High Throughput Testing (HTT)

Overview of Pro-Test and Praxis

HTT Overview

High Throughput Testing (HTT) is a new technology which provides a solution to the problem of excessive test cases and/or poorly planned test case development.

HTT enables you to reduce the total number of test cases while ensuring a predetermined coverage level.

HTT Overview (cont.)

Many organizations which are currently responsible for testing have seen their requirements explode into an unmanageable number of test cases. As the total number of test cases has increased to an extraordinary number, they have been forced to choose a subset of all possible combinations.

The goal of HTT is to ensure all pairs test case coverage with a minimal number of test cases.

All Pairs Coverage

What does “All Pairs Coverage” mean?

In most testing scenarios you are given a set of factors (or variables) for which there can be more than one level (or value). For example, if your testing involves different Operating Systems, then the Factor would be “Operating System” and the levels might be “Windows NT”, “Windows 2000”, and “Windows XP”.

Other factors might include the amount of RAM, internet access type, and browser version.

All Pairs Coverage (cont.)

Assuming that we intend to test our line of business application using the factors and levels indicated in the table on the right, then it would be desirable to have at least one test case which includes every possible pair of test levels.

OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

All Pairs Coverage (cont.)

If all pairs are covered in our test cases, it indicates that if we pick **any** level in **any** factor (for example Netscape) then **at least one** test case will pair that level with all other possible levels.

OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

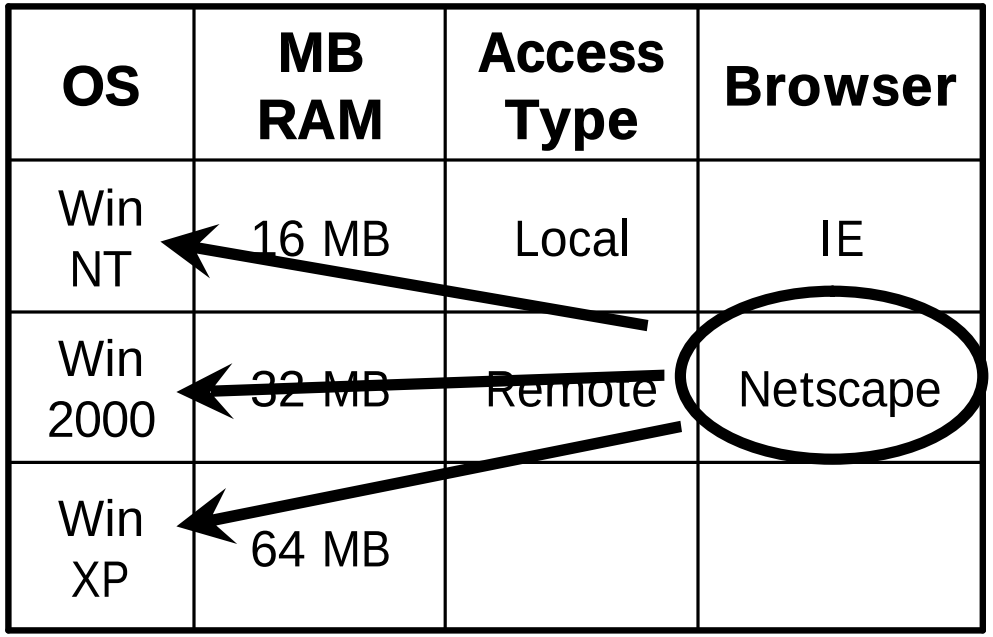
All Pairs Coverage (cont.)

Therefore, a test case must be created which pairs Netscape with Win NT.

OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

All Pairs Coverage (cont.)

Not only must Netscape be included with Windows NT in a test case, but another test case must also include Win 2000 and yet another test case must include Win XP.



OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

All Pairs Coverage (cont.)

Additionally, a test case must be included which pairs Netscape with 16 MB, another with 32 MB, and another with 64 MB.

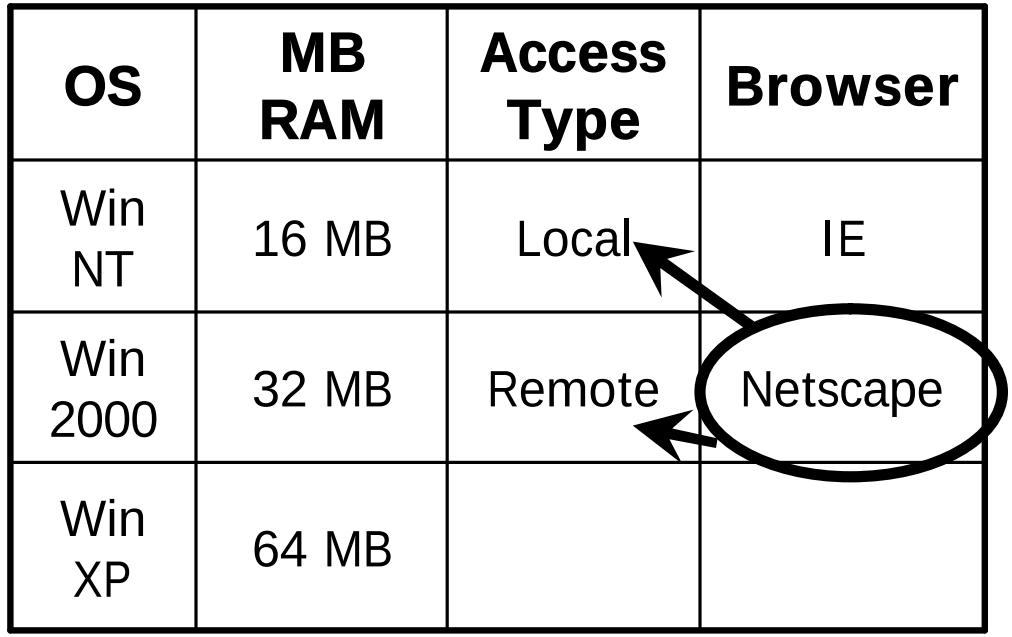
OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

All Pairs Coverage (cont.)

Finally, a test case must be included which pairs Netscape with Local access and another test case which pairs Netscape with Remote access.

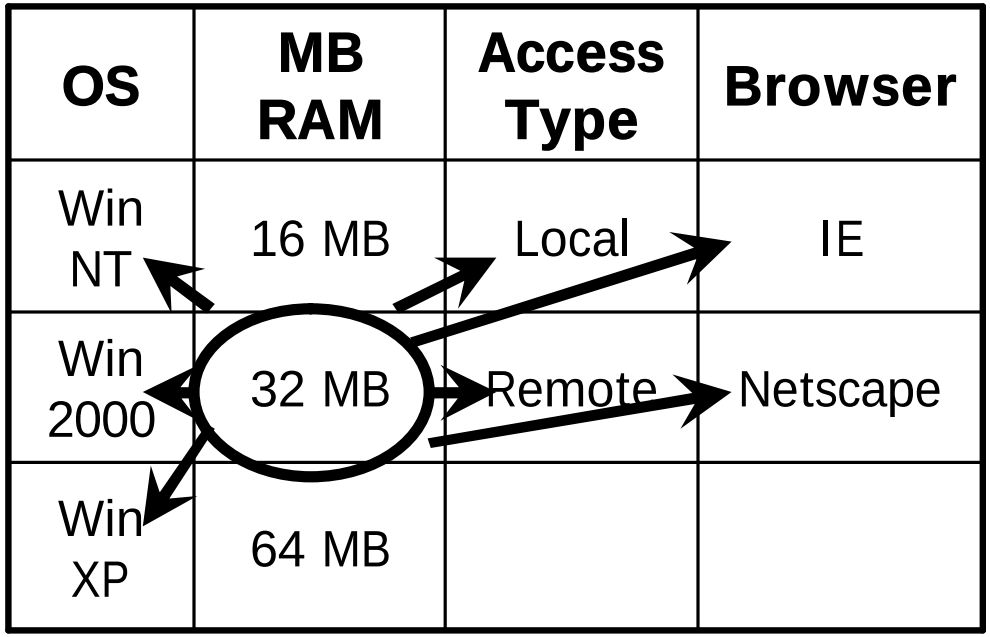
Note that Netscape has a total of 8 possible pairings, which are Win NT, Win 2000, Win XP, 16MB, 32MB, 64MB, Local, and Remote.

OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		



All Pairs Coverage (cont.)

If all pairs are covered by the test cases, that guarantees that no matter which level is picked a test case will cover ALL pairs of other levels. For example, if the level 32MB was chosen, then a test case must pair 32 MB with Win NT, Win 2000, Win XP, Local, Remote, IE, and Netscape.



How many test cases?

While all pairs coverage is certainly a desirable property, at first it seems cost prohibitive. However, in a single test case multiple pairs are being tested. For example, consider the following test case.

OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

	OS	MB RAM	Access Type	Browser
Test Case 1	Win2000	16MB	Local	Netscape

How many test cases?

In this single test case, there are a total of 6 pairs of levels which are tested.

1. Win 2000 with 16MB
2. Win 2000 with Local
3. Win 2000 with Netscape
4. 16MB with Local
5. 16MB with Netscape
6. Local with Netscape

	OS	MB RAM	Access Type	Browser
Test Case 1	Win2000	16MB	Local	Netscape

All Pairs Coverage

This allows all pairs to be tested in fewer test cases than one might think. The following nine test cases provide all pairs coverage.

#	OS	MB RAM	Access Type	Browser
1	Win 2000	64 MB	Local	IE
2	Win 2000	16 MB	Remote	Netscape
3	Win XP	16 MB	Local	IE
4	Win NT	32 MB	Remote	IE
5	Win XP	64 MB	Remote	Netscape
6	Win 2000	32 MB	Remote	IE
7	Win NT	16 MB	Remote	Netscape
8	Win XP	32 MB	Local	Netscape
9	Win NT	64 MB	Local	IE

Comparison With All Combinations

How does all pairs differ with all combinations?

The difference is easiest to see in a simple case. A simplified form of the previous example is shown to the right. Note that the factors all have 2 levels and MB RAM has been removed. This leaves us with 3 factors each at two levels.

OS	Access Type	Browser
Win NT	Local	IE
Win 2000	Remote	Netscape

Comparison With All Combinations

All pairs is shown on the left with all combinations shown on the right.

All Pairs in 4 test cases

#	OS	Access	Browser
1	WinNT	Local	Netscape
2	WinNT	Remote	IE
3	Win2000	Local	IE
4	Win2000	Remote	Netscape

All combinations in 8 test cases.

#	OS	Access	Browser
1	WinNT	Local	IE
2	WinNT	Local	Netscape
3	WinNT	Remote	IE
4	WinNT	Remote	Netscape
5	Win2000	Local	IE
6	Win2000	Local	Netscape
7	Win2000	Remote	IE
8	Win2000	Remote	Netscape

Comparison With All Combinations

Note that the all pairs test cases are a subset of the all combinations test cases.

All Pairs in 4 test cases

#	OS	Access	Browser
1	WinNT	Local	Netscape
2	WinNT	Remote	IE
3	Win2000	Local	IE
4	Win2000	Remote	Netscape

All combinations in 8 test cases.

#	OS	Access	Browser
1	WinNT	Local	IE
2	WinNT	Local	Netscape
3	WinNT	Remote	IE
4	WinNT	Remote	Netscape
5	Win2000	Local	IE
6	Win2000	Local	Netscape
7	Win2000	Remote	IE
8	Win2000	Remote	Netscape

Comparison With All Combinations

When you cover all combinations you are covering each pair more than once which increases the number of tests. In this example, each pair is covered twice.

All combinations in 8 test cases.

#	OS	Access	Browser
1	WinNT	Local	IE
2	WinNT	Local	Netscape
3	WinNT	Remote	IE
4	WinNT	Remote	Netscape
5	Win2000	Local	IE
6	Win2000	Local	Netscape
7	Win2000	Remote	IE
8	Win2000	Remote	Netscape

Comparison With All Combinations

If all combinations provides more coverage, then why not use it instead of all pairs?

As the number of factors and levels increases the number of test cases required for all combinations quickly becomes unmanageable. All pairs provides a manageable alternative to all combinations coverage.

Factors and levels	All Combinations	All Pairs
5 factors at 3 levels each	243	11
6 factors at 4 levels each	4096	23
7 factors at 6 levels each	279,936	56
10 factors at 7 levels each	282,475,249	89

Comparison With DOE Designs

As many organizations are currently engaged in some form of a Six Sigma initiative, the comparison of all pairs to DOE designs is inevitable.

The goal of an DOE design is to provide orthogonal estimates of each factor for the purposes of quantitative analysis such as least squares regression.

2^2 Full Factorial

#	A	B
1	-1	-1
2	-1	1
3	1	-1
4	1	1

Comparison With DOE Designs

If you have two factors which both have two levels the all pairs test cases would match the 2 Factor Full Factorial.

2^2 Full Factorial

#	A	B
1	-1	-1
2	-1	1
3	1	-1
4	1	1

Comparison With DOE Designs

If you extend the problem to have three factors at two levels, then the logical design to choose would be the 3 factor half factorial (or 2^{3-1} Fractional Factorial). Again, in this limited case all pairs and a DOE design create an identical solution.

2^{3-1} Fractional Factorial

#	A	B	C
1	-1	-1	1
2	-1	1	-1
3	1	-1	-1
4	1	1	1

Comparison With DOE Designs

However, that is where the similarity ends. If you add a fourth factor at two levels the DOE design approach forces you to choose an 8 run design or a 2^{4-1} Fractional Factorial. All pairs can be covered in just 5 test cases.

2^{4-1} Fractional Factorial

#	A	B	C	D
1	-1	-1	-1	-1
2	-1	-1	1	1
3	-1	1	-1	1
4	-1	1	1	-1
5	1	-1	-1	1
6	1	-1	1	-1
7	1	1	-1	-1
8	1	1	1	1

All Pairs Test Cases

#	A	B	C	D
1	-1	1	1	-1
2	1	-1	1	-1
3	-1	-1	-1	1
4	1	1	-1	-1
5	1	1	1	1

Comparison With DOE Designs

The most significant weakness of DOE designs doesn't lie in their increase in testing requirements but rather in how they are created. Almost all designs assume all factors have exactly two or three levels. In actual practice, this is rarely if ever the case.

If we return to our original example, there is no DOE design (other than all combinations) which can handle the mixed number of levels in this design.

OS	MB RAM	Access Type	Browser
Win NT	16 MB	Local	IE
Win 2000	32 MB	Remote	Netscape
Win XP	64 MB		

Comparison With DOE Designs

Summary of differences between HTT and DOE designs.

	HTT	DOE Designs
All factors at two or three levels	**Yes**	**Yes**
Mixed levels for each factor	**Yes**	No
Minimum number of cases for all pairs	**Yes**	No
Compatible with constraints*	**Yes**	No
Compatible with previous test *	**Yes**	No

* For more information about constraints and previous test see http://www.sigmazone.com/protest_features.htm.

Creating All Pairs Test Cases

The creation of all pairs test cases is a complex numerical problem which has been solved using complex optimization algorithms and heuristics. Digital Computations offers two solutions to help with your HTT requirements.

Pro-Test – A Windows based software package that will handle light duty HTT implementations.

Praxis ™ – A new service in which we can customize the test cases to meet your specific requirements.

Pro-Test

Pro-Test v 1.0 is a Windows based stand-alone application that can generate simple all pairs solutions. Pro-Test's features include:

- Implements HTT to generate all pairs coverage
- Each factor can have a different number of levels
- Generate test cases while considering constraints
- Account for previous test
- Export test cases in a variety of formats including XML, Excel, and HTML

For more information on Pro-Test see http://www.sigmazone.com/protest.htm.

Praxis™

Praxis is a new service-based HTT solution. Praxis offers a custom application of HTT to your problem based upon your specific needs. Examples of what Praxis can do in addition to Pro-Test include:

- One-on-one interaction with an HTT consultant to help you get started.
- Regression test cases which account for previous all pairs tests which were completed.
- Ability to influence the number of times each pair is covered.
- Post-testing follow up to determine which pair actually failed, provided a test case has failed.
- Metrics which include the number of times each pair or three way combination has been covered.
- Partial or complete three way combination test coverage.
- Minimal number of test to provide double coverage of all pairs.
- Much more...

For more information about Praxis please contact sales@sigmazone.com.

HTT Overview

www.SigmaZone.com