ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

THE MEANING
OF CONFORMANCE
TO STANDARDS

TR/18

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BRIEF HISTORY

This Report was produced during 1982 and 1983 by a working party
with the active participation of ten members. The Report dis-
cusses conformance in general and identifies general criteria
for establishing conformance by standards of various categories.

The Member Companies of the Association reserve for themselves
individually expression of views on the complex legal and com-
mercial issues arising in many countries relating to certifica-
tion of conformance.

The Report was adopted unanimously by ECMA at its General Assembly
in June 1983.

TABLE OF CONTENTS

THE MEANING OF CONFORMANCE TO STANDARDS

1. ## PURPOSE

   Drafting computer standards and gaining international agreement to them is an expensive and time consuming process, therefore ECMA is anxious to ensure that standards are as valuable to all concerned, whether suppliers or users, as it is possible to make them.

   ECMA also believes firmly that the real value of computer standards depends on the existence of a comprehensive set of such standards. In general, the effectiveness of any one computer standard has to be considered in relation to other members of that set. It follows that if conformance to any standard is in doubt, that fact can seriously call in question the value of conformance to many other standards where no such doubt should really exist.

   Therefore ECMA will seek to clarify the position over conformance to all kinds of computer standards in the interests of users, suppliers and the general public alike. That is the purpose of this report.

   It is helpful to distinguish very clearly between conformance and certification.

   ### Conformance

   Conformance to a standard may be claimed for a computer product (hardware or software) if:

   i)   the standard is intended to cover entities of the class to which the product belongs, and

   ii) the product satisfies all the mandatory clauses including chosen alternative clauses of the standard, if any, and

   iii) the product satisfies any chosen optional clauses, and

   iv) a clear declaration is provided of the standard alternatives and/or options to which the product is claimed to conform.

   ### Certification

   Certification means the issue of a document declaring that a particular (sample of i) product has been checked for conformance to a standard or standards. Certification is, as is known, mandatory in some countries for some standards e.g. related to human safety or connections to PTT services.

   The process of certification implies some form of product examination and checking. Any body can issue a certificate. If the certificate is issued by the supplier of the product, the procedure is called "self-certification"; if by an inde-

pendent body, neither supplier nor purchaser, it is called "third party certification".

The status and validity of a certificate clearly depend on the reputation and/or authority of its issuer and his evident competence to declare the conformance of the product, whether from a knowledge or inspection of its design, results of tests or otherwise. To be of value to a user, a certificate of product conformance obviously demands some assurance that all samples of a product actually supplied thereafter, conform as strictly as the test sample.

Ideally, conformance should result from the product design; it should be a matter of technically ascertainable facts that can be established unambiguously by reproducible tests or checks. However, establishing conformance quite unambiguously by tests or checks, is, in some cases, beyond the state of the art.

For a wide range of standards, suppliers themselves are obviously well placed to make statements with varying degrees of commitment as to the conformance of their products to particular standards. ECMA believes that in general manufacturers will want to make their own statements about the conformance of their products, and that it is appropriate that they should do so.

In respect of different statements manufacturers may wish to make about conformance, it is evidently desirable for the alternative terms to have agreed significance. Some first suggestions on this issue are incorporated in this report, simply as a basis for further discussion.

As a manufacturers' organization ECMA will not take a position as to whether or not third party tests are advisable. Such a choice is entirely dependent on a variety of customer considerations, among which are government regulations. However, it is in the interest of both parties to realize that third party tests do need considerable expertise, whereas such expertise as well as knowledge of the design is in most cases available at suppliers' level. Thus third party tests can add considerable administrative complexity and often delay, to say nothing of significantly adding to cost.

2. PRINCIPLES OF CONFORMANCE

Any organization publishing standards in any field does so on the assumption that they will benefit both suppliers and users of products. What those benefits are and how they come about are matters calling for close examination because not all of them are equally easily achieved, nor do they all apply to every class of standard.

Historically, the earliest standards were probably physical standards for weights and measures. Obviously, these bene-

fitted both merchants and their customers; the customers avoided short measure and honest merchants giving full measure were not driven out of business by less scrupulous competitors. Broadly similar considerations apply today to most standards, including computer standards.

Innumerable standards are now relied upon in business and industry, for example, to ensure interchangeability of parts in producing and repairing machinery and plant in the factory and in the home. Not merely must the parts fit so that mechanism can be assembled (and spare parts procured), they must be made of suitable materials so that they do not wear out too fast or fail, say to provide the correct degree of friction, as in brake lining. In such cases, a hierarchy of standards is needed, starting with the primary ones for length mass and time, then going on to more complex matters such as the form of screw threads and including others defining methods for measurement of hardness, say of escapement parts in a watch. The actual design of any particular watch would then also call for a set of manufacturers' internal standards defining the dimensions and other characteristics of its parts. Checking the conformance of any component part will involve checking its conformance within defined limits of tolerance to each clause of each of the relevant standards.

Obviously many such general considerations will apply to the setting of standards for computer products. For instance, consider the set of standards required to make sure that it is possible to interchange data on magnetic tape between two computer systems. Clearly it is necessary to stipulate (with acceptable tolerance levels) the physical characteristics of the tape, its width, thickness and magnetic properties and also the dimensions and material of the reel on which the tape is wound. Then the limits of size, position and magnetic strength of the recorded elements on the tape must be defined. Given conformance with these criteria, one could feel confident that individual magnetic elements recorded on a tape by one tape transport could be successfully read by another.

However, unless there is also agreement about the meaning of certain recorded bit combinations, it may still not be possible even to stop the tape correctly between blocks. Alternatively, if one simply relies on the absence of recorded signals in interblock gaps, then those gaps must be of defined sizes and (in general) free from spurious signals and so on. Again, there must be some agreed way of recognizing the start and end of the tape to avoid breaking it or unwinding it completely from the reel.

Further, if a computer attached to a transport reading an interchange tape is to make sense of the elements recorded on the tape, the bit combinations in the recorded elements must conform to some agreed code. There must also be information on the tape to identify both the tape itself and the data written on it, in other words a label. So certain elements of a procedural protocol for the reading and writing processes must be incorporated into a magnetic tape interchange standard.

Thus, the successful interchange of data, on magnetic tape say, is likely to depend on conformance not merely to one but to a whole set of particular specialized standards for character codes, for recording these on magnetic tape, for labelling or identifying the tape, for the format of the data and so on. These in turn rely for their validity on certain primary standards, not only of physical measurement, e.g. of length or magnetic properties, but also of sets of characters in the case of codes. As was stressed above, this is so well known and even obvious as to be commonly forgotten or ignored.

But it is very important to be clear what may properly be said for instance about conformance to data interchange standards. In other words what it is that is actually required to conform.

A question as to whether a particular magnetic tape transport conforms to a certain set of data interchange standards, can thus be answered only by a statement about its capability of recording and reading tapes in accordance with those standards, since the standards in fact say nothing explicitly about tape transport as such.

When checking for conformance to a magnetic tape interchange standard, one should look upon the transport, the computer driving it, and the computer software together as equivalent to a piece of test equipment. It is convenient, indeed it may be essential, to make use of a transport in determining conformance to a tape interchange standard, although the transport itself is not the subject of that standard. This type of distinction will be seen to be even more important in later discussion of conformance to other kind of standard. What is implied is that when either drafting or reading a standard one must be very clear as to precisely what entities are and what entities are not affected directly by that standard.

3. SOME PROBLEMS OF CONFORMANCE

In this section some of the problems that have arisen in establishing conformance are examined. Ideally, any standard ought to be written in such a way that conformance can be established, if not unambiguously, at least to the joint satisfaction of a typical vendor and a typical purchaser. Conformance would be checked with one hundred per cent certainty either by a set of physical measurements, by direct inspection or by performing certain functional tests that give yes or no answers, or some combination of the three. But not all standards are amenable to this approach. For example, particular difficulties have arisen in defining conformance, notably in connection with programming language standards. An early example of such a standard would apply only to the language, and would consist of definitions of what could legi-

mately be said in that language and how it was to be ex-
pressed. Typically, it would prescribe a set of commands
that could be written and made to apply to certain defined
classes of variable or operand, what those commands meant and
what the proper results of executing the commands should be.
In effect, such language definitions postulated a hypothetical
machine that could execute directly programs written in the
language, though usually such a machine did not exist.

The difficulties that arose in deciding conformance led to the
introduction of conformance clauses in language specifications
These clauses often stated both the conditions to be satisfied
by a program purporting to be written in the language and by an
implementation in the form of a compiler/computer combination.
One example is the conformance specification of the ANSI stan-
dard X3.60 for Minimal BASIC. It defines conformance by a pro-
gram and also by a compiler implementation and is fairly typical
of,though rather shorter than, those to be found in the COBOL,
FORTRAN and PL/1 standards.

If one were asked whether a language standard can or ought to be
applicable to a compiler, one should consider the precision with
which it is possible to determine whether the compiler, together
with the hardware on which it is designed to run, precisely
emulates the hypothetical machine implied by the standard,
command by command. In the strictest sense, this cannot be done
by testing. High-level commands are written in terms of general
operands described by symbols, whereas any real (emulating) machine
operates logically and arithmetically on bit patterns. A corres-
pondence between the transformation of actual bit patterns and
the transformation of the ideal operands is difficult to define
precisely and unambiguously. For this reason if for no other,
it is usually impractical to verify exactly the operations of
individual commands. Moreover, unless the emulation is by
an interpretive process one command at a time, the sequence of
machine level instructions generated by a compiler for each
high level command will depend on the sequence of other high
level commands in which it is embedded. It is thus possible in
practice to verify only the results of several commands taken
as a sequence on selected ranges of operands. The combinations
of sets of machine, level sequences of instructions and of
values of operands are limitless, and only a small fraction
of all possible command sequences can be explored in the testing.
Experience has shown that extensive testing is necessary if
troublesome misinterpretations of a language standard are to
be detected.

Other more mundane reasons why it may not be completely straight-
forward to determine whether a given product conforms to a
specific standard include:

i)   the drafting of the standard itself may not be clear or complete, (e.g. the test limits have not been defined), so that its very interpretation is contentious,

ii)   no satisfactory method of testing conformance was (or could have been) laid down so that technical disputes arise in interpreting test results,

iii)   the product in question fails to embody every aspect of the standard, even though it conforms in respect of those aspects it does embody,

iv)   the product does conform in every defined respect but it incorporates additional features of a similar kind to those specified and which could, for example, affect interchanges of data or programs, interworking between equipments or interchange of units of equipment,

v)   the standard left options to the implementor that mean that a desired form of interworking can be frustrated.

The first two of these reasons imply some weaknesses in standards that could possibly have been eliminated in the drafting process and that in future are more likely to be avoided now that stress is being placed on the importance of doing so. However, as has been explained in connection with programming languages, comprehensive testing for conformance may be strictly impossible, so that while the position can certainly be improved, absolute conformance may not be a valid concept in every instance.

The last three reasons however relate to decisions by the designer or supplier of a product intended to conform to, or to interwork with, other products in accordance with some standardized protocols or procedures. The level of standardization achieved may be entirely adequate and acceptable in some contexts, but not others. It is also clear that both the force and the value of statements of conformance depend on the extent to which the standard was drafted with a clear intention of making conforming products identical, interchangeable or interworkable. Very often the variation in the drafters' intentions here has been enormous. In the case of programming language standards, the drafters were clearly unable to meet the objective of completely standard entities (programs or compilers) that would interwork with no difficulty at all.

In these circumstances, it becomes specially important that statements made by different suppliers are on similar lines, so that one does not claim conformance in circumstances where another would not feel justified in doing so. A possible code for manufacturers is outlined in Section 6 below. But it is equally important that users understand clearly what manufacturers' statements about conformance mean, and if confirmed, what benefits they as users can expect to derive from the level of standardization implied.

4. CRITERIA FOR CONFORMANCE BY STANDARDS FOR DIFFERENT CATEGORIES
    OF PRODUCT

An empirical review of ECMA standards revealed three main
classes of method for establishing conformance, namely:

- physical measurements, or

- inspection for the unambiguous presence of a characteristic,
  or

- some validation of the (statistical) behaviour of the pro-
  duct under non-exhaustive test conditions.

The results of physical (or other) measurements must fall
within limits laid down in the standards, which may also need
to quote the methods of measurement. Inspection is used, for
example, to check conformance to bit combinations of a
character code, resulting in an unambiguous pass or fail
for each such feature. Validation is normally used to check
conformance of a compiler; it is also expected to be employed
to test advanced communication protocols.

The survey found that some standards included clauses defining
criteria for conformance, but many did not. Again, many
standards implied a combination of methods of checking, though
normally one was more significant than the others. Naturally,
standards calling for inspection or physical measurements led
to fairly clear cut criteria for passing or failing and tended
to embrace many fewer options, alternatives or implementor-
defined features. As a result in these cases conformance
clauses were often omitted. Standards for languages or pro-
tocols that implied validation procedure, did not always lead
to clear cut pass or fail criteria and thus resulted in lengthy
statements of the conformance criteria. At the opposite ex-
treme are safety standards where it is mandatory for a pro-
duct to conform to every relevant clause. Each clause in one
particular safety standard quotes the appropriate test methods
and limits.

The state of the art in checking conformance to standards is
itself evolving, as are opinions as to what it is reasonable
to claim. Detailed research into the methods of conformance
to multi-level communication protocols is going on, notably
at the NPL in the UK and under Project Rhin in France.

Some weight has to be given also to the practical conse-
quences of any uncertainty over conformance. In the case
of safety standards where injury or loss of life could be
involved, there should be as little uncertainty as possible.
In the case of data interchange standards, again, clear cut
definitions are obviously desirable.

It is also most desirable that communication protocols be so
defined as to lead to unambiguous implementations, since the

resolution of failures of automatic equipment to inter-
communicate is a most difficult and time consuming process.
Exactly how far exchanges of programs in high-level languages
between systems could ever be guaranteed by conformance to
standards without human intervention is a matter of serious
debate, although many would accept it as a desirable aim.

Accordingly, on pragmatic grounds the following classifica-
tion is proposed:

I   Basically physical standards e.g. for safety or
     for media for data interchange

II   Codes and Formats

III   Programming Languages

IV   Communication Protocols.

The methods of checking used will not be exclusively of any
one type, but for classes I and II the order in which the
test conditions are applied does not affect the result, so
that a pass/fail result is likely to be achievable.

The objects of such a classification are:

i)   to help those drafting standards to minimise the un-
      certainty associated with conformance checking, and

ii)   to help computer users to appreciate more fully what
      claims to conformance mean and what they promise.

These matters are further explored in the next section.

5.   SIGNIFICANCE OF CONFORMANCE CLAIMS

In this section are given some idealized meanings of confor-
mance to standards in each of the above categories. It is
accepted that a claim to conform may be substantiated by the
passing of certain checks or tests. Ultimately the claim
rests on the product having been correctly designed to con-
form. For many reasons, such ideal meanings may not always
be applicable today. Consideration of deviations from these
ideals does, however, lead to practical recommendations.

Before discussing categories of standards individually, the
terms alternative, optional, additional or implementor-
defined features are introduced.

5.1   Alternative Features

Some standards have specified two or more mutually exclusive
ways of providing for certain facilities or functions. Where
such alternatives are specified, the implementor must adopt
one or other of the alternatives and state which. The choice

of an alternative is thus by definition mandatory, and in any given form of product, alternatives are mutually exclusive.

5.2 Optional Features

As distinct from alternatives, some standards specify optional features or characteristics. An implementor is free to choose whether or not to include an optional feature without affecting conformance. However, the implication is that if he does include an option, it should be in the manner stated by the standard and its inclusion should also be declared. Options may or may not be mutually exclusive of one another.

5.3 Additional Features

Features not defined in the standard are sometimes added to products; provided the standard features are not compromized or affected by such additions, so that a user can disregard the additions if he wishes, then conformance is not affected.

5.4 Implementor-Defined Features

Certain standards have called for features to be provided in a manner defined by implementor, for example, the collating sequence in COBOL. All implementor-defined features must be specified by a supplier. Implementor-defined features are undesirable since they can seriously restrict the scope for interchange or interworking, and ideally would not be allowed at all. Some mitigation of these ill effects has come about where a number of suppliers have chosen common definitions for such implementor-defined features.

5.5 Significance of a Claim to Conform to Standards of the Proposed Classes

The following are statements of the ideal, not necessarily of current practice.

5.5.1 Class I - Physical Standards including Safety Standards

Conformance involves checking to mandatory clauses of the standard; the result of each check gives a clear indication of pass or fail and there is no need to do tests or checks in any particular sequence or combination. The results will be the same. Conformance means passing all tests or checks.

5.5.2 Class II - Codes and Formats

The standard will distinguish mandatory from optional features and define both the tests or checks applicable as well as the category or categories of object covered

by the standards. Checking will involve establishing:

i) conformance with all mandatory features including declared alternatives,

ii) that in respect of each optional feature, a declaration has been made of the option selected,

iii) conformance to chosen options.

5.5.3 Class III - Programming languages

A programming language standard defines a programming language and not its compilers which are means by which programs written in that language are converted for execution. The standard does not define a compiler explicitly though in practice the problem is to test compilers.

One can envisage high-level test programs or suite of test programs so devised that all features of a language are systematically exercised. If these test programs when submitted to a compiler produced a machine level program that ran and produced the intended results, one could infer that the compiler was (in general) capable of compiling source code written in accordance with the language standard.

For compilers the term "validation" is used increasingly to mean checking to see that a compiler will properly handle programs written in a given high-level language. The issue is not one of testing for absolute conformance since that is not achievable. Obviously a validation process will not often give an unequivocal result, more a quality rating. The only unequivocal result would be an abject failure. The reasons for this were explained in section 3 above.

To test a claim that a program has been written in a specified programming language, the program could be submitted to a compiler known to be effective for that language and for a particular computer. If the compiler a) compiled the program, and b) the program ran and gave the intended results for each of a set of carefully chosen input parameters, it might then reasonably be deduced that the program submitted was correctly written in that language.

5.5.4 Class IV - Communication Protocols

Establishment of conformance rules for standards for communication protocols has been handicapped by:

- the new architectural approach needed,
- the consequent lack of working experience,

- the inherent complexity of the functions to be performed.

Thus procedures for conformance testing are immature and, indeed, the very meaning of conformance in this context is still under discussion.

6. RECOMMENDATIONS

The above considerations lead to the formulation of specific recommendations. These are addressed in turn to authors of standards specifications, to suppliers and to users of computer products and services. It is recognized that some of these recommandations are not new; they have been made before and are being carried out by some groups at least. But this is not universally true.

6.1 To Authors of Standards

6.1.1 Clearly identify the object of the standard.

6.1.2 Specify the field of application of the standard.

6.1.3 Lay down a conformance clause.

6.1.4 Define applicable and necessary test conditions and/ or appropriate methods for testing/checking the features of the standard.

6.1.5 Minimize and if possible eliminate altogether, the inclusion of alternatives, options or implementor-defined features in the standard.

6.1.6 Make it a mandatory requirement for claiming conformance to the standard that the implementor should declare any alternatives and options adopted.

6.2 To Suppliers

6.2.1 Declare conformance of individual products (in appropriate form of words).

6.2.2 Declare deviations from standard (if any).

6.2.3 Declare those alternative and optional features allowed by the standard that were actually adopted.

6.2.4 Declare and describe in adequate detail any implementor-defined features and any relevant additional features.

6.3 To Users

6.3.1 Study carefully the wording and full implications of the text of all relevant standards realizing that for many

applications conformance to a coherent set of standards is required.

6.3.2 Be especially clear as to what object is covered and what objects are not covered by any given standard.

6.3.3 Study suppliers declarations closely, especially in respect of declared alternative and optional features.

6.3.4 Realize that even small deviations from standards may have a severe impact throughout an entire system.

6.3.5 If in doubt seek advice from suppliers or qualified consultants as to what conformance implies.

6.3.6 Do not use standards as a substitute for procurement specifications. Such documents will often refer to standards, but must include much other information.