Model-Based Quality Assurance of The SMB2 Protocol Documentation

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Microsoft Protocol Documentation

- Part of the company's interoperability initiative
  - Principles http://www.microsoft.com/interop/principles
- Addresses compliance requirements
- Publicly available
  - http://msdn2.microsoft.com/en-us/library/cc216514.aspx

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Protocol Engineering Team

- Quality assurance of protocol documentation
  - Ensure accuracy and usability
- Unique challenge
  - Testing documents (not software)
  - Volume
    - 250+ protocols in Windows alone (25,000+ pages of documentation)
      - Scope is extending (Office, .Net, …)
- Requires innovative methods and tools

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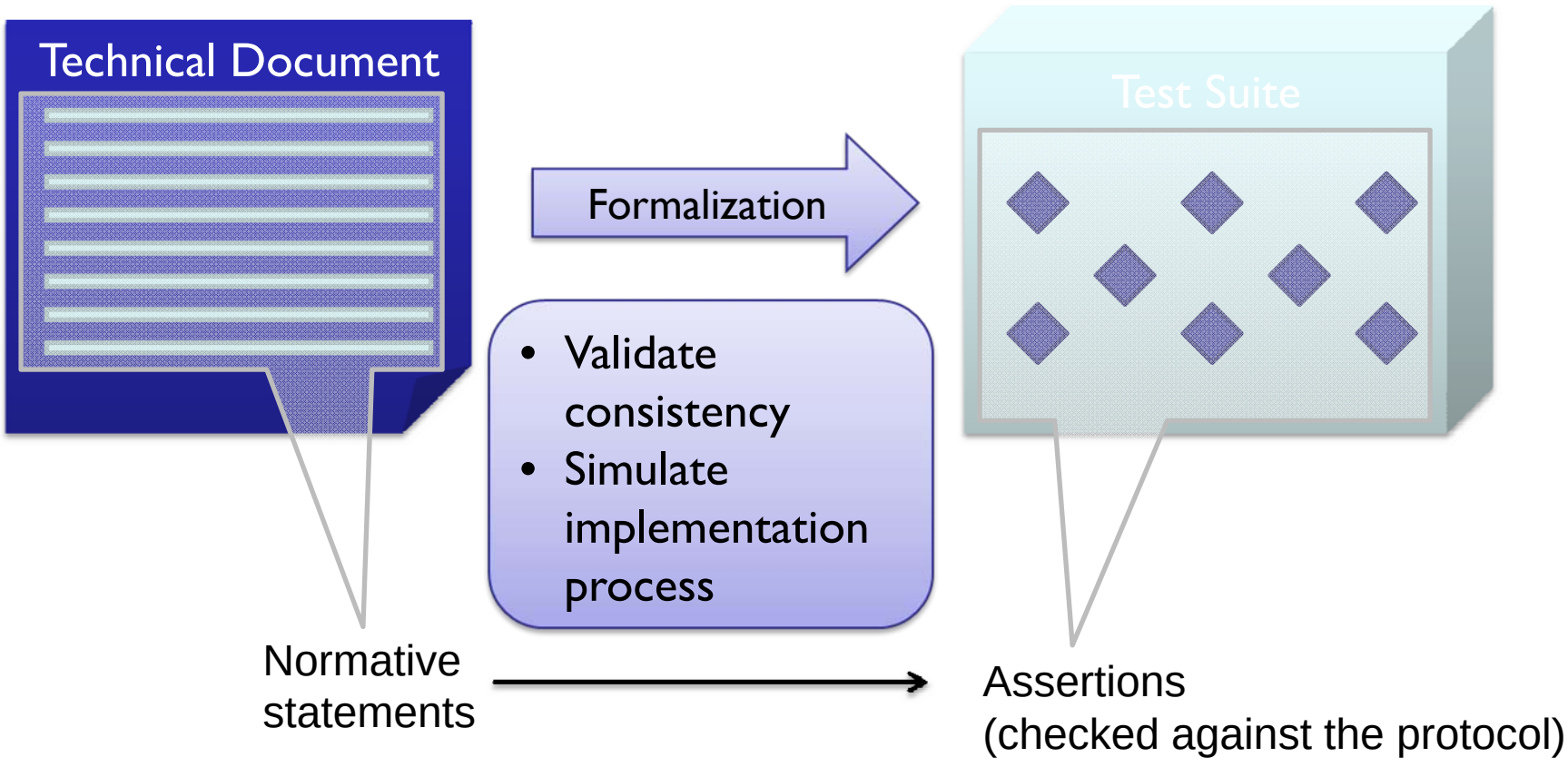
Test-Driven Document Analysis



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Document Testing Approach

Developing model and test suite

- From technical document (TD) alone
- Black box
  - Only data on the wire is controlled and observed
- Clean-room approach
  - ~300 vendors in China and India
  - No previous knowledge of implementation details
  - ~50 Microsoft employees
    - Management and tools infrastructure

Ensures:

- ✓ Usability of document
  - Simulates protocol development conditions
- ✓ Accuracy of document
  - Discovers discrepancy between document and implementation

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Out of Scope

- Exhaustive implementation testing
- Stress/performance testing
- Certification testing
- Documentation completeness testing
- Client behavior testing

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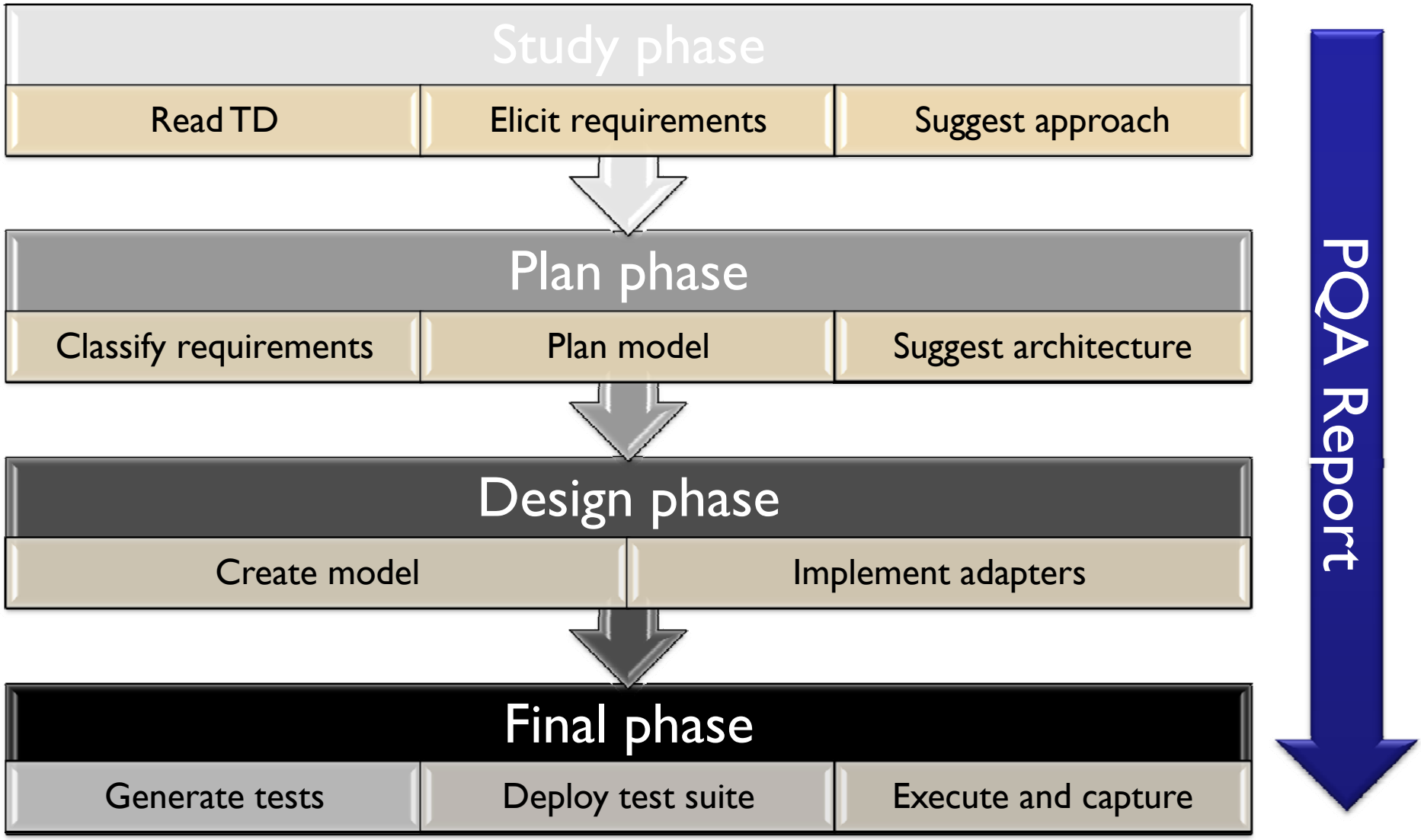
Document Testing Process



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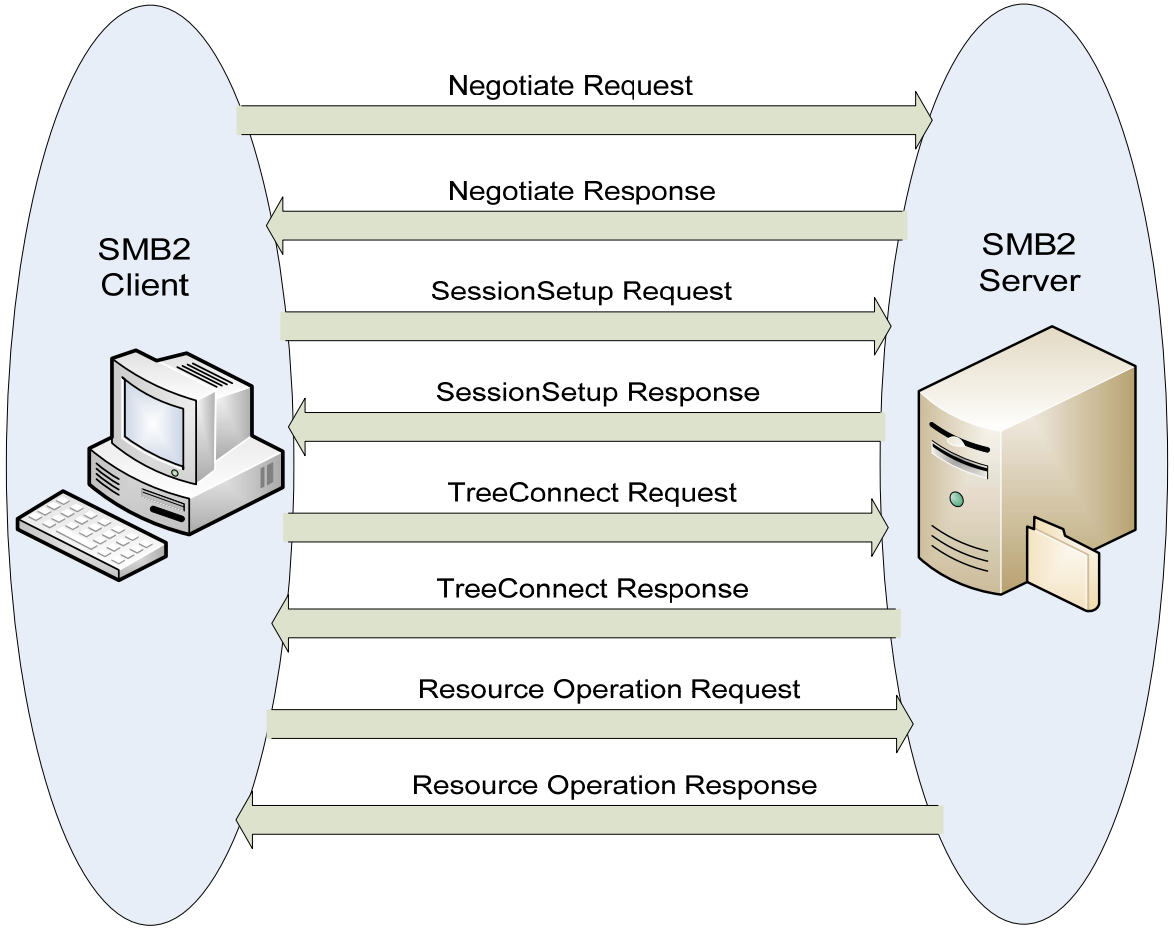
Running Example: SMB2
Server Message Block Version 2



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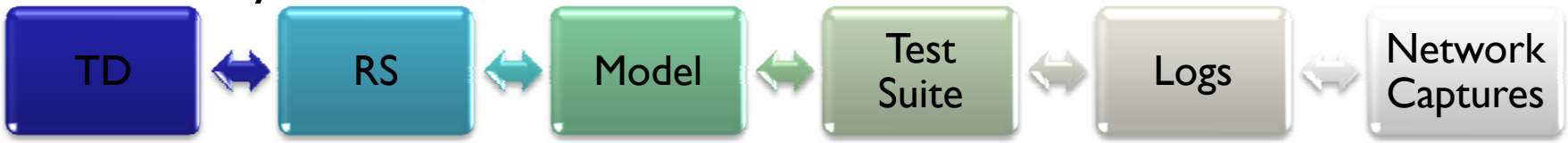
Requirements

- Gathered from TD alone
  - Gatherers are not expert in the particular protocol
    - Windows-specific behavior listed as separate requirements
- Predefined template and guidelines for
  - Identifying requirements (statements) in the TD
  - Classifying them according to
    - verifiability criteria
    - verification strategy (test suite, adapter)
- Requirements Specification (RS)
  - Reviewed by independent reviewers
  - Main input for model design
- Traceability



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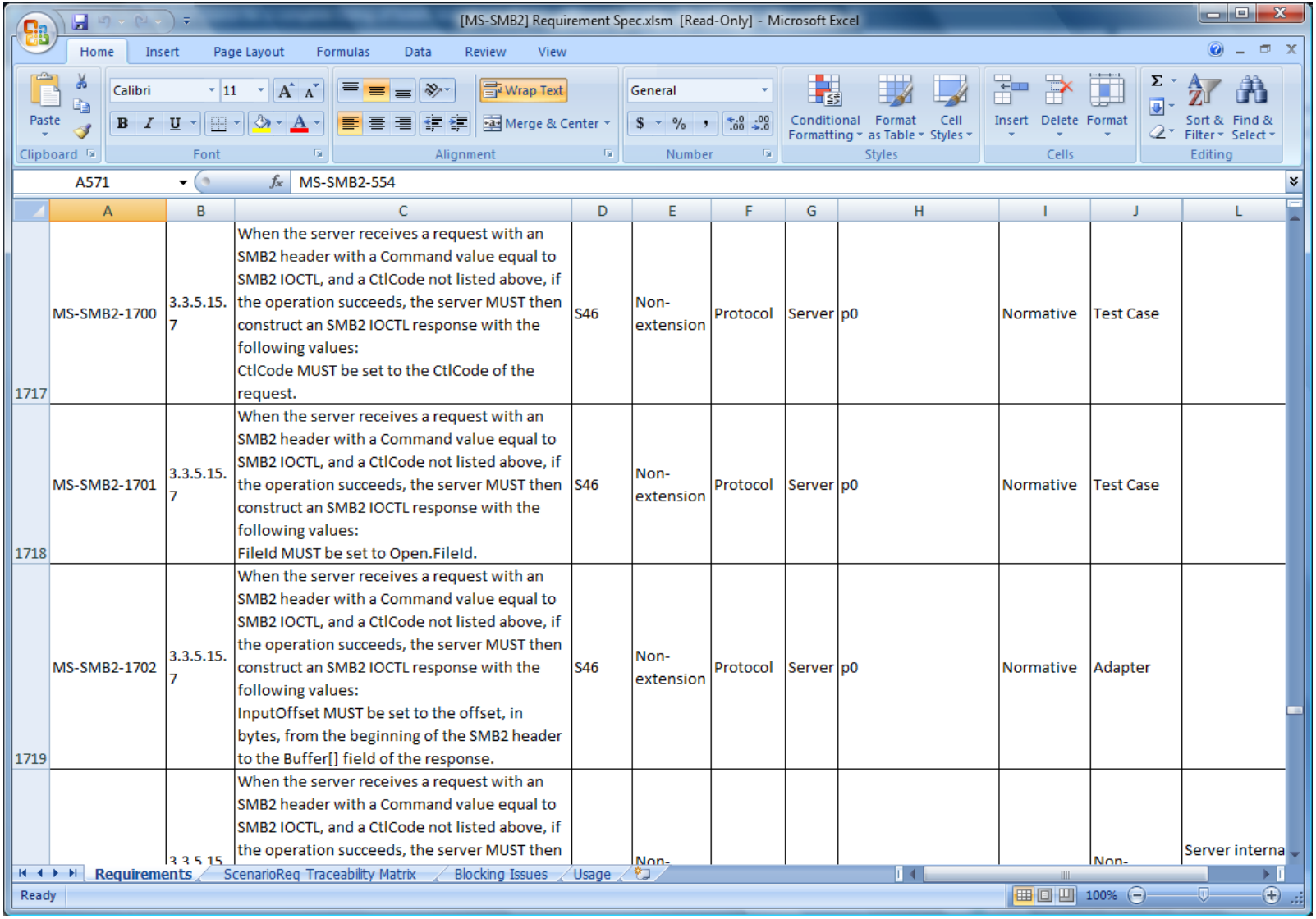
Requirement Spec: SMB2



	A	B	C	D	E	F	G	H	I	J	L
1717	MS-SMB2-1700	3.3.5.15.7	When the server receives a request with an SMB2 header with a Command value equal to SMB2 IOCTL, and a CtlCode not listed above, if the operation succeeds, the server MUST then construct an SMB2 IOCTL response with the following values: CtlCode MUST be set to the CtlCode of the request.	S46	Non-extension	Protocol	Server	p0	Normative	Test Case	
1718	MS-SMB2-1701	3.3.5.15.7	When the server receives a request with an SMB2 header with a Command value equal to SMB2 IOCTL, and a CtlCode not listed above, if the operation succeeds, the server MUST then construct an SMB2 IOCTL response with the following values: FileId MUST be set to Open.FileId.	S46	Non-extension	Protocol	Server	p0	Normative	Test Case	
1719	MS-SMB2-1702	3.3.5.15.7	When the server receives a request with an SMB2 header with a Command value equal to SMB2 IOCTL, and a CtlCode not listed above, if the operation succeeds, the server MUST then construct an SMB2 IOCTL response with the following values: InputOffset MUST be set to the offset, in bytes, from the beginning of the SMB2 header to the Buffer[] field of the response.	S46	Non-extension	Protocol	Server	p0	Normative	Adapter	
		3.3.5.15	When the server receives a request with an SMB2 header with a Command value equal to SMB2 IOCTL, and a CtlCode not listed above, if the operation succeeds, the server MUST then		Non-						Server interna

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Protocol Quality Assurance Report (PQAR)

- Template-based document
- Incrementally produced
- Central point of documentation of progress
- After finalization, turns into test suite documentation for sustained engineering

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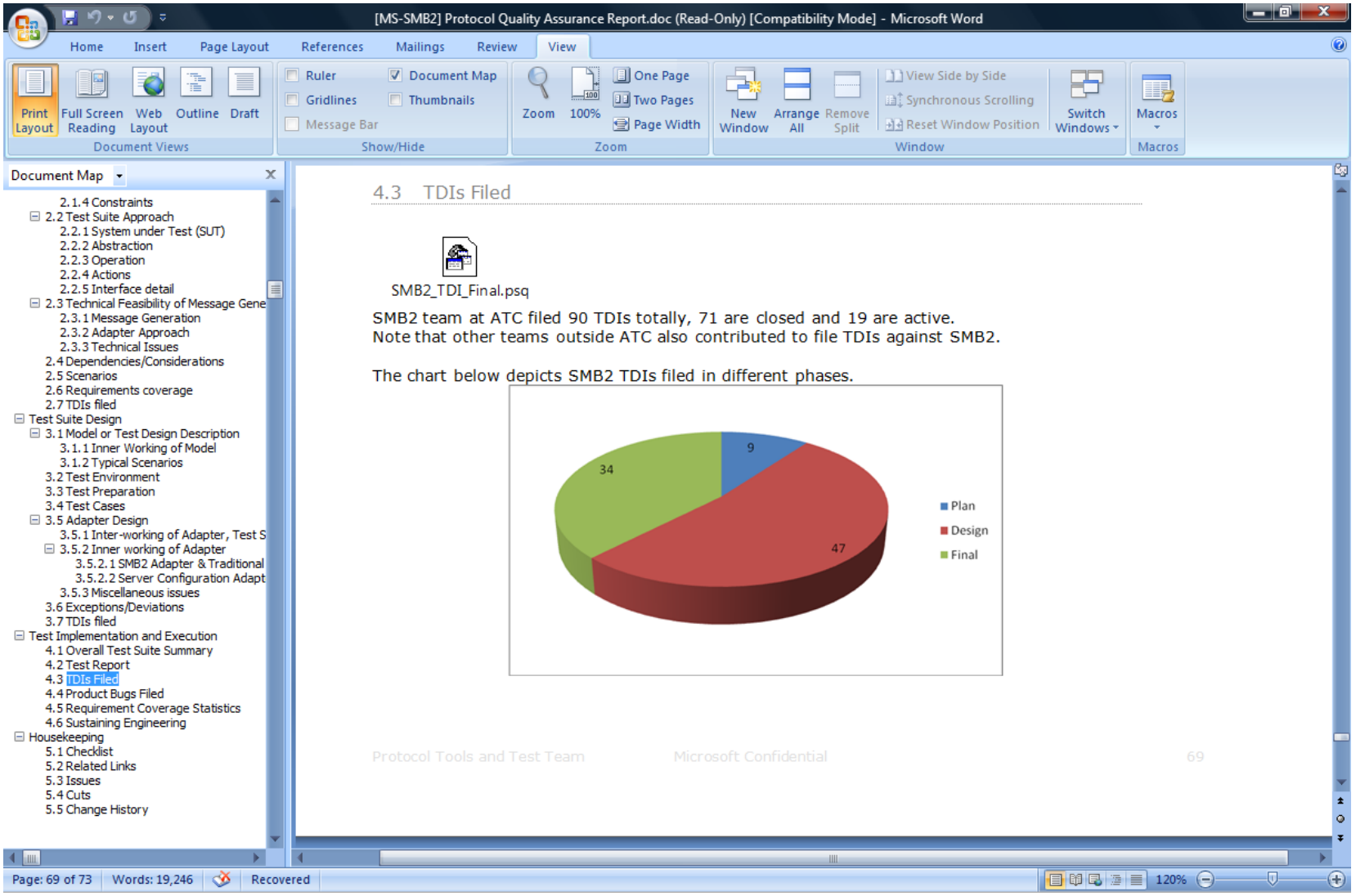
PQAR: SMB2



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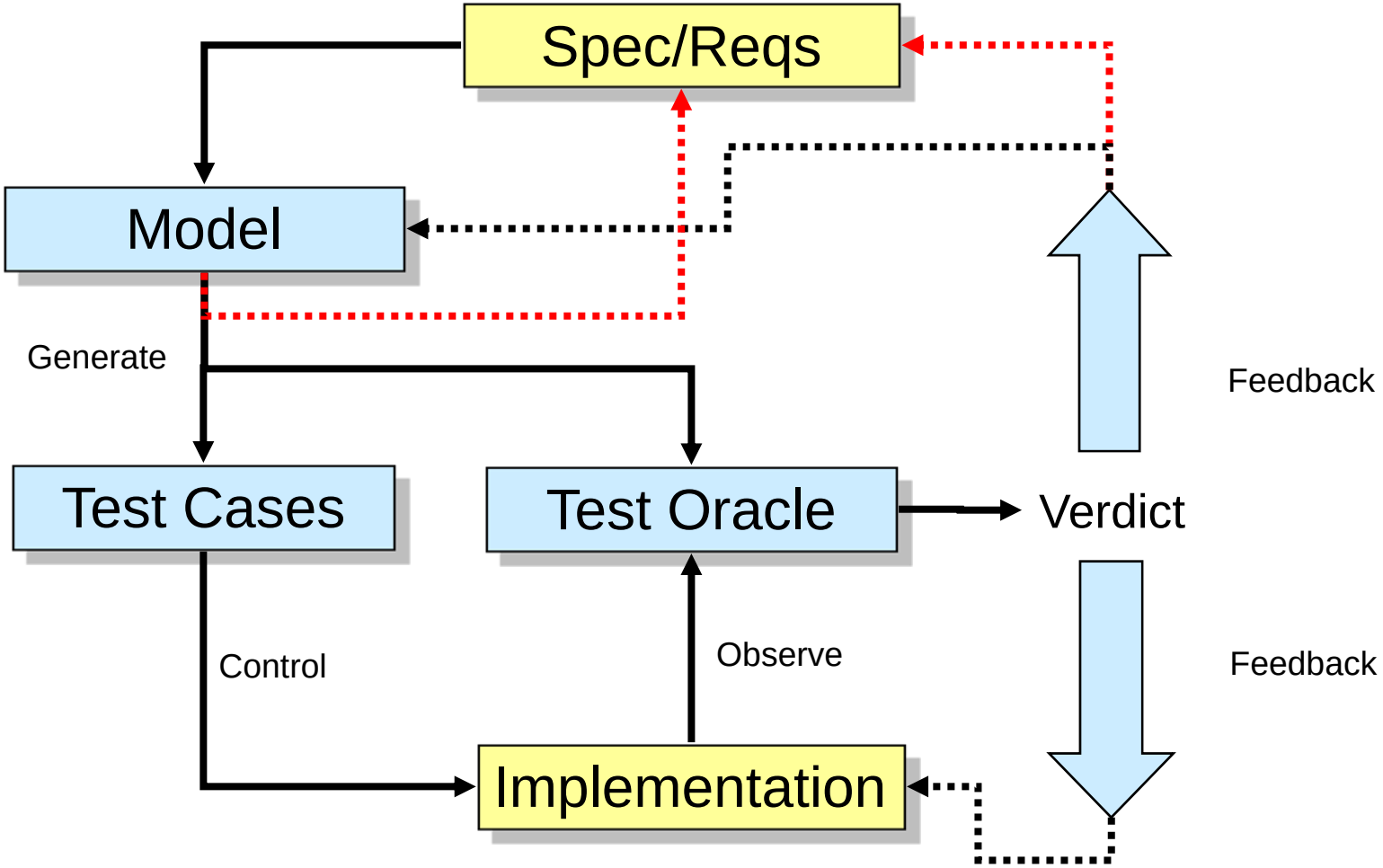
Model-based testing (MBT)

A "light-weight" formal method



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MBT Technology: Spec Explorer 2007

- Mature technology from Microsoft Research
  - First version, 2002
- Multiple modeling styles and languages
  - Programs, patterns, diagrams
- State machine extraction from model program
- Data generation (pairwise combinations, stochastic selection, etc.)
- Test code generation from state machine
- Model composition
- IDE integration

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Test Representation

- Problem: getting data on the wire and back
  - Known problem for protocol testing
  - E.g. TTCN-3
- Our solution: extension to Visual Studio Test Framework
  - Unit tests: concise test case representation
  - Test adapters written in a managed language (C#)
- Protocol Test Framework (PTF)
  - Custom support for dealing with protocols
  - Automatic data packet (de)serialization
    - Based on declarative definitions
  - Protocol-specific logging capacity (beacon packets)

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Adapter interface: SMB2


```
public interface ISmb2SetupAdapter : IAdapter
{
    void AssumeShareExists(int shareId, ShareType type);
    void AssumeShareDoesNotExist(int shareId);
   …
}

public interface ISmb2Adapter : IAdapter
{
   void TreeConnectRequest(
     int relativeMessageId,
     int creditRequest, int shareId);
   event TreeConnectResponseHandler TreeConnectResponse;
   …
}

public delegate void TreeConnectResponseHandler(int relativeMessageId,
    int creditResponse, int treeId, ShareType shareType);
```

- Methods represent stimuli (test *control*)
- Events represent responses (*test observation*)

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Contract Model Program: SMB2


```
…
static SetContainer<int> fileIds;
static int fileIdsInFlight;
static SequenceContainer<Request> inflight;
…

[Action]
static void CreateRequest(int sequenceId, int creditRequest,
                          [Domain("OpenTreeDomain")]int treeId,
                          CreateType disposition,
                          [Domain("FileNameDomain")]string fileName)
{
  Contracts.Requires(fileIds.Count - fileIdsInFlight > 0);
  CheckRequest(sequenceId, creditRequest);
  inflight.Add(new CreateRequest(sequenceId, treeId, disposition, fileName));
  fileIdsInFlight++;
}
```

- Uses rich (infinite) model state
- Exploration slices an FSM

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Test Selection: SMB2


```
machine StateMachine() : Actions
{
   construct model program from Actions where namespace = "SMB2.Model"
            // construct contract model from C#
}

machine AllSync() : Actions
{
   // compose contract model with test purpose
   (   AssumeShareExists(1, ShareType.DISK);     // assume one share
       SetupConnectionAndSession(1);             // setup session (window=1)
       ...                                       // wildcard from here
   )
   || StateMachine
}

machine TestsForAllSync() : Actions
{
    // construct test cases
   construct test cases where strategy = "longtests" for AllSync
}
```


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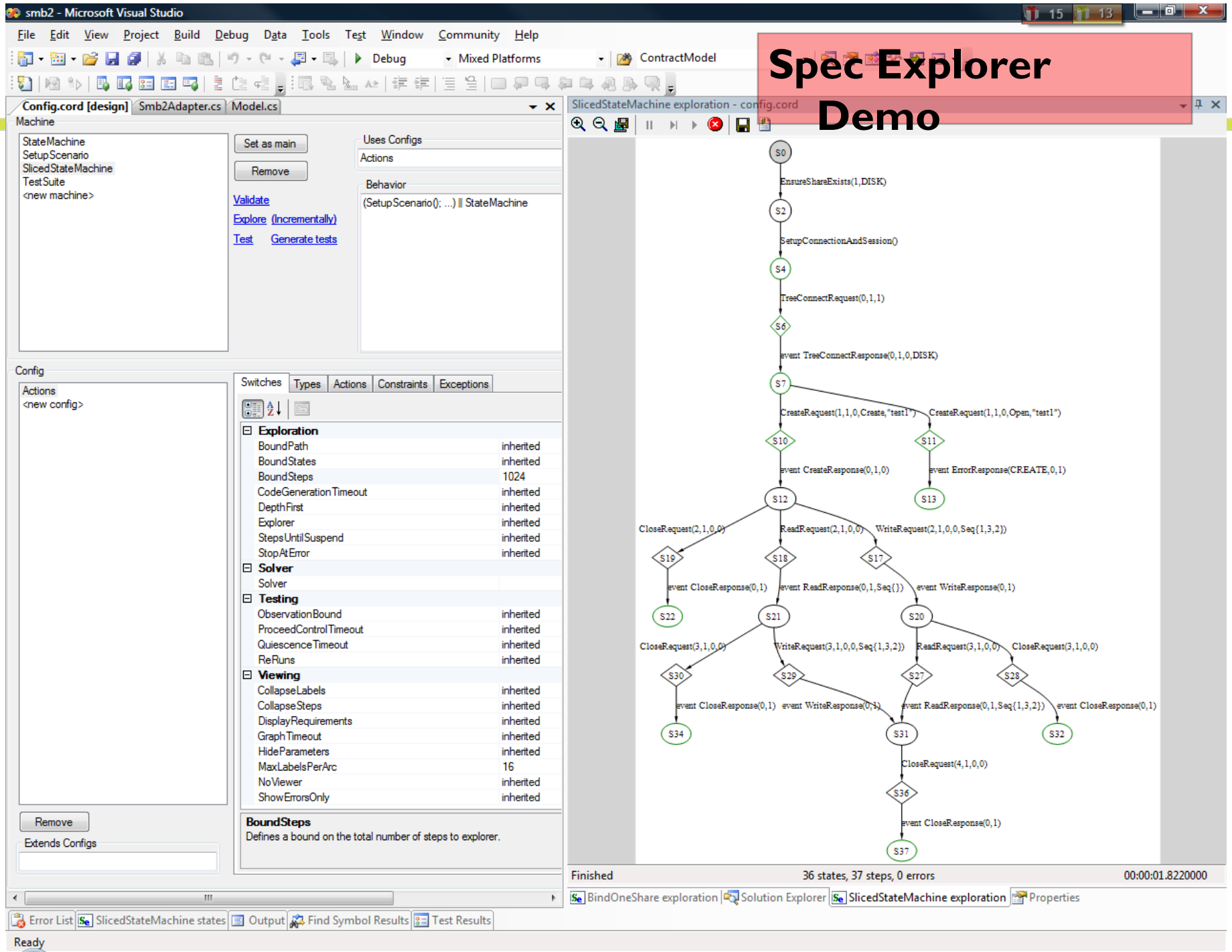
smb2 - Microsoft Visual Studio
File Edit View Project Build Debug Data Tools Test Window Community Help
Debug
Mixed Platforms
ContractModel
Spec Explorer Demo
Config.cord [design]
Smb2Adapter.cs
Model.cs
Machine
StateMachine
SetupScenario
SlicedStateMachine
TestSuite
<new machine>
Set as main
Remove
Validate
Explore (Incrementally)
Test
Generate tests
Uses Configs
Actions
Behavior
(SetupScenario(); ...) || StateMachine
Config
Actions
<new config>
Switches
Types
Actions
Constraints
Exceptions
Exploration
BoundPath inherited
BoundStates inherited
BoundSteps 1024
CodeGenerationTimeout inherited
DepthFirst inherited
Explorer inherited
StepsUntilSuspend inherited
StopAtError inherited
Solver
Solver
Testing
ObservationBound inherited
ProceedControlTimeout inherited
QuiescenceTimeout inherited
ReRuns inherited
Viewing
CollapseLabels inherited
CollapseSteps inherited
DisplayRequirements inherited
GraphTimeout inherited
HideParameters inherited
MaxLabelsPerArc 16
NoViewer inherited
ShowErrorsOnly inherited
Remove
Extends Configs
BoundSteps
Defines a bound on the total number of steps to explorer.
SlicedStateMachine exploration - config.cord
S0
EnsureShareExists(1,DISK)
S2
SetupConnectionAndSession()
S4
TreeConnectRequest(0,1,1)
S6
event TreeConnectResponse(0,1,0,DISK)
S7
CreateRequest(1,1,0,Create,"test1")
CreateRequest(1,1,0,Open,"test1")
S10
S11
event CreateResponse(0,1,0)
event ErrorResponse(CREATE,0,1)
S12
S13
CloseRequest(2,1,0,0)
ReadRequest(2,1,0,0)
WriteRequest(2,1,0,0,Seq{1,3,2})
S19
S18
S17
event CloseResponse(0,1)
event ReadResponse(0,1,Seq{})
event WriteResponse(0,1)
S22
S21
S20
CloseRequest(3,1,0,0)
WriteRequest(3,1,0,0,Seq{1,3,2})
ReadRequest(3,1,0,0)
CloseRequest(3,1,0,0)
S30
S29
S27
S28
event CloseResponse(0,1)
event WriteResponse(0,1)
event ReadResponse(0,1,Seq{1,3,2})
event CloseResponse(0,1)
S34
S31
S32
CloseRequest(4,1,0,0)
S36
event CloseResponse(0,1)
S37
Finished
36 states, 37 steps, 0 errors
00:00:01.8220000
BindOneShare exploration
Solution Explorer
SlicedStateMachine exploration
Properties
Error List
SlicedStateMachine states
Output
Find Symbol Results
Test Results
Ready

Conclusions

- Our process provides confidence in document quality
  - But: testing can only prove the presence of errors!
- Using advanced technologies and processes
  - Driving the state of the art in the area
  - Proof that MBT scales in industry testing
- Making technologies available to the community
  - Various publications
  - Network Monitor freely released
  - Spec Explorer to follow

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The End (Thanks!)

Q&A

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