Test Assertions Guidelines

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Abstract:

This document provides guidelines and best practices for writing test assertions along with mandatory and optional components of a test assertion model.

Status:

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Introduction

This document is a guide to test assertions. Its purpose is to help the reader understand what test assertions are, their benefits, and most importantly, how they are created. As you will discover, test assertions can be an important and useful tool in promoting quality of specifications, test suites and implementations of specifications. You will learn that there are many ways to create test assertions.

By following the guidance in this document, you are more likely to develop well-defined test assertions that can have many useful purposes and applications (for example, as the starting point for a conformance test suite for a specification). Experiences in developing test assertions will be shared, along with lessons learned, helpful tricks and tools, hazards to avoid, and other snippets of knowledge that may be helpful in crafting test assertions.

Organization of the document:

Section 1 the rationale for test assertions

Section 2 describes basic design principles sufficient for simple cases of test assertions

Section 3 advanced features related to test assertions

Appendices provide a glossary of important terms, references, a listing of prior art and a worked example.

Scope

These guidelines are intended to apply to any technology or business field but some of the text may apply more to the technical field of software engineering which is the primary focus. The examples describe an arbitrary mechanical device so as to ensure a general understanding whatever the background of the reader. This document is limited to the essentials of test assertions with an expectation that a further document will follow to cover matters in greater depth and detail.

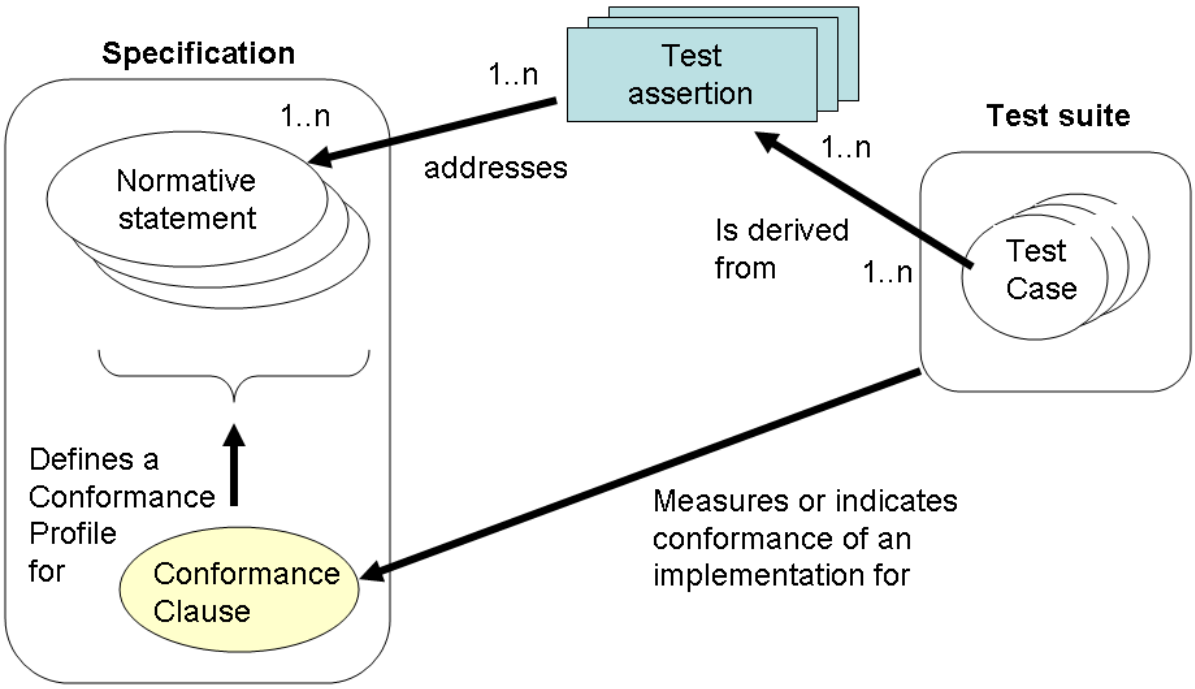
1 Rationale

1.1 What is a Test Assertion?

A test assertion is a testable or measurable expression for evaluating adherence of part of an implementation to a normative statement in a specification.

There is always a need to make explicit the relationship between a test assertion and the precise part of the specification to which it applies.

Fig.1 The Role of Test Assertions



The specification will often have a clause called a conformance clause[1] [CONF1][CONF2] which identifies those parts of the specification to which adherence is required for an implementation to be said to be conformant. Testing such conformance entails matching test results to specification statements for which there is directly or indirectly a conformance requirement. Test assertions sit between the specification and conformance clauses and any tests to be conducted to determine conformance or otherwise. The test assertion is not the same as a conformance clause as such. Test assertions are sometimes defined prior to the completion of the specification and may even then be referred to in the wording of the conformance clause to make it clear exactly what conformance will entail. Sometimes test assertions are authored after both specification and conformance clauses have been finalized. Reference to definitions of the following

[1] See description of 'conformance clause' in Glossary, Section 4

terms in the Glossary, Appendix A, may avoid confusion between related concepts: 'Conformance Clause', 'Test Assertion', 'Test Case', 'Test Metadata' and 'Tag'.

A Note on Testability

Judging whether the test assertion is testable may require some knowledge about testing capabilities and resource constraints. Sometimes there is not much knowledge of what actual testing conditions will be. In such cases the prime objective of writing test assertions is to provide a better understanding of what is expected from implementations in order to fulfill the requirements. In other cases, the test assertions are designed to reflect a more precise knowledge of testing conditions. Such test assertions can then be use as a blueprint for test suites.

1.2 Benefits of Test Assertions

Improving the Specification

Test assertions may help to provide for a tighter specification: Any ambiguities, contradictions and statements which require unacceptable resources for testing would be noted as they become apparent during test assertion creation. If there is still opportunity to correct or improve the specification, these notes can be the basis of comments to the specification authors. If not developed by the specification authors, test assertions should be reviewed and approved by them. This improves quality and time-to-deployment of the specification so best results are achieved when assertions are developed in parallel with the specification.

Facilitating Testing

Test assertions provide a starting point for writing a conformance test suite or an interoperability test suite for a specification that can be used during implementation. They simplify the distribution of the test development effort between different organizations while maintaining consistent test quality. By tying test output to specification statements, test assertions improve confidence in the resulting test and provide a basis for coverage analysis (estimating the extent to which the specification is tested).

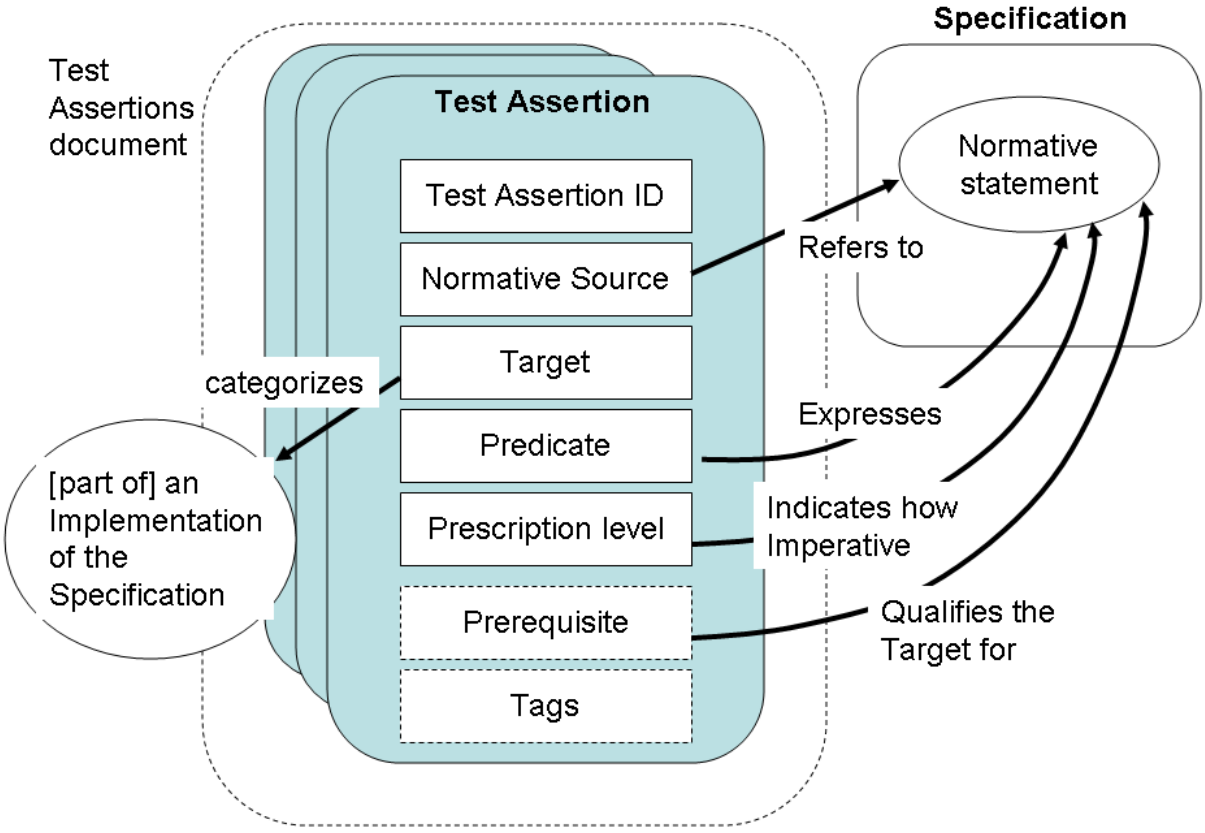
2 Designing a Simple Test Assertion

This section aims to cover the simpler aspects of test assertions. Some of the more complex aspects are covered later in Section 3.

2.1 The Structure of a Test Assertion

Some of the elements which comprise a test assertion are considered core while others are optional.

Fig.2 Anatomy of a Test Assertion



Core Test Assertion Parts

A test assertion must include, implicitly or explicitly:

Test Assertion Identifier

This unique identifier facilitates tools development and the mapping of assertions to specification statements. It is recommended that the identifier be made universally unique.[2]

Normative Source(s)

These identify the precise specification requirements or normative statements that the test assertion addresses.

Test Assertion Target

Such a target categorizes an implementation or a part of an implementation of the referred specification.

Predicate

A predicate asserts, in the form of an expression, the feature (a behavior or a property) described in the referred specification statement(s). If the predicate is an expression which evaluates to “true” over the test assertion target, this means that the target exhibits this feature. “False” means the target does not exhibit this feature.

Prescription Level

A keyword that qualifies how imperative it is that the requirement referred in Normative Source, be met. See possible keyword values in the Glossary.

Optional Test Assertion Parts

In addition, a test assertion may, optionally, include:

Prerequisite(s)

A test assertion Prerequisite is a logical expression (similar to a Predicate) which further qualifies the applicability of the test assertion (TA) to an instance of the test assertion Target. It may include references to the outcome of other test assertions. If it evaluates to "false" then the test assertion is to be considered 'not applicable', meaning the test assertion is not relevant to this Target instance.

Tag(s)

Test assertions may be assigned 'tags' or 'keywords', which may in turn be given values. These tags give an opportunity to categorize the test assertions. They allow grouping of the test assertions, e.g. based on the type of test they assume or based on their target properties.

---

[2] One way to do this is to designate a universally unique name for a set of test assertions and to include this name along with the identifier when referencing the test assertion from outside of this set.

2.2 Best Practices

In an actual test assertion definition, the above properties are often explicitly represented as elements of the test assertion. For example:

Consider the following as a requirement from a specification on “widgets” (we will build on this example throughout these guidelines):

```
[requirement 100] “A widget MUST be of rectangular shape”.
```

Here is a test assertion addressing this requirement:

```
TA id: widget-TA100-1[3]

Target: widget

Normative Source: “widget specification”, requirement 100

Predicate: [the widget] is of rectangular shape

Prescription Level: mandatory
```

The assertion predicate is worded as an assertion, not as a requirement (the 'MUST' keyword is absent from the predicate but reflected in the prescription level). It has a clear Boolean value: either the statement is true, or it is false for a particular target. The case of how to write a predicate for specification statements that convey optionality (for example, using keywords SHOULD, MAY, etc.) is examined later.

Note that a concrete representation of a test assertion may omit some of these elements provided they are implicit, as discussed later.

2.2.1 Granularity of Test Assertions

Consider now the following statement in the widget specification:

```
[requirement 101] “A widget of medium size MUST use exactly one AA battery
encased in a battery holder.”
```

There are actually two requirements here that can be tested separately:

> (requirement 101, part 1) A medium-size widget MUST use exactly one AA battery.
>
> (requirement 101, part 2) A medium-size widget MUST have a battery holder encasing the battery.

[3] Just as we have done with the examples, it is useful to create and follow a scheme or convention when assigning test assertion identifiers. In the examples here we base the test assertion identifier on a combination of broad target category and specification requirement reference number, suffixed with extra characters because it is worth remembering that there is likely to be a many-to-many relationship between specification requirements and test assertions.

Because of this it is possible to write two test assertions:

TA id: widget-TA101-1a

Target: medium-size widget

Normative Source: specification requirement 101, part 1

Predicate: [the widget] uses exactly one AA battery.

Prescription Level: mandatory

TA id: widget-TA101-1b

Target: medium-size widget

Normative Source: specification requirement 101, part 2

Predicate: [the widget] has a battery holder encasing the battery.

Prescription Level: mandatory

The granularity of a test assertion is a matter of judgement. A single test assertion instead of two could have been written here, with the predicate: "[the widget] uses exactly one AA battery AND has a battery holder encasing the battery". This choice may later have an impact on the outcome of a test suite written for verifying the conformance of widgets. With a single test assertion, a test case derived from this test assertion will not be expected to distinguish between the two failure cases. Using two test assertions - one for each sub-requirement - will ensure that a test suite can assess and report independently about the fulfillment of each sub-requirement. Other considerations such as the different nature of tests implied or the reuse of a test assertion in different conformance profiles [VAR], may also lead to the adoption of "fine-grained" instead of "coarse-grained" test assertions. Usage considerations will dictate the best choice here.

2.2.2 Implicit Test Assertion Parts

It was noted earlier that a concrete representation of a test assertion may omit elements provided they are implicit. A common case of implicit test assertion components is the implicit target: when several test assertions relate to the same target, the latter may be described just once as part of the context where the test assertions are defined, so that it does not need to be repeated. For example: all test assertions related to requirements about the widget power supply in a widget specification, may be grouped in the section "Widget Power Supply Requirements", suggesting that they share the same target.

The predicate may be implicit: In some specifications where all requirements follow a similar pattern, it is often possible to straightforwardly derive the assertion predicate from a requirement – for example, using a simple rule - so that the predicate does not need to be explicitly stated every time. Take, for example, requirement 101, part 1 "A medium-size widget MUST use exactly one AA battery". Compare this text with the predicate of its test assertion, widget-TA101-1a, "[the widget] uses exactly one AA battery". There is so much similarity between the requirement text and the test assertion predicate text that an implementation may decide there is too much overhead in writing the predicate to warrant it and decide to merely use a quotation of the requirement in the normative source as an implicit predicate.

2.2.3 Optional Statements: Prescription Level

The requirement 101 in the widget example in Section 2.2.1 has a mandatory character: it is an absolute requirement using the keyword MUST.

Interpreting the outcome of such test assertions is straightforward. Test cases derived from such test assertions can make a clear statement of conformance to the specification for the target under test: '(test assertion predicate = “true”)' means not only that the target exhibits the specified feature of the specification, but also that the target fulfills a specification requirement, since this feature is required.

However there might be several ways to conform to a specification, also known as dimensions of variability [VAR]. While both conforming, two implementations may not exhibit the same features. This section considers one of the most obvious cases of variability: optional features.

What if the specification statement is optional, i.e. it uses RFC keywords SHOULD / RECOMMENDED or MAY / OPTIONAL?

Examples:

```
[statement 102] “It is RECOMMENDED for a widget to be waterproof.”
[statement 103] “A widget MAY have a metallic casing.”
```

Such (normative) statements cannot be construed as formal requirements – a widget will not fail to conform to the specification if it is not waterproof, or if it has a plastic casing. However, establishing conformance is not the sole objective of test assertions. Some test suites are intended to evaluate the capabilities of an implementation – for example, which options it implements - regardless of conformance considerations. Even with a conformance objective in mind, a clear separation must be made between:

(a) Describing a condition under which a target can be said to exhibit a specified feature. This is the role of the test assertion.

(b) Deciding if a target satisfies a conformance criterion. This is the role of one or more test cases that are derived from a test assertion, the outcome of which might be interpreted according to a conformance profile.

Therefore, test assertions can be written for such statements 102 and 103, simply focusing on the specified feature and its related predicate, ignoring the prescription level in the predicate and including it instead as the separate component of that name, for which suitable values are enumerated ('`mandatory`', '`preferred`', '`permitted`', '`not permitted`' and '`not recommended`'):

```
TA id: widget-TA102-1
Target: widget
Normative Source: specification statement 102
Predicate: [the widget] is waterproof.
Prescription Level: preferred
```

TA id: widget-TA103-1

Target: widget

Normative Source: specification statement 103

Predicate: [the widget] has a metallic casing.

Prescription Level: permitted

3 Advanced Features

We have considered the five essential elements of the test assertion: identifier, reference, target, predicate and prescription level. In practice there may be a need for further features to better cater for corner cases such as

- specifications where the normative statements are embedded wholly or partly in tables and diagrams
- specifications which normatively reference other specifications
- specification and test assertions versions
- inheritance and dependencies between specifications
- redundancy of excessively repeated assertions elements
- test assertion targets which are categorized in conformance clauses.

3.1 Complex Predicates

Recalling the previous example requirement:

> `[requirement 101] "A widget of medium size MUST use exactly one AA battery and be encased in a battery holder."`

The target could be defined as "a medium-size widget" (as in section 2.2.1) or as just "a widget". The latter is a natural decision in case our specification requirement uses the wording: "`[requirement 101] If a widget is medium size, then it MUST use exactly one AA battery and be encased in a battery holder.`" In this case (combining, for simplicity of our example, our two test assertion predicates for widget-TA101-1a and widget-TA101-1b into one predicate) we could have had:

> `TA id: widget-TA101-2a`
>
> `Target: widget`
>
> `Normative Source: requirement 101`
>
> `Predicate: if [the widget] is medium-size, then [the widget] uses exactly one AA battery AND the battery is encased in a battery holder.`
>
> `Prescription Level: mandatory`

The target category is broad, but the predicate part is really of interest only for a subset of this category (the medium-size widgets). Usage considerations should again drive the decision here: a test suite that is

designed for verifying all widgets, and does not assume a prior categorization of these into small / medium / large sizes, would be better off with test assertions that only use “widget” as target, such as widget-TA101-2a.

Note: As an important part of the test assertion, even when the target is implicit, not explicit, it must be that the target for each assertion is clearly identifiable.

A test assertion predicate may, then, be a Boolean expression - a composition of atomic predicates using logical operators AND, OR, NOT. A test assertion predicate may also be of the kind: “if (condition) then (expression)”.

The predicate is worded in an abstract way, still close to the wording of the specification. No indication is given of what kind of test procedure will be used (how to determine the number and type of batteries, etc.), nor of the detailed criteria for the condition evaluation (for example, what kind of battery holder is acceptable). Such details are normally left to the test cases that can be derived from the test assertions. These test cases will determine the precise criteria for conforming to the specification. However, if a precise criterion for interpreting the battery holder requirement is provided in an external specification - either referred directly by the widget specification or by a related conformance clause - then a test assertion must use this criterion in its predicate. Such a test assertion must then refer not only to the specification requirement in its reference property, but also to the external specification or to the conformance clause that refers to this specification.

3.2 Prerequisites

An issue with the previous test assertion (widget-TA101-2a) is that it will apply to all widgets, while the specification requirement is obviously of interest only for targets that are medium-sized. With widget-TA101-2a , the target predicate will always evaluate to “true” even when the widget is NOT medium-sized. Indeed, from a logical viewpoint, a predicate of the form “if <condition> then <property>” will always be true when <condition> is “false”. (The only way such a predicate evaluates to “false”, is when <condition> is “true” and <property> is “false”).

On the other hand if all widgets are categorized according to their claimed size prior to testing, then a test case implementing widget-TA101-2a will uselessly repeat the “size” test. In this situation the test assertions written in section 2.2.1 (widget-TA101-1a and widget-TA101-1b) are a better choice than widget-TA101-2a.

Assuming that the size of widgets is not a given but is subject to testing, how can we indicate that a preliminary test on the widget size must be done, and that the test assertion predicate must only apply if the widget is medium-size, meaning that otherwise the test assertion is considered as “Not Applicable”? This is done by introducing a prerequisite element in the test assertion:

```
TA id: widget-TA101-2b

Target: widget

Normative Source: requirement 101

Prerequisite: [the widget] is medium-size

Predicate: [the widget] uses exactly one AA battery AND has a battery
holder encasing the battery.

Prescription Level: mandatory
```

The Prerequisite element is a logical expression of the same nature as the Predicate, which concerns the same target instance.

The possible outcomes of a test assertion with a prerequisite become:

> **Not Applicable**: If the prerequisite evaluates to “false”, then the test assertion does not even apply for this target (or its outcome can be stated as “Not Applicable”). A test case derived from this test assertion should not even be executed on this target: the result of doing so would be meaningless.
>
> **True**: If the prerequisite evaluates to “true”, and the test assertion predicate evaluates to “true”, then the target is exhibiting the feature described in the addressed specification requirement.
>
> **False**: If the prerequisite evaluates to “true”, and the test assertion predicate evaluates to “false”, then the target is NOT exhibiting the feature described in the addressed specification requirement.

3.3 Test Assertions for Properties

Requirements addressed by test assertions may be related to specific properties of a target. Let us assume that there are specification requirements that define under which conditions a widget qualifies as “medium-size”. In other words, widgets do not come with a sticker that makes this categorization obvious by announcing small / medium / large. Instead, the size label is a property that is itself defined in the widget specification and that is subject to verification, like any other normative statement. In such a case, when writing test assertions, it is not a good idea to consider this property as part of the definition of the target category as we did in widget-TA101-1a and widget-TA101-1b, because the category of a widget could not be identified prior to doing any test on this widget.

Assume that the following requirement defines the “medium-size” property:

```
[requirement 104] “A widget that weighs between 100g and 300g and is from
5 to 15 centimeters long in its longer dimension, is a medium-size widget.”
```

There is a major distinction between requirement 104 and requirement 101:

> requirement 101 uses “medium-size” as a prerequisite: its predicates only concern widgets that are already established as being medium-size.
>
> requirement 104 defines how to qualify a test assertion as medium-sized.

The test assertions for requirement 104 can be written as:

```
TA id: widget-TA104-1

Target: widget

Normative Source: specification requirement 104

Predicate: [the widget] weighs between 100g and 300g.

Prescription Level: medium-sized:mandatory
```

Note that the "mandatory" prescription level is now relative to the claimed property ("medium-size"): the specification does not mandate all widgets to be "medium-size", but for a widget to claim the "medium-size" property, the predicate must be "true". The prescription **intent** must clearly be indicated in the Prescription Level element, e.g. by prefixing the level value (here "mandatory") with the property name ("medium-size").

TA id: widget-TA104-2

Target: widget

Normative Source: specification requirement 104

Predicate: [the widget] is from 5 to 15 centimeters long in its longer dimension.

Prescription Level: medium-sized:mandatory

The test assertions widget-TA104-1 and widget-TA104-2 will be used to derive test cases that verify if the property "medium-size" applies to some widget. A "false" outcome for their predicates is an indicator that the medium-size property does not apply. It is not indicative of a violation of the specification itself. Such test assertions are called here "Property test assertions" to distinguish them from test assertions that are used as indicators of conformance to a specification. However, both types of test assertions are designed in the same way, with a predicate that indicates whether or not a target satisfies some feature or property.

There is no mention of the “medium-size” property at all in the predicates of test assertions ‘widget-TA104-1’ and ‘widget-TA104-2’. This is because this property is precisely what needs to be established by a test suite containing test cases that are derived from these test assertions. Only when a target (here a widget) evaluates to “true” for these two test assertions, will it be considered as medium-size. These test assertions are only concerned with the nature of these tests, not with how to interpret their outcome.

3.4 Prerequisites Referring to Other Test Assertions

Now that we have a means to establish the “medium-size” property, we can use a more precise prerequisite element in the test assertion for the requirement 101. Because Test Assertions have been written for testing the property “medium-size”, we can refer to these in the Prerequisite:

TA id: widget-TA101-2c

Target: widget

Normative Source: specification requirement 101

Prerequisite: widget-TA104-1 AND widget-TA104-2

Predicate: [the widget] uses exactly one AA battery AND has a battery holder encasing the battery.

Prescription Level: mandatory

When a prerequisite element is quoting other test assertion(s), as seen above, with the prerequisite: (widget-TA104-1 AND widget-TA104-2), such references must be understood as short for: (widget-TA104-1 outcome = 'true' AND widget-TA104-2 outcome = 'true').

The prerequisite could have been stated as an explicit predicate in widget-TA101-2c, i.e. widget-TA101-2c could have been rewritten as:

TA id: widget-TA101-2d

Target: widget

Normative Source: specification requirement 101

Prerequisite: [the widget] weighs between 100g and 300g AND [the widget] is from 5 to 15 centimeters long in its longer dimension.

Predicate: [the widget] uses exactly one AA battery AND has a battery holder encasing the battery.

Prescription Level: mandatory

Here widget-TA101-2c is semantically equivalent to widget-TA101-2d. However, because the notion of “medium-size” is itself specified as a property that is subject to verification and enforcement, it is useful to write test assertions for this property. It is then preferable to reuse such test assertions as prerequisites whenever this property is assumed. If the notion of medium-size evolves in future releases of the widget specification, the test assertion does not need to be altered: only its prerequisite test assertion needs to be, while all test assertions that explicitly state the prerequisite predicate would need be updated.

3.5 Various Normative Sources

The normative content addressed by a test assertion is not always a single, well-identified specification requirement. The normative source may include:

- Multiple (non contiguous) specification statements.
- Non-textual content: tables and diagrams.
- Normative statements that present some testability challenges.

In the above cases, it is often useful or necessary to "derive" a new textual statement that will be the actual normative source for the test assertion, and for which the predicate outcome will unequivocally indicate fulfillment or violation. This derived statement may in turn be worded so that the Predicate is implicit (see 2.2.2). In the case of "multiple statements", although using several references is possible in the Normative Source element, it is recommended to derive a new consolidated statement. Identifying the normative source subject to a test assertion may be a delicate exercise, as the source material is often dependent on its context for its meaning. A derived statement may be then necessary.

Even when the normative statement is a well identified portion of text in the specification, the following cases may occur:

- The normative source is implicit, as explained in 2.2.2. This means that there is no explicit element in the test assertion pointing at the specification part that is addressed. This may be the case when the test assertion normative source can be inferred from the location of the test assertion within the specification document itself.
- The specification document is itself expressed as a set of test assertions. This is possible by inserting in the "normative source" part of the test assertion, the normative statement itself instead of a reference to it.

3.6 Test Assertion Grouping

When writing test assertions, as the specification is being analyzed, it is usual to group certain test assertions together, either as having a special status, such as all accredited test assertions for a given specification, or as sharing a particular characteristic, such as a common category of test assertion target.

A special kind of grouping is the container of all test assertions which belong to a particular specification or profile. Here the container may be the specification document itself if it includes within it the test assertions to be associated with it.

Ways to group test assertions include two of special note: - explicit listing of test assertions by their identifiers (section 3.6.1) and a more implicit grouping by a common but not unique property such as the tag names or tag values assigned to the test assertions (section 3.6.2).

3.6.1 Lists (Dimensions of Variability)

To explicitly identify a group of test assertions they can be listed explicitly by their unique test assertion identifiers. This makes it clear once and for all which assertions belong to that particular group and which do not. In addition to such a list, the logical reason which determines whether a test assertion is a member or not of that list will need to be stated, at least to help with understanding and maintenance of the list.

For example:

```
TA List id: A001
List Description: all assertions describing 'Size' requirements
List Members:  TA001, TA002, ..., TA008
```

Note that although, in this example, we have avoided enumerating each and every test assertion identifier by using an ellipsis ('...'), such methods introduce a possible weakness. It might be overlooked during maintenance of the test assertions or the test assertion list if a later test assertion is given an ID of TA002a and therefore is implicitly rather than explicitly made a member of this particular list. This may be a mistake since the new test assertion TA002a might not relate to the list description of 'Size' requirements. A list is completely explicit about every test assertion member when every member test assertion is listed explicitly by its test assertion identifier.

For example:

```
TA List id: A001

List Description: all assertions describing 'Size' requirements

List Members:  TA001, TA002, TA003, TA004a, TA004b, TA005, TA006, TA007,
TA008
```

Such a list may be regarded as 'fixed', 'frozen' or 'closed'. A test assertion added later with identifier TA005a, if it is to be included in this list, would require a change to the list (with possible version or change control implications) or the creation of a new list (with a new list identifier, if a list identifier is included with the list).

Test Assertion Document

A list of test assertions related to either conformance or interoperability testing will need special care with respect to version control and change management and therefore it will need to be clear what criteria are being used to determine which test assertions are members of the list and which are not. The special case of a container for all test assertions related to a given specification or profile, say, is a special example of a most explicit list, although here the method used to define such a list may involve the use of inclusion of the test assertion itself (rather than just its identifier) within a special document or package. One way to create such a list is to include all such related test assertions within a document, which we might call a 'Test Assertion Document'. Other synonymous terms might be 'Test Assertion List'. 'Specification Analysis' or 'Test Assertion Set'. Note that the container of this complete set of test assertions might instead be the document of the specification or conformance profile [VAR] itself, when test assertions are included, say, within the text of the actual specification or profile.

3.6.2 Tags (Test Assertion Metadata)

Another way to define a group of test assertions is to use a non-unique property of such assertions rather than just using their unique identifiers in a list or containing the test assertions themselves in a document. To this end, test assertions may be assigned metadata in the form of non-unique 'tags' or 'labels'.

For example, test assertion 'widget-TA104-2' might be tagged as 'Size-Property-Description':

TA id: widget-TA104-2

Target: widget

Normative Source: specification requirement 104

Predicate: [the widget] is from 5 to 15 centimeters long in its longer dimension.

Prescription Level: medium-sized:mandatory

Tag: Size-Property-Description

Then it might be included in a list of test assertions related to 'Medium Size' requirements, along with other assertions, say, tagged 'Size-Related' but NOT, say, with test assertions 'Small-Size-Related'.

TA List id: A002

List Description: all assertions describing 'Medium Size Widget' requirements

List Members: All test assertions with Tag 'Size-Property-Description' AND Tag 'Size-Related' AND NOT Tag 'Small-Size-Related'

This we have called a 'List' but it is in fact defined rather more implicitly than if every member were listed by its identifier, as described in the previous section (section 3.6.1). In fact a more explicit and well-defined list might combine both tags and identifiers to group the assertions:

For example:

TA List id: A002

List Description: all assertions describing 'Medium Size Widget' requirements

List Description: All test assertions with Tag 'Size-Property-Description' AND Tag 'Size-Related' AND NOT Tag 'Small-Size-Related'

List Members: TA001, TA002, TA003, TA004a, TA004b, TA005, TA006, TA007, TA008

So a tag is a further, optional test assertion element useful in grouping test assertions. It may sometimes be useful to create tags as name-value pairs.

For example, tagging a test assertion:

Tag: Widget-Size=Medium

This would allow all test assertions related to requirements for medium sized widgets to be grouped to facilitate, say, testing of just the medium-sized widgets or a conformance profile relating just to medium-sized widgets.

Note that several such filters can be applied to the same set of assertions and any given assertion can appear in more than one grouping.

Special consideration when using tags for grouping is to be given to the stages in the workflow of test assertion authoring and maintenance and subsequent use at which changes might be made to tags and their values. Specially there may be the addition of new tags, perhaps by adding metadata which is separate to the documented test assertion. If metadata for test assertions is defined and maintained separately from the test assertions it may be subject to an entirely different set of version and change control rules and methodologies. In this case, a distinction might need to be made between tags which were part of the original test assertion and those whose list membership might be different to that which was known or expected at the time the list was defined.

For example, consider a list defined using tags but without explicitly listing test assertion identifiers:

```
TA List id: A002

List Description: all assertions describing 'Medium Size Widget'
requirements

List Description: All test assertions with Tag 'Size-Property-Description'
AND Tag 'Size-Related' AND NOT Tag 'Small-Size-Related'
```

If TA004a is originally tagged 'Size-Related' but the workflow allows it also to be subsequently tagged 'Small-Size-Related', then there will need to be rules defined which determine whether the test assertion is still a member of List 'A002'.

3.7 The Case of Multiple Specifications

Modularity and succinct description within specifications can be achieved by leveraging existing specifications that are referenced by other specifications. Specification writers often create "umbrella specifications". These are widely scoped specifications that delegate certain normative descriptions to other "referenced specifications".

Specification modularity may also come from a “prototypical specification” - a "base specification" - from which specialized derivative specifications may define specific information for a given context.

For proper specification analysis, inclusion of test assertions from both the umbrella (or base) specification and all the referenced specifications should be considered.

Two aspects of analysis of multiplicity of the normative sources are considered:

- Specification Visibility (Section 3.7.1) deals with how assertions from a referenced specification are considered or described in the umbrella specification.
- Composition of Assertions (Section 3.7.2) describes how predicates and prerequisites can express various relationships between umbrella and referenced specifications.

3.7.1 Specification Visibility

Consider a case where a specification is the normative source but it itself refers normatively to a second specification. Consider firstly the case where there is no visibility of any test assertions covering this second specification. Here there may be a prerequisite that all test assertions for the second specification be treated as a single Boolean requirement.

In a second case the specification refers to a second specification for which the test assertions are given visibility and here the test assertions of the first specification may refer to individual or groups of test assertions of the second specification as explicit prerequisites. Of course, any number of normative sources may be involved, some with test assertions visible, others not.

3.7.2 Composition of Assertions

There are three dimensions that describe how assertions from a referenced specification may be included within an umbrella specification:

- 'scope of inclusions',
- 'conditionality of inclusions',
- 'modification of inclusions'.

These relationships between specifications can be expressed using a test assertion. This form of a test assertion is a specific form of an assertion, as it expresses some form of conformance (like a conformance clause).

Multiple dimensions can be expressed within these relationships (for example, a subset of test assertions from a reference spec may be conditionally included in an umbrella specification).

Scope of inclusions

An umbrella specification usually relates to a referenced specification by assuming or requiring conformance of its implementation to this specification. These conformance requirements can be expressed in a test assertion's prerequisite or predicates.

The scope of this conformance may be determined by the expressions in these prerequisites or predicates.

The logical expressions used in the predicate may also include a conformance requirement for varying scopes of the (current) umbrella specification as follows:

- conformance to an (entire) umbrella specification
- conformance to a profile of the umbrella specification
- conformance to a specific normative statement from the umbrella specification

Similarly, the logical expressions used in a prerequisite may also include a conformance requirement for varying scopes of the external specification as follows:

- conformance to an (entire) referenced specification
- conformance to a profile of an referenced specification
- conformance to a specific test assertion from an referenced specification

A simple example might be a wholesale inclusion that describes where a target in an umbrella specification is completely conformant to the assertions of a referenced specification.

```
TA id: widget-TA108-1

Target: Widget

Normative Source: Conformance clause to Mini-Widget Small Box
Specification 1.2

Prerequisite: [the widget] is conformant to Mini-Widget Small Box
Specification 1.2

Predicate: [the widget] is conformant to WidgetSpec 1.0

Prescription Level: mandatory
```

Interpretation: "A widget that conforms to the Mini-Widget Small Box Specification 1.2. must be conformant to the WidgetSpec 1.0 specification."

Another example might be a partial inclusion that describes a case where a target in an umbrella specification is conformant to some subset of assertions in a referenced specification. Subsets of a specification are described as 'Conformance Profiles', and may be expressed via grouping constructs (using 'lists'):

```
TA id: widget-TA109-1

Target: Widget

Normative Source: Conformance clause to WidgetSpec 1.0

Prerequisite: [the widget] is conformant to the "smaller box" Conformance
Profile of the Mini-Widget Small Box Specification 1.2

Predicate: [the widget] is conformant to WidgetSpec 1.0

Prescription Level: mandatory
```

Note: "Some portion of the test assertions for the Mini-Widget Small Box Specification 1.2 are identified in a list to indicate their inclusion in the Smaller Box conformance profile"

Interpretation: "All widgets conformant to the WidgetSpec 1.0 specification must also be conformant to the 'smaller box' assertions of the WidgetMobile Small Box Specification 1.2"

Conditionality of Inclusions

This dimension of inclusion describes the conditionality whether assertions in an umbrella specification is conformant to a referenced specification. The prerequisite of the assertion may:

a. require that optional portions of the referenced specification be implemented in the umbrella,

b. conditionally require optional portions of the referenced specification be implemented in the umbrella (for example, based on the presence of hardware or some other such support), or

c. make remaining (required) portions of the referenced specification to be optional

The example of widget-TA108-1 already shows how a widget describes mandatory conformance. The following widget describes a conditional conformance:

TA id: widget-TA120-1

Target: Widget

Normative Source: specification requirement 120 in WidgetSpec 1.0

Prerequisite: IF [the widget] has restriction of box size 760 mm x 480 mm x 100 mm or less THEN [the widget] is conformant to the Conformance Profile of the Mini-Widget Small Box Specification 1.2.

Predicate: [the widget] is conformant to WidgetSpec 1.0

Prescription Level: mandatory

Interpretation: "All widgets conformant to the WidgetSpec1.0 specification must also be conformant to the assertions of the WidgetMobile Small Box Specification 1.2 IF the widget is smaller (or equal) in size to 760 mm x 480 mm x 100 mm "

Modification of Inclusions

This dimension of inclusion describes where an umbrella specification is conformant to a referenced specification, where some subset of assertions must be modified. This assumes some partitioning of the unchanged assertions and modified assertions. You can use "lists of assertions" to describe in the pre-requisite the subset of assertions that the umbrella specification is conformant to "unchanged". The remaining test assertions (changed set) can be individually specified as test assertions of the umbrella specification.

Typically, assertions are modified in a referenced specification to be strengthened in a few ways:

- strengthening the prescription level of an assertion (eg. x MAY do y => x MUST do y), or

- strengthening the meaning of an assertion with additional requirements (eg. IF x THEN z => IF (x AND y) THEN z).

3.8 Specification Versions

Where a specification is the basis for test assertions there needs to be consideration of how to support further versions and maybe any previous versions of that specification. One solution is to create a set of test assertions for each specification version. The references to specifications may include the identification of the precise specification version but this may restrict that test assertion to just one version of a specification. Such a simple strategy is less than ideal as it results in a need to re-author the test assertions each time there is a new specification version.

Another method of dealing with multiple specification versions is to create a repository of test assertions for a specification and properly tag each test assertion for the versions of the specification where it is valid. This can be accomplished by introducing 2 tags, `VersionAdd` and `VersionDrop`.

`tag: VersionAdd`: the lowest numerical version to which the test assertion applies.

`tag: VersionDrop`: the lowest numerical version number to which the test assertion does NOT apply.

Both `VersionAdd` and `VersionDrop` are optional tags. The absence of both tags would mean that the test assertion is valid in all specification versions. If only a `VersionAdd` tag exists and its value is X, the test assertion will be valid in version X of the specification and all subsequent versions. If only a `VersionDrop` tag exists and its value is Y, the test assertion will be valid in all versions of the specification prior to version Y. If both `VersionAdd` and `VersionDrop` tags exist, the test assertion will be valid in version X and all subsequent version up to (and not including) version Y. Based on these rules, one can easily generate the set of test assertions that apply to a specific version of the specification.

Care must be taken when going from one version of a specification to another. The test assertion author must identify all test assertions that are the same between versions, that are dropped from one version, that are added to one version, and that are modified between versions. Test assertions that are the same, are dropped, or are added can easily be handled with the `VersionAdd` and `VersionDrop` tags.

Test assertions that are modified are trickier to handle. One could treat the modified test assertions as two separate test assertions and tag them with the appropriate `VersionAdd` and `VersionDrop` tags. Unfortunately, this approach does not provide any indication that the updated assertion is related to the test assertion in the prior specification.

Note that in order to track the evolution of a test assertion, it is important to preserve the test assertion identifiers across revisions of the specification. This is important because it is also important to maintain the relationship between a test assertion and the tests associated with that test assertion.

3.9 Variables

Variables have a similar role in test assertions as in other technologies. They provide a means for consistently sharing values across multiple assertions and with other processes. The writer of a set of test assertions can use a variable to assert that all occurrences of that variable must have the same value, even if that value cannot be known at the time the test assertions are written. For example, consider a set of assertions all sharing a reference to the line (mains) voltage supplied by the local electric utility, where the specific locality will vary. By declaring a variable for this value and distinguishing the name by, for

example, representing it in upper case (UTILITY-VOLTAGE), each test assertion can use it within its elements and expressions.

Note: Some people prefer the term "parameter" and would say that the test assertions in question are "parameterized."

The following example also shows the use of the variable within the predicate. Here, specification requirement 130 depends on the utility voltage, expressed as variable 'UTILITY-VOLTAGE'.

```
Variable: 'UTILITY-VOLTAGE' the AC voltage the voltage commonly provided
for hand-held electrical appliances and laptop computers.
...

TA id: widget-TA130-1

Target: electrical widget

Normative Source: specification requirement 130

Predicate:  [the electrical widget] contains an embedded AC adapter for
the UTILITY-VOLTAGE.

Prescription Level: mandatory
```

Variables can be used across elements in a single test assertion, e.g. in the prerequisite (see section 3.2) and other parts of a test assertion. For example, requirement 130 may be restricted only to widgets that have a compliance requirement for this voltage:

```
Prerequisite: [the electrical widget] is compliant with UTILITY-VOLTAGE
```

In some cases, the variable has a value known or assigned during test assertion authoring, and is simply used to allow agile resetting of its value. In other cases, the variable can be declared in name only, leaving the value to be assigned at a subsequent stage, such as in an implementation itself or in a conformance clause for a profile, level or module. The value might be measured during testing and could be associated with a property (see section 3.3). For example, if the medium-size property is true for a widget, the SIZE variable is set to the value "medium".

A particular consideration in using variables is variable scope. For example, a grouping construct might be a place to declare variables whose scope only applies to those test assertions associated with that grouping. This allows the same variable and its value to be used across several test assertions while avoiding problems with name clashes in test assertions outside of the variable's scope.

3.10 Target Categories

As mentioned in section 2.1, the Target element of a test assertion generally defines a category of objects or parts of an implementation under test. For example, the test assertion target “widget” represents any object that qualifies as a widget.

It is often the case that different targets (or categories) are related, for example one target is a subcategory of another target . As a consequence:

- Two test assertions that apparently have different targets, will in fact apply to the same implementation (or part of).
- A test assertion may be used as a prerequisite of another test assertion, in spite of having a different target definition.

For these reasons such target dependencies should be explicitly stated. Such dependencies may be defined outside test assertions, such as in an object-oriented model. But often it may be convenient to remind of them in the test assertion itself.

Example: consider a Target named "electrical-gizmo" that is a subcategory of the "widget" Target. This means all test assertions for widget also apply to electrical-gizmo. One way to express this dependency is to use tags. In the following example, a tag named "target-isa" will remind the reader of the test assertion that the electrical-gizmo target is (also) a widget target:

```
TA id: gizmo-TA300
Target: electrical-gizmo
Normative Source: specification requirement 300
Prerequisite: [The gizmo] has a low-battery indicator.
Predicate: The low-battery indicator of [the gizmo] is a red LED that is
flashing below 25% charge.
Prescription Level: mandatory
Tag: target-isa = widget
```

Another way to indicate that this target is also a widget, is to use the prefix notation '`widget:electrical-gizmo`' instead of just '`electrical-gizmo`' for the target element in a test assertion:

```
TA id: gizmo-TA300
Target: widget:electrical-gizmo
```

Both modes of annotation (tag or target prefix) make it clear that an electrical-gizmo is also a widget. This will help the grouping of test assertions based on the target to which they apply. It also helps writing prerequisites that refer to other test assertions. For example, knowing that the electrical-gizmo is also a widget, and assuming there is already a test assertion (widget-TA123) written:

```
[statement 123] A widget MAY have a low-battery indicator.
```

then it is possible to reuse the test assertion for Requirement 123 as a prerequisite:

TA id: gizmo-TA300

...

Prerequisite: widget-TA123

Another kind of target dependency is the Composition relationship: Target T2 is a component of Target T1 if an instance of T1 contains an instance of T2. For example, assuming widgets always have at least one switch to control their operation, Target “switch” is a component of Target “widget”. Knowledge of this target composition relationship brings the same benefits as for subcategories:

- Grouping all test assertions that apply to widgets often should include the test assertions that apply to widget components.
- A test assertion on widget may use in its prerequisite a test assertion on the switch that is part of this widget. For example, addressing the requirement "`the gizmo must stop when the switch is off (Req# 400)`" may use as prerequisite a test assertion (called here "TA-switchoff") that addresses the requirement "`A switch must cut its electrical circuit when in OFF position`". This would guarantee that the switch is tested first, in related test programs.

TA id: gizmo-TA400

Target: electrical-gizmo

Normative Source: specification requirement 400

Prerequisite: TA-switchoff(target: the switch of the gizmo)

Predicate: [the gizmo] stops when the switch is off.

Prescription Level: mandatory

Appendix A. Glossary

Conformance

The fulfillment of specified requirements by a product, document, process, or service.

Conformance Clause

A statement in the Conformance section of a specification that provides a high-level description of what is required for an artifact to conform. It, in turn, refers to other parts of the specification for details. A conformance clause must reference one or more normative statements, directly or indirectly, and may refer to another conformance clause.

Implementation

A product, document, process, or service that is the realization of a specification or part of a specification.

Normative Source

Identifies the precise specification requirements or normative statements that the test assertion addresses. (See also Section 2.1.)

Normative Statement, or Normative Requirement

A statement made in the body of a specification that defines prescriptive requirements on a conformance target.

Predicate

Asserts, in the form of an expression, the feature (a behavior or a property) described in the referred specification statement(s). If the predicate is an expression which evaluates to “true” over the test assertion target, this means that the target exhibits the feature. “False” means the target does not exhibit the feature.

Prerequisite

A test assertion prerequisite is a logical expression which further qualifies the applicability of the test assertion to the test assertion target. It may include references to other test assertions. It evaluates to true or false and if false then the assertion is to be considered 'not applicable', meaning that the test assertion is not relevant to its target.

Prescription Level

The test assertion defines a normative statement which may be **mandatory** (MUST/REQUIRED), **not permitted** (MUST NOT), **permitted** (MAY/OPTIONAL) **preferred** (SHOULD/RECOMMENDED) or **not recommended** (SHOULD NOT). This property can be termed its prescription level.

Tag

Test assertions may be assigned 'tags' or 'keywords' which allow their grouping and give an opportunity to categorize the targets.

Test Assertion

A testable expression for evaluating adherence of part of an implementation to a normative requirement statement in a specification. It describes the expected output or behavior for the test assertion target within specific operation conditions, in a way that can be measured or tested.

Test Assertion Document

A container for a complete set of test assertions, often those related to all or part of a specification or conformance profile. In some cases the container is the specification itself with test assertions included within it. Test assertions can be added to the document, removed or changed within it using a change and version management procedure.

Test Assertion Target

Implementation or part of an implementation that can be the object of a test assertion or test case. (See also Section 2.1.)

Test Case

Consists of a set of a test tools, software or files (data, programs, scripts, or instructions for manual operations) that verifies the adherence of a test assertion target to one or more normative statements in the specification. Typically, a test case is derived from one or more test assertions. Each test case includes: (1) a description of the test purpose (what is being tested - the conditions / requirements / capabilities which are to be addressed by a particular test), (2) the pass/fail criteria, (3) traceability information to the verified normative statement(s), either as a reference to a test assertion, or as a direct reference to the normative statement.

Test Metadata

Test metadata is metadata included in test cases to facilitate automation and other processing.

Variable

Employed by the writer of a test assertion to refer to a value that is not known at the time the test assertion is written, but will be determined at some later stage, possibly as late as the middle of running a set of tests. It is also employed to enable several assertions to share a value (set once, used by many), like a variable in other technologies.

Appendix B. References

[CONF1] Conformance requirements for Specifications (OASIS, March 2002) see http://www.oasis-open.org/committees/download.php/305/conformance_requirements-v1.pdf

[CONF2] Conformance testing and Certification Framework (OASIS, Conformance TC, June 2001) see http://www.oasis-open.org/committees/download.php/309/testing_and_certification_framework.pdf

[TD] Test Development FAQ, WG note (W3C, 2005) see http://www.w3.org/QA/WG/2005/01/test-faq

[VAR] Variability in Specifications, WG note (W3C, 2005) see http://www.w3.org/TR/2005/NOTE-spec-variability-20050831/

[TMD] Test Metadata, QA Interest Group note, (W3C, September 2005) see http://www.w3.org/TR/2005/NOTE-test-metadata-20050914/

Appendix C. Prior Art

Numerous prior art examples exist for the structure and usage of test assertions.

Voting Systems Standard (EAC), (2007)

http://www.eac.gov/files/vvsg/Final-TGDC-VVSG-08312007.pdf

The use of targets and their categorization using classes and sub-classes was noted. Object oriented classification is an interesting technique for categorising test assertion targets, though it was considered that the treatment of target categorization in the present guidelines should take a broader scope.

Unisoft have published their own Glossary of Assertion Based Testing Terms, again for POSIX

http://www.unisoft.com/glossary.html

[See also DejaGnu Testing Framework below.]

The DejaGnu Testing Framework - A POSIX conforming test framework – is based on a use of test assertions

http://www.delorie.com/gnu/docs/dejagnu/dejagnu_6.html

This builds on the POSIX assertions definitions and of particular note is the analysis of outcome interpretations. The present guidelines do not give extensive coverage to this because it is considered to fit better with the domain of test suites where outcomes can be related to the knowledge of testing methods to be used. However, it is noted that test assertions may be used by some as a means of generating or authoring test suites and in these case special note may need to made of the various possibilities there may be in interpreting outcomes of tests based on a given test assertion.

Test assertions developed with a particular testing framework in mind include those developed by the WS-I for their web services profiles. For example for the Basic Profile version 1.1

http://www.ws-i.org/Testing/Tools/2005/01/BP11_TAD_1-1.htm

Similarly W3C publishes test suites based on test assertions for HTML and SOAP specifications:

HTML 4.01 Test Suite - Assertions (2002)

http://www.w3.org/MarkUp/Test/HTML401/current/assertions/assertions_toc.html

SOAP Version 1.2 Specification Assertions and Test Collection (2003)

http://www.w3.org/TR/soap12-testcollection/

The following documents are milestones in the development of the current thinking on test assertions as presented at a basic level in the present guidelines:

A Test Assertion Guideline draft was initiated within the OASIS Technical Advisory Board, (2004-2005)

http://www.oasis-open.org/committees/document.php?document_id=20661&wg_abbrev=ebxml-iic

Work in W3C lead to the QA Framework: Specification Guidelines (W3C, November 2004)

http://www.w3.org/TR/qaframe-spec/

A Test Assertion Guide was later drafted in W3C (W3C Editors' Draft, 2006)
http://www.w3.org/2006/03/test-assertion-guide

Other methodologies for the creation of test assertions or similar artefacts:

Constraint Languages have special relevance when defining test assertions for specifications involving specification normative statements which make use of standards such as XML Schemas and UML diagrams.

Object Constraint Language (OCL) and Unified Modeling Language (UML), Object Management Group, Inc.

http://www.omg.org/technology/documents/modeling_spec_catalog.htm#OCL

OCL is a formal constraint language used to define constraints for UML. It can have a special role in testing based on UML methodologies. It includes methods for defining preconditions and prerequisites as well as postconditions: There may be some overlap with test assertion prerequisites. Where a specification includes UML diagrams it may be useful to use OCL expressions within or in the place of test assertion predicates. Similarly XPath expressions may play a key role in predicates involving XML. In both of these special cases there may be good reason to specialize the structure of the test assertion to facilitate use of such expression languages.

Appendix D. Worked Example

Dummy Widget Specification 1.1

Worked Example 'Specification'

April 2008

...

Section 100

A widget MUST be of rectangular shape, as shown below.

<< diagram of widget showing basic rectangular shape >>

Fig 67

Section 101

A widget of medium size MUST use exactly one AA battery and have a red button on top (see below).

<< diagram of widget with battery and red button on top >>

Fig 68

The mechanisms by which the widget delivers its functionality is not subject to this specification.

Section 102

It is RECOMMENDED for a widget to be waterproof. If it is not waterproof then it MUST have a warning label stating that it is not waterproof.

Section 103

A widget MAY have a metallic casing. If it does have a metallic casing it MUST have a waterproof coating.

Section 104: Localizations of Widget Size

For implementations of widgets for use in the European Union a widget that weighs between 100g and 300g and is from 5 to 15 centimeters long in its longer dimension, is a medium-size widget. However, in USA the widget is medium-sized if it weighs between 4oz and 12oz and is from 2 inches to 6 inches long.

<< Table of widget sizes >>

Table 21

Test Assertions for Dummy Widget Specification 1.1

Example Test Assertions

June 2008

...

Test Assertions for Specification Sections 100 to 104

TA id: widget-TA100-1

Target: widget

Normative Source: specification requirement 100

Predicate: [the widget] is of rectangular shape

Prescription Level: mandatory

TA id: widget-TA101-1a

Target: medium-size widget

Normative Source: specification requirement 101, part 1

Predicate: [the widget] uses exactly one AA battery.

Prescription Level: mandatory

TA id: widget-TA101-1b

Target: medium-size widget

Normative Source: specification requirement 101, part 2

Predicate: [the widget] has a red button on top.

Prescription Level: mandatory

TA id: widget-TA102-1

Target: widget

Normative Source: specification statement 102, part 1

Predicate: [the widget] is waterproof.

Prescription Level: preferred

TA id: widget-TA102-2

Target: widget

Normative Source: specification statement 102, part 2

Prerequisite: (widget-TA102-1 = false)

Predicate: [the widget] has a label warning that it is not waterproof.

Prescription Level: mandatory

TA id: widget-TA103-1

Target: widget

Normative Source: specification statement 103, part 1

Predicate: [the widget] has a metallic casing.

Prescription Level: permitted

TA id: widget-TA103-2

Target: widget

Normative Source: specification statement 103, part 2

Prerequisite: widget-TA103-1

Predicate: [the widget] has a waterproof coating over its metallic casing.

Prescription Level: mandatory

TA id: widget-TA104-1

Target: widget

Normative Source: specification requirement 104

Predicate: [the widget] weighs between WEIGHT-A and WEIGHT-B.

Prescription Level: medium-sized:mandatory

TA id: widget-TA104-2

Target: widget

Normative Source: specification requirement 104

Predicate: [the widget] is from LENGTH-A to LENGTH-B long in its longer dimension.

Prescription Level: medium-sized:mandatory

Variable Scope for Localizations of Widget Sizes

The following variables apply to:

Test Assertion References:

widget-TA104-1

widget-TA104-2

Variable: 'GEOPOLITICAL-LOCATION' the geopolitical location of use of the widget, allowed values being strings enumerated in country code list ...

Variable: 'WEIGHT-A' a weight and its units. If GEOPOLITICAL-LOCATION is 'US' then WEIGHT-A is 4oz. If GEOPOLITICAL-LOCATION is 'EU' then WEIGHT-A is 100g.

Variable: 'WEIGHT-B' a weight and its units. If GEOPOLITICAL-LOCATION is 'US' then WEIGHT-B is 12oz. If GEOPOLITICAL-LOCATION is 'EU' then WEIGHT-B is 300g.

Variable: 'LENGTH-A' a length and its units. If GEOPOLITICAL-LOCATION is 'US' then LENGTH-A is 2 inches. If GEOPOLITICAL-LOCATION is 'EU' then LENGTH-B is 5cm.

Variable: 'LENGTH-B' a length and its units. If GEOPOLITICAL-LOCATION is 'US' then LENGTH-B is 6 inches. If GEOPOLITICAL-LOCATION is 'EU' then LENGTH-B is 15cm.