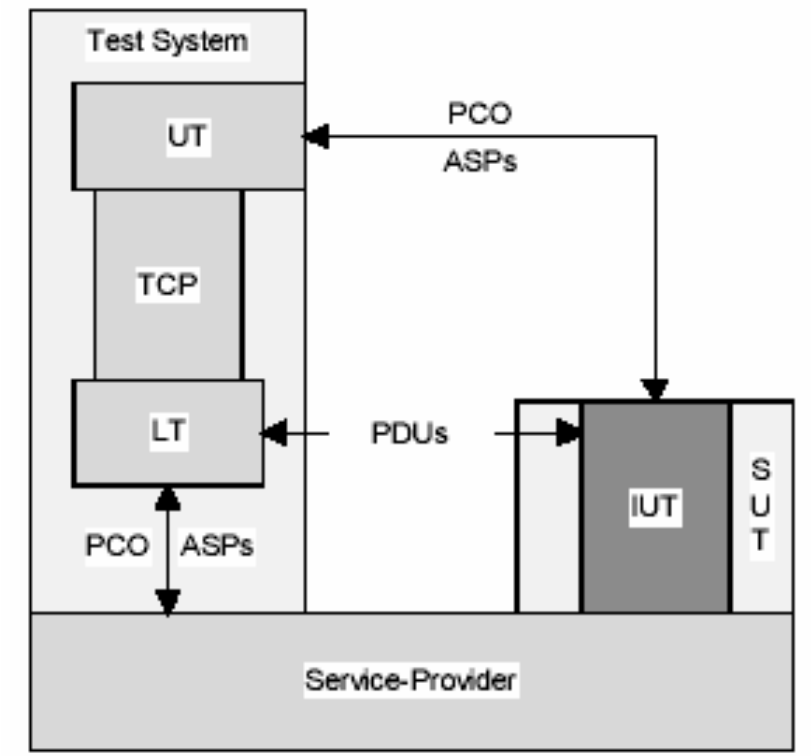
Test Cases, Test Proposes and Verdicts

- **One Test Case for each Test Purpose representing one Requirement from the Requirements Clause**
- **To get a Pass verdict, the Implementation Under Test (IUT) must respond correctly when the Tester exhibits three different kinds of behaviour:**
  - Valid
  - Invalid
  - Inopportune
- **For each of the three Tester behaviours, the IUT may be assigned a Pass, Fail or Inconclusive verdict**

The Local Test Method

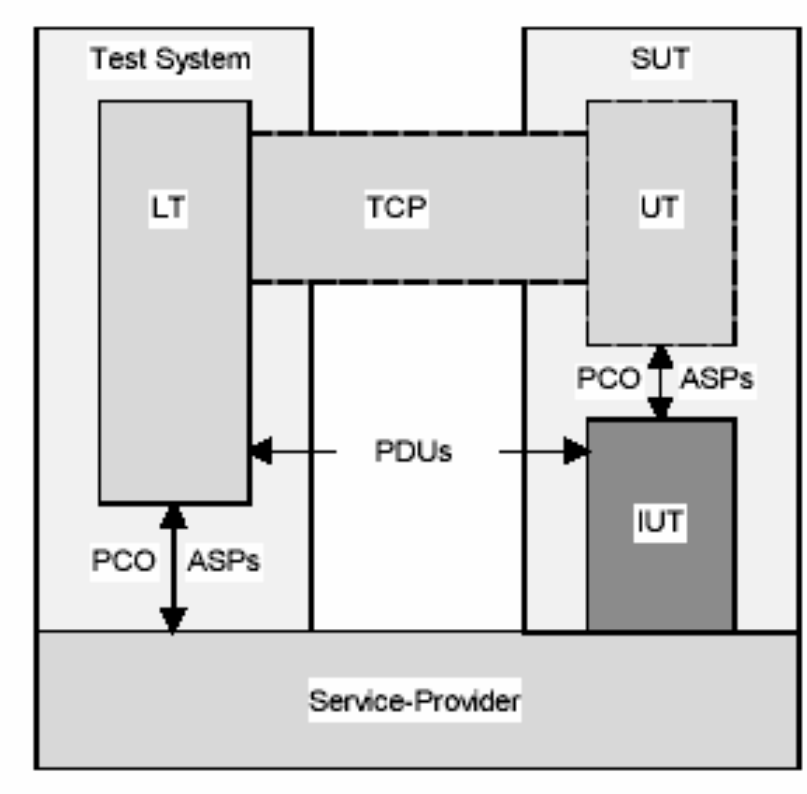
There are two PCOs. UT and LT both reside on the Test System. The upper boundary of the IUT is standardized hardware interface that plugs into the Test System.

UT Upper Tester
LT Lower Tester
PCO Point of Control and Observation
IUT Implementation Under Test
SUT System Under Test
ASP Abstract Service Primitive
PDU Protocol Data Unit
TCP Test Coordination Procedure



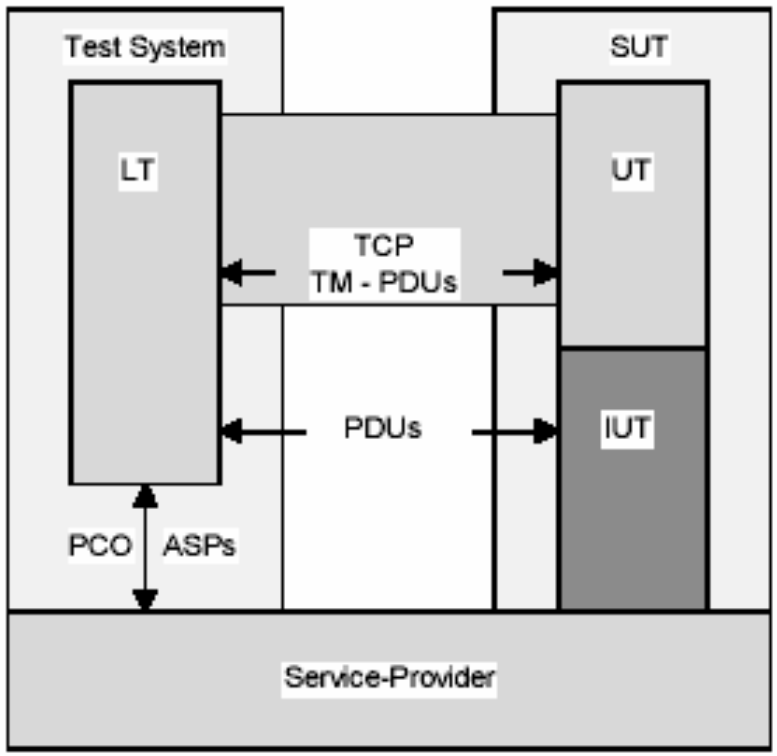
The Distributed Test Method

There are two PCOs. The UT is located in the SUT. The LT is located in the Test System. Access to the upper boundary of the IUT is required to carry out testing either by human action or a programming interface.



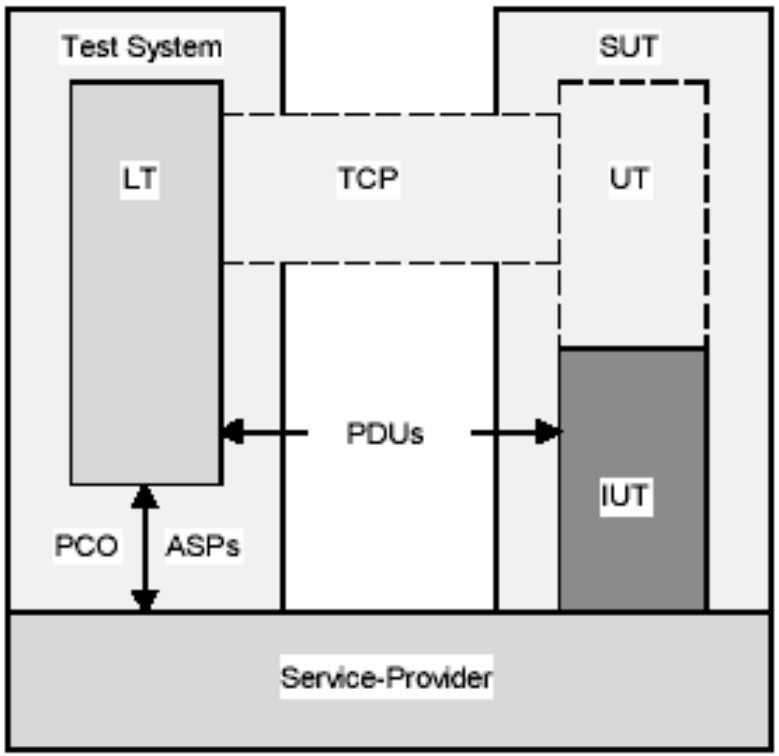
The Coordinated Test Method

There is only one PCO and no UT. UT is integrated with TCP. The desired effects at the upper boundary of the IUT are realized by a special TCP called the standardized Test Management protocol. The method facilitates the highest degree of automation and security.



The Remote Test Method

There is only one PCO and no UT or TCP. The Tester has no access to the upper boundary of the IUT. The desired effects at the upper boundary are informally described in the test suite and are carried out at the SUT by the test operator



Notation for Description of Test Suites and Test Methods

TTCN-1

- Tree and Tabular Combined Notation Edition 1
- ISO/IEC 9646-3 (1995)
- ITU-T Recommendation X.292 (1995)
- Non-concurrent TTCN

- **TTCN-2**
  - Tree and Tabular Combined Notation Edition 2
  - ISO/IEC 9646-3 (1998)
  - ITU-T Recommendation X.292 (1998)
  - Concurrent TTCN
- **TTCN-3**
  - Testing and Test Control Notation Three (2003)
  - ITU-T Recommendation Z.140

ATS Test Case in TTCN-2

Test Case Dynamic Behavior

Test Case Name : Ver_Gen_GFC0_VC
Group : General/
Purpose : Verify that the IUT encodes all GFC bits to '0' in a VCC
Default :
Comments : Requires a VC connection. Ref 3.3/PICS 3.5.1

Nr	Label	Behavior Description	Constraints Ref	Verdict	Comments
1		<IUT!CELL>	USER_CELL(VPIvcc,VCIvcc)		Request that the IUT sends a general user data cell on VCC.
2		START T_Opr			
3		(GFC_VAL:='0000'B)			
4	LB1	LT_PCO?CELL	USER_CELL(VPIvcc,VCIvcc)		
5		[CELL.GFC=GFC_VAL]		Pass	GFC='0000'
6		[CELL.GFC<>GFC_VAL]		Fail	GFC<>'0000'
7		LT_PCO?CELL	CELL_UNASSIGNED		
8		GOTO LB1			
9		?TIMEOUT T_Opr		Incon	Inconclusive - timeout
10		LT_PCO?OTHERWISE		Fail	

Detailed Comments : Selection Ref:SEND_USER_CELL_VC
(answered 'yes' in PIXIT question 8 : Can the IUT be forced to send a User data cell on demand (User_Cellpar)?)

Extract from the "graphical" (.gr) output from
af-test-0060.000: Conformance Abstract Test Suite
for the UNI 3.1 ATM Layer of End Systems

Example TTCN-3 Format

```
function PO49901(integer FL) runs on MyMTC
{
   L0.send(A_RL3(FL,CREF1,16));
   TAC.start;
   alt {
       [] L0.receive(A_RC1((FL+1) mod 2))
   {
              TAC.cancel;
               verdict.set(pass)
          }
       [] TAC.timeout {
              verdict.set(inconc)
          }
       [] any.receive {
               verdict.set(fail)
          }
   }
   END_PTC1() // postamble as function
   call
}
```

In what Standards are these defined

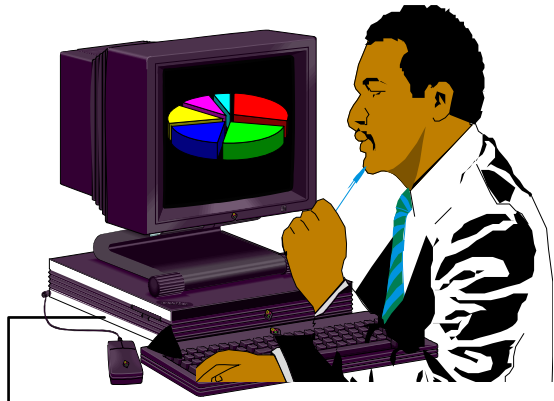
- **X.290 series Recommendations on Methodology**
  - Terms and Definitions
  - Testing process including test reports
  - Test notation (TTCN)
  - Test Methods
  - Abstract Test Suite specification
  - Executable Test derivation
  - Requirements on test laboratories and clients
- **Standards to be produced as required by X.290**
  - Requirements Clause
  - Test Suite Structure and Test Purposes (TSS&TP)
  - Implementation Conformance Statement (ICS)
  - The Abstract Test Suite
  - Implementation eXtra Information for Testing (IXIT)

What Standards are Missing Today

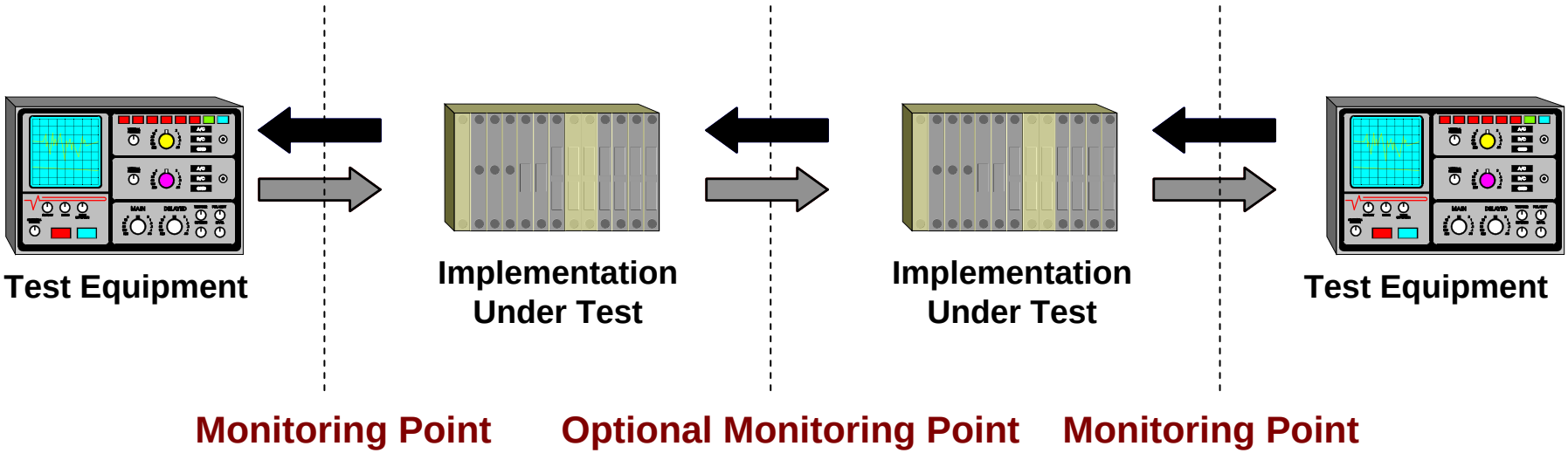
- **For each Protocol**
  - Requirements Clauses
  - TSS&TP
  - PICS and ICS Proformas
  - PIXIT and IXIT Proformas
  - Abstract Test Suites

Interoperability Testing

- A *method* for determining to what extent *two or more* implementations *function together* for some range of applications over a specific communications medium



General Configuration for Interoperability Testing



An Interoperability Test Case

Extract from af-test-0035.000: Interoperability Abstract Test Suite for the ATM Layer

Test Case ID: ATM/Cell Relay/6

Test Case Name: Interoperability in the “uncontrolled access” mode, VCC.
Test Purpose: To verify interoperability in the “uncontrolled access” mode on VCC.
Pre-requisite: Run if SUTs implement VCC.
Reference: [1], Section 3.3
Test Configuration: #1

Test Set-up:
1. Establish at least 3 bi-directional VCCs between Testers A and B.

Test Procedure:
1. Tester A generates a cell stream with GFC field set to 0 of test traffic type H for each VCC.
2. Tester B monitors the received cell stream.
3. Repeat this test with the relative positions of SUTs A and B interchanged.

Verdict Criteria:
All cells inserted at the originating end points shall appear in the terminating end points of VCCs

Interoprability Testing Standards

- **Z.itfm series Recommendations on Methodology**
  - work in progress
  - two major contributions - ETSI, Korea
  - similar methodology to X.290 Recommendation
  - some new concepts are being discussed
- **Standards to be produced as required by Z.itfm**
  - Requirements Clause
  - Test Suite Structure and Test Purposes (TSS&TP)
  - Implementation Conformance Statement (ICS)
  - The Abstract Test Suite
  - Implementation eXtra Information for Testing (IXIT)

What Standards are Missing

- **Methodology and Framework**
  - Test procedures, test methods etc. are yet to be defined
  - TTCN is likely to be sufficient for specifying Interoperability test suites
- **For each Protocol**
  - Requirements Clauses
  - TSS&TP
  - PICS and ICS Proformas
  - PIXIT and IXIT Proformas
  - Abstract Test Suites

Two types of Standards that apply to CIT

- **Voluntary**
  - **Market-driven**
- **Regulatory**
  - **Required by national law**

Trusting the Test Results

- **Who does the testing**
  - Third-party testing (independent test laboratory)
  - Second-party testing (product procurer or user)
  - First-party testing (product supplier)
- **Testing can be made formal enough for certification of tested products**

Adding Confidence

- **Accreditation**
  - competence to carry out testing
  - competence to issue certifications
- **Certification**
  - conformity to a quality system standard
  - conformance to a protocol standard

Why Accreditation and Certification

- A business is successful but unknown on the export markets
- It needs to gain confidence of customers that it can meet their requirements
- The business aligns its manufacturing processes with internationally recognized quality system ISO 9001 or ISO/IEC 9646 conformance standard
- The business is assessed by an independent body which issues a certificate of conformity or accreditation
- The business uses the certification or accreditation to establish itself as a reliable organization

From Conformance Testing to Conformity Assessment

A process of accredited *evaluation* and *approval*

- the use of accredited standards and guides
- accreditation of test facility
- harmonization and recognition of accreditation and certification criteria
- validation of the means of testing
- carrying out the testing
- evaluation of the test report
- certification that product conforms to standard
- mutual recognition of test results by different countries and regions

Who Accredits

- The checking of Conformity Assessment organizations is the job of accreditation bodies
- Organizations are granted accredited status if they demonstrate their competence to
  - Operate testing laboratories
  - Operate calibration laboratories
  - Certify quality systems
  - Certify products

Examples of Voluntary Bodies

- International Standards Bodies
  - ITU-T, ISO/IEC, ISO/CASCO, ETSI
- National and Regional Standards Bodies
  - SCC (Canada), ANSI (US), AFNOR (France), BSI (UK)
- National Accreditation Bodies
  - SCC, UL, EA, RAB, ANSI
- National Certification Bodies
  - SCC, CSA, UL, EA, ANSI

Examples of Regulatory Bodies

- **The Federal Communications Commission (FCC) in the US**
  - independent US government agency, responsible to Congress
  - Established by the Communications Act of 1934
  - Regulates interstate and international communications by radio, television, wire, satellite and cable
- **European Union Directives**
  - European voluntary standards can acquire legal force in creating the single European Market
  - The EU is responsible for issuing and policing Directives agreed by the Council of Ministers
  - EMC, Safety, Radio and Telecommunications Terminal Equipment, environment
- **Canadian Federal Department of Industry (Industry Canada)**
  - Telecommunications Apparatus Assessment and Testing
  - certification and registration of the apparatus complying with technical requirements and specifications
  - label or marking to indicate that a apparatus has been certified

Summary

- Conformance testing methodology and framework is defined in ISO and ITU-T
  - ISO/IEC 9646 seven-part standard
  - ITU-T X.290 series Recommendations
  - ISO 17025 Test Laboratory Accreditaion
- Interoperability testing methodology and framework is being defined in the draft X.itfm Recommendation
- Examples of Regulatory testing organizations
  - Industry Canada
  - US Department of Commerce
  - European Union
- International harmonization
  - ILAC - International Laboratory Accreditation Cooperation

Conclusions

- Conformance testing improves product quality and chances of product interoperability
- Interoperability testing is a check to determine if interoperability of conforming products has been achieved
- Conformance testing methodology and framework standard exist
- Interiperability testing methodology and framework standard is being progressed
- Supporting standards for conformance and interoperability testing do not exist and no plans are in place to develop them
- Standards should be tested for errors and ambiguities prior to approval (as is done in IETF)
- Accreditation and Certification are useful for buyer confidence, access to foreign markets and meeting regulatory requirements