Introduction to SW Test Automation

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Objectives

- Introduce the basic concepts of SW test automation
- Focus on automating test execution

Prerequisites

- Familiarity with SW testing

Notes

- Ask any time.
- Turn your cell silent.

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References

- Software Test Automation: Effective use of test execution tools

- The Automated Testing Handbook

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Outline

- Introduction
- Test Automation Process
- Test Automation Frameworks
- Test Tools
- More about Test Scripting
- Maintainable tests
- Metrics
- Automation Issues

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Test Automation

- Activities and efforts that intend to automate engineering tasks and operations in a software test process using well-defined strategies and systematic solutions.

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Why Test Automation?

- Run existing (regression) tests on a new version of a program.
- Run more tests more often.
- Perform tests which would be difficult or impossible to do manually.
- Better use of resources
- Consistency and repeatability of tests
- Earlier time to market
- Increased confidence

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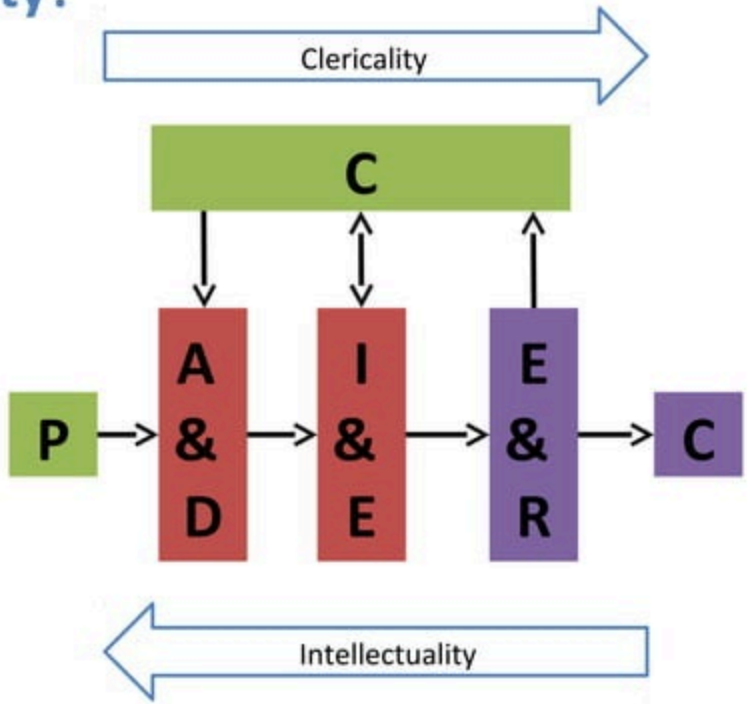
What to Automate; Intellectuality or Clericality?



Testing and Test Automation

Testing

- Application expertise
- What to test
- Test cases

Test Automation

- Development expertise
- How to test
- Test scripts

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Test Automation Myth: It is Simple, Everyone can do It

- Promoted by the sales people
  - Record the script
  - Enhance the script with few steps
  - Run and report with a button click
- Under this influence, test managers think proudly that al their team members are doing automation.

Test Automation Truth: It is a SW Development Task

- It should be designed, developed and tested.
- Needs strong programming background in most cases
- Test automation are ass[illegible] SW development assets.

Test Automation Myth: Commercial Tools are Expensive

- Companies tend to build their own tools using scripting languages (Perl and Python).
- Questionable tool quality
- Poorly estimated costs
- No standardization

Test Automation Truth: They are Not!

- Tester cost ~ $100K/year including overheads to use tool
- Tool license ~ $8K/5 years = $1.6K/year
- Average tool support fees ~ $1.6K/year
- Total tool cost = $3.2K/year

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Test Automation does not Replace Manual Testing

- Volatile SW, rare tests, impossible to verify automatically tests or tests that require interaction
- Manual tests find more defects than automated tests.
- Quality of tests (How does the automated test reported its success/failure?)
- Test automation does not improve effectiveness.
- Test automation may limit SW development.
- Tools have no imagination.

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Why does Test Automation Fail?

- Unrealistic expectations
- Poor testing practice (Automating chaos just gives faster chaos.)
- Expectation that automated tests will find a lot of new defects.
- False sense of security.
- Maintenance of automated tests.
- Technical problems (Automation tool is a SW. Also tested SW might not be testable.)
- Organizational issues (Support, champions, licensing ...)

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Test Automation Process

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Automation Objective

- Answer this question with numbers *"Why to automate?"*

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Feasibility

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Scope

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Classical Return on Investment (ROI)

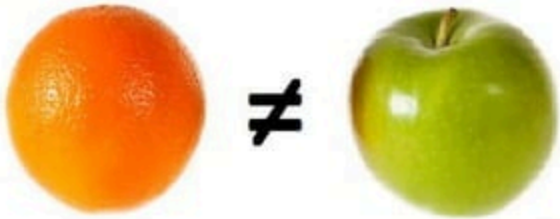
Return on Investment Calculator for Test Automation

	Manual Testing	Automated testing
Cost to design test cases	$6000	$6000
Cost of tool		$5000
Cost to implement automation of test cases		$11000
Total costs of automation		$16000
Cost to execute a full cycle of test cases (tester effort)	$5000	$1000
Number of cycles per release	3	3
Cost of testing per release	$21000	$9000
Saving per release		$12000
Releases per year	4	4
Benefit per year		$48000
Saving per year (benefit - investment in automation)		$32000
ROI (benefit/investment)		2 times (200%)

Problems w/ Previous ROI Calculation

- We are comparing an apple to an orange.
  - Manual and automated testing are really different.
  - They give different information.

- Cost of multiple execution of automated tests vs. manual tests cant be compared.
  - You would r s manually.



Real ROI

- ROI can be calculated as Total benefit derived from automation / Total cost of automation.

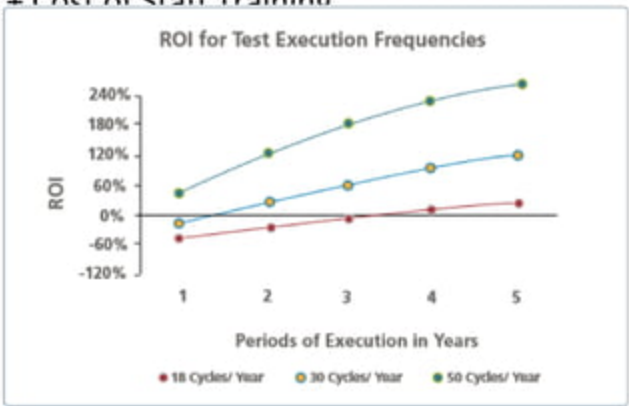
Drivers	Direct Benefits	Indirect Benefits
People	Savings in staffing costs due to efficient redeployment of workforce	Motivated workforce, increased customer satisfaction
Process	Savings in testing lifecycle costs due to reduced execution time	Enhanced process efficiency, innovations
Technology	Improved productivity due to additional test cycles within a given schedule	Lower application lifecycle costs resulting from improved product quality

Drivers	One Time Costs	Recurring Costs
People	• Cost of training staff on automation tools • Staffing costs for automation script development	Staffing costs for automation script maintenance
Process	• Costs for establishing new processes (workflow,configuration management, process management, etc.)	Not Applicable
Technology	• Cost of hardware and software • Licenses for automation	Cost of maintaining hardware and automation software

Test Execution Automation ROI

- Benefit/Execution Cycle = Manual Execution Time – Automation Execution Time

- Automation Cost = Cost of HW and SW + Cost of Scripts Development and Maintenance + Cost of Staff Training



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Automation Framework

- A set of assumptions, concepts and tools that provide support for automated software testing.
- A reusable set of libraries or classes for a software system (or subsystem)
- A correctly implemented test automation framework can further improve ROI by reducing the development and maintenance costs.

Automation Frameworks Evolution

Buy or Make Decision?

There is no single best testing tool; rather, different tools are more or less appropriate in different environments.

Scripts and Data

Scripted w/ low effort but maintained @high cost

1 Script = 1 Test Case
Testers need to know scripting

Scripted w/ high effort but maintained @ low cost

1 Script = Many test cases
Testers need not to know scripting

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Test Suites

- Grouping of related tests related, either by their function or by the area of the application they impact

- All tests in a suite should share the same beginning and ending context, to allow suite packaging.

- Test suite documentation should include:
  - Tests
  - Sequence
  - Context
  - Data
  - Suite dependencies

Execution Cycles

- Different cycles: normal, fix cycle or regression cycle

- Each cycle should consider:
  - Setup; automatically by the cycle or manually by human intervention
  - Context; all suite should share the same beginning and ending context
  - Sequence scheduling
  - Cleanup ; any housekeeping tasks (removing temp files; backups ...)

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Test Execution and Maintenance

- Ideally, no humans involved.

- Documented through test logs and error logs automatically
  - Test logs (test cases status, performance statistics, configurations tested and totals)
  - Error logs (failed tests and scripts, application states and diagnostic data)

- Analyzing logs is necessary to verify their accuracy and there are no:
  - False failures (test environment, application change or test error)
  - Duplicate failures
  - False passes (test error or missed errors)

- Analysis result may fire maintenance activities for scripts and data if any.

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C/C's of a Good Test Automation Framework

- Script-less representation of automated tests (shortens learning curve of tester and visualizes tests for better understanding)
- Data-driven ability for quick and large test data manipulation.
  - Must interface to spreadsheets and databases
- Concise reporting to ease scripts debugging and results verification
- Correctly coupled to application (tightly or loosely coupled?)

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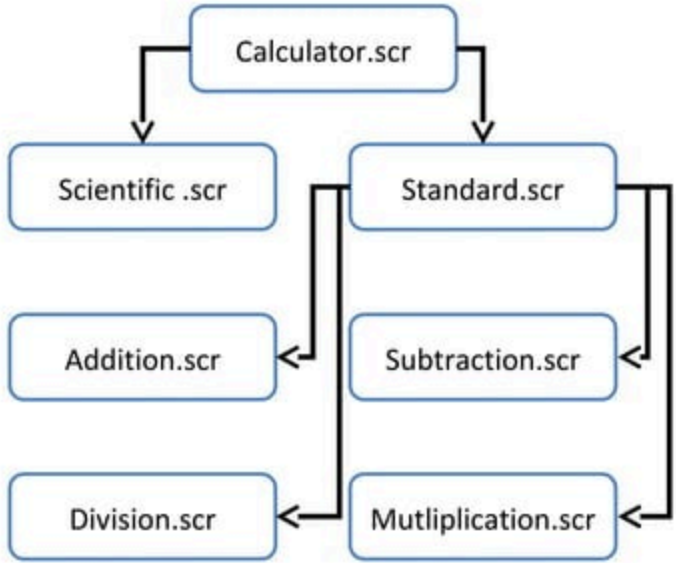
Modular Testing Framework

- Creation of small independent scripts
- Scripts are used to construct larger tests and scenarios.
- Suitable for automation of large stable applications

Modular Testing Framework Example



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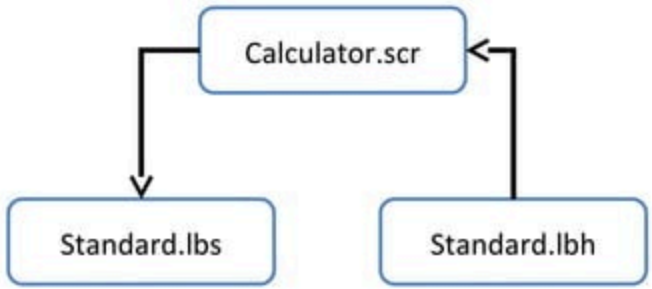
Test Library Framework

- Creation of procedures and functions instead of scripts

- Suitable for automation of small to medium stable applications



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Data-Driven Framework

- Test data are read from data files.
- Data is loaded into variables in the coded script.
- Allows quick execution of large number of scripts
- Suitable for applications under development

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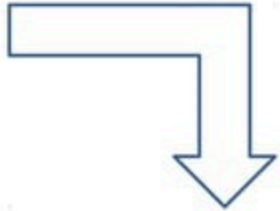
Data-Driven Framework Example

After recording script once; data can be extracted into a data pool then extended by various set of data to increase the tests of payment information.



Credit Card Number	Expiration Date	Order
1111222233334444	12/2005	Yes
1111222233334444	1/2005	Yes
1111222233334444	13/2005	Yes
1111222233334444	0/2005	Yes

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Keyword or Table – Driven Framework

- Application independent
- Building action and keywords independent of the automation tool
- Suitable for small applications

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Keyword or Table – Driven Framework cont'd

Keywords & data

Test automation code

Test automation framework

Automated test cases

Keyword or Table – Driven Framework Example

Window	Control	Action	Arguments
Calculator	Menu		View, Standard
Calculator	PushButton	Click	1
Calculator	PushButton	Click	+
Calculator	PushButton	Click	3
Calculator	PushButton	Click	=
Calculator		Verify Result	4
Calculator		Clear	
Calculator	PushButton	Click	6
Calculator	PushButton	Click	-
Calculator	PushButton	Click	3
Calculator	PushButton	Click	=
Calculator		Verify Result	3

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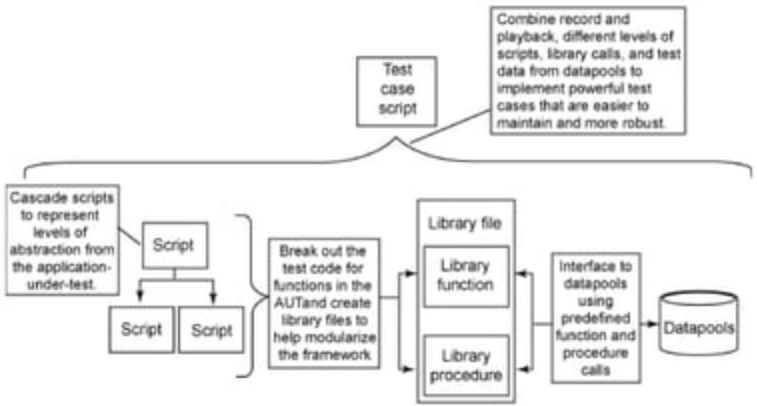
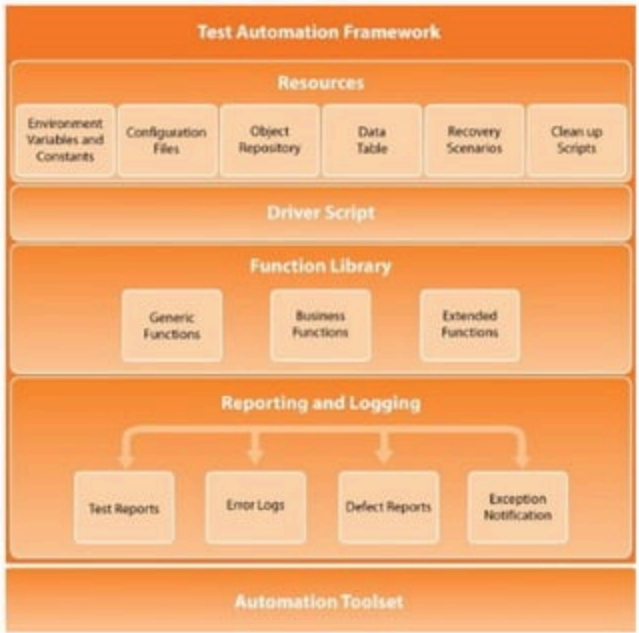
Hybrid Framework

- Most commonly implemented combining the best of all frameworks



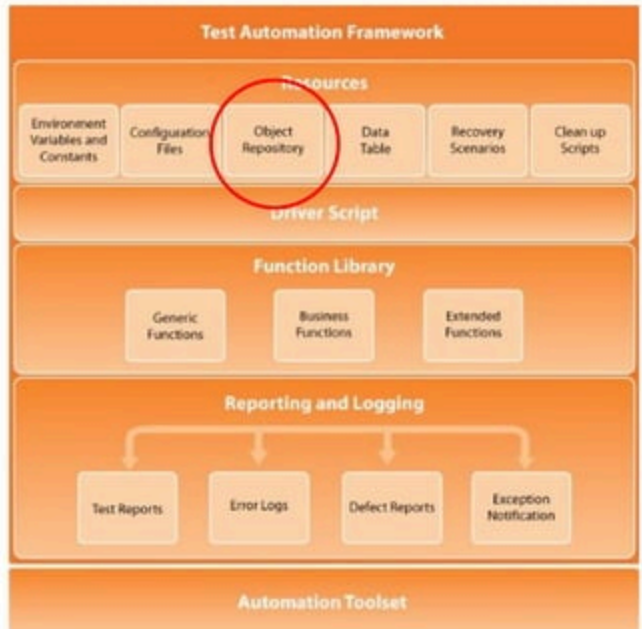
- Suitable for medium and large applications with long shelf life

Elements of a Well Designed Automation Framework



Object Repository

- Object Repository contains objects for GUI based testing.
- Any GUI change is modified at central location avoiding rework of scripts.



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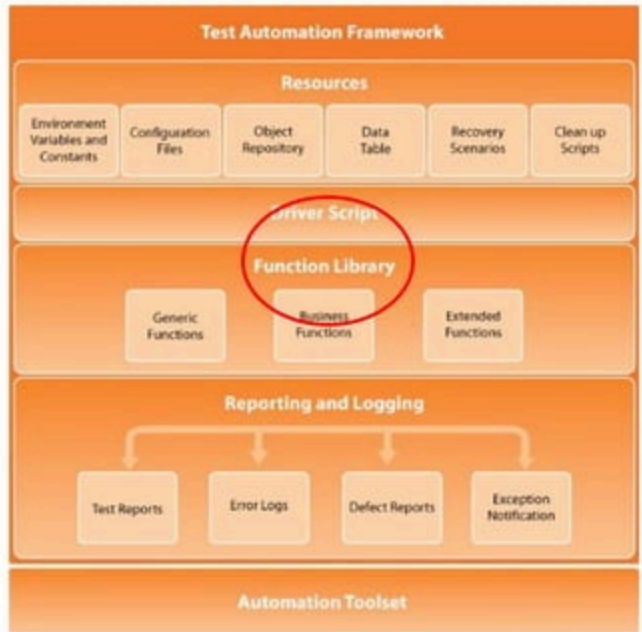
Function Library

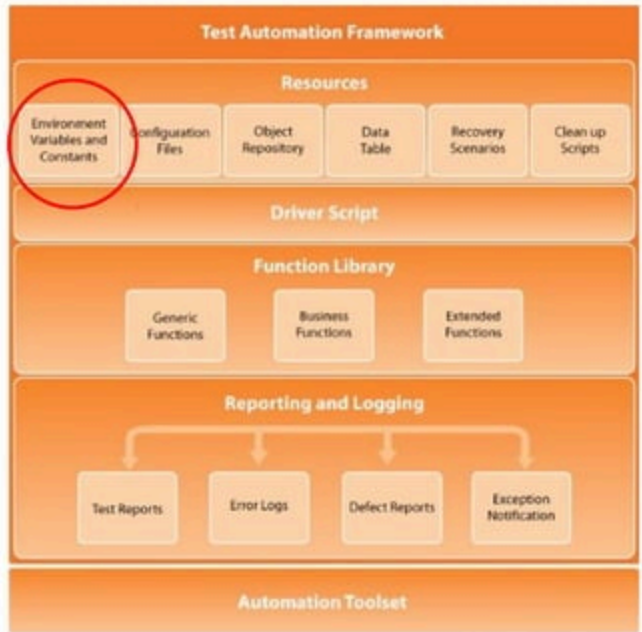
- Basic building block and defines a common set of reusable functions

- Reusable across applications as well as business functions across the application



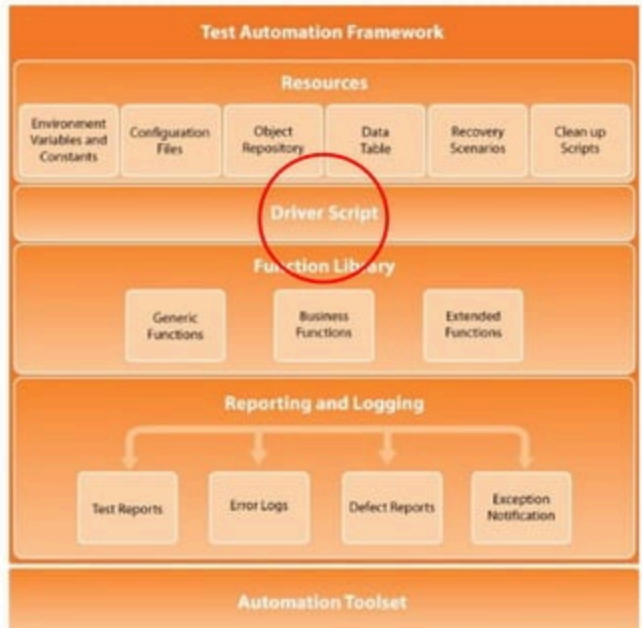
Global Variables and Constants

- Used across the automation test suite to:
  - Fine tune test suites
  - Enable reference modification dynamically
  - Ensure maintainability



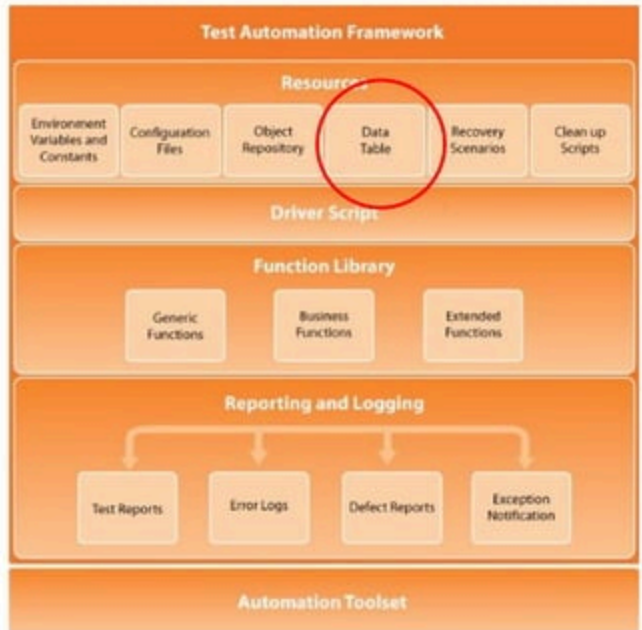
Test Script

- Critical components
- It has logic to perform and verify scenarios or functions.



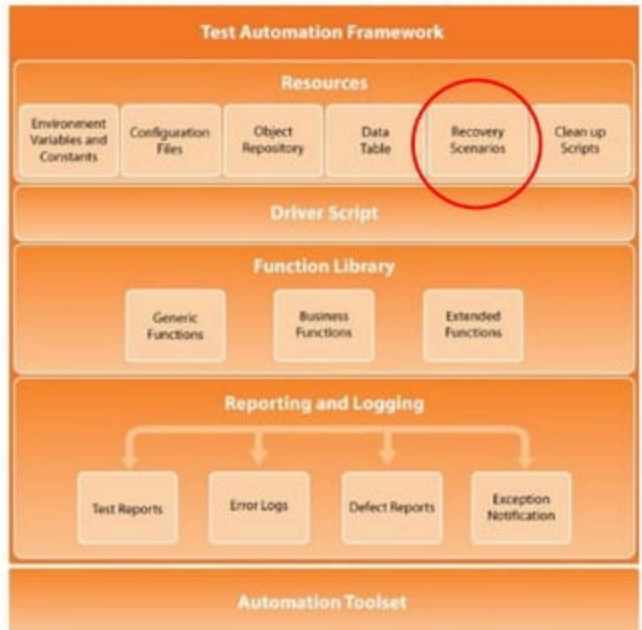
Test Data

- Application specific
- Inputs, outputs and environment data
- Is common to store inputs and outputs in files or any other media
- Environment data is commonly generated @ run time from the script



Recovery Scenarios

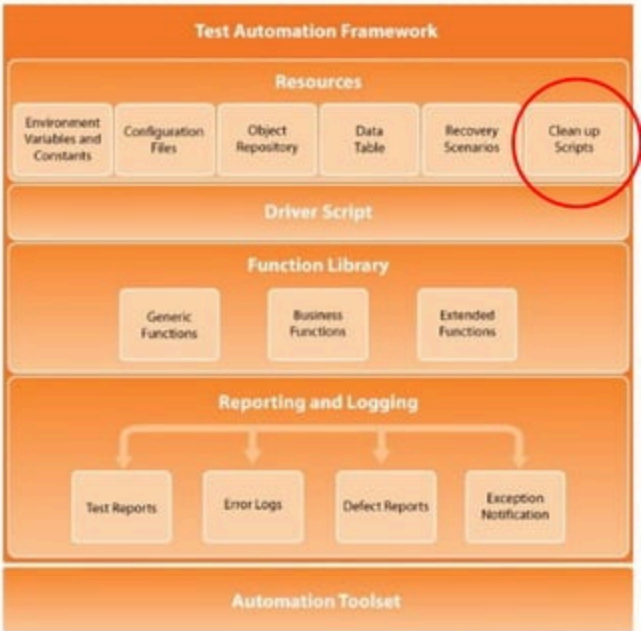
- Guarantee robustness of test scripts
- Handle unexpected exceptions that may halt execution



Cleanup Scripts

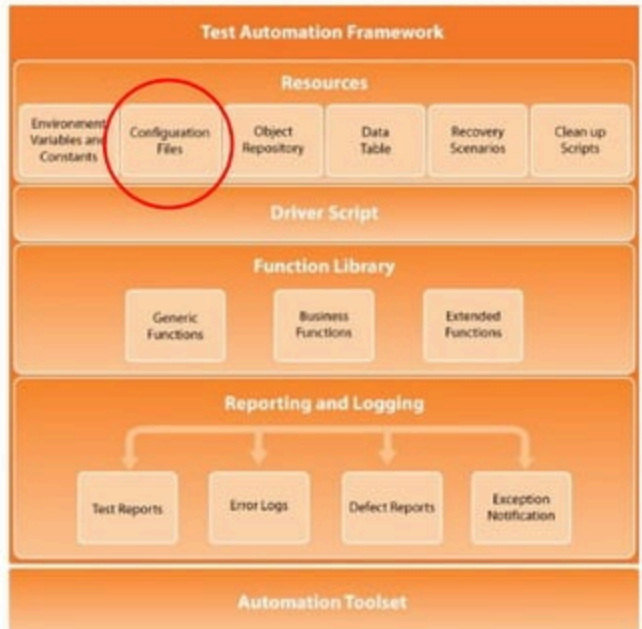
- Release all used resources after script execution to return the suite to a base state

- Developed for successful completion of scripts and at the end of recovery scenario



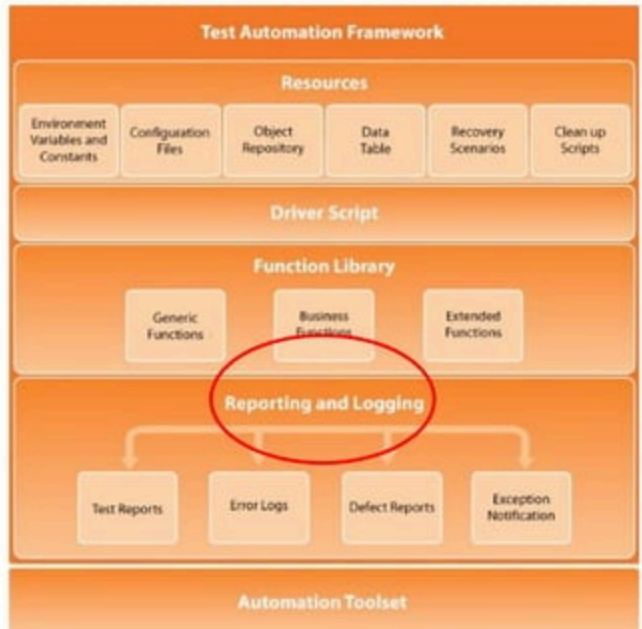
Configuration Files

- Maintain global settings and application parameters that will change w/ the test environment



Reporting

- Test results should be easily accessible and understood.
- It is also important to generate debugging information during execution at different points and record them.
- Goal is to minimize investigation times and help fixing problems quickly.
- Be aware of application behavior alteration.



Automation Framework Checklist

- ❑ Complete test plan document
- ❑ Defined business scenarios
- ❑ Minimal or no scripting by testing teams
- ❑ Data-driven tests to expand test coverage
- ❑ Verifications added

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Test Tools Selection

- Huge in number
- Different purposes
- Choosing the right tool is a strategic step for the automation success.
- Many things to be considered.
  - Technical
  - Organizational
  - ...
- Buy or make decision is a non-trivial project.
  - 3 ~ 10 people for 4 ~ 6 person weeks in medium sized organizations

Start w/ Requirements not the Market

- To ensure that you make an appropriate decision in ultimate time
  - Selection w/o a requirement is like a boat w/o a sail.

- Looking for tools in the market might lead to wrong decision w/ undesirable results
  - Difficulties in making the tool work at the intended environment
  - Slowing down of test teams
  - Losing management support
  - Crippling the automation efforts to overcome the above factors

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Tool Selection Team

Leader

- Management skill or position
- Helicopter view over the organization
- Focal point and may be regarded as the tool champion

Others

- Representatives from different areas
- Different skills and jobs
- Tool advocates in the organization

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Tool Selection Process

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Identifying Need

- **What are the problems to be solved?** (manual testing problems, no time for regression, inadequate documentation, eliminating error-prone test activities, inaccurate or coverage measures ...)
- **Explore different solutions** (tools are not always the solution) to reach highest impact with lowest cost.
- **Timing of the tool selection** is crucial for success and a major factor in the tool decision buy in (no major organizational panic, dissatisfaction w/ current situation and management commitment).
- **How much help tool will provide?** What are the benefits?
- **Estimate the costs** to reach these benefits **then calculate the ROI.**

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Identify Constraints

- Constraints if overlooked will lead to wasted effort and money

- Constraints include:
  - Environment al
  - Co-residency with the SUT
  - Supplier
  - Cost
  - Political
  - Quality

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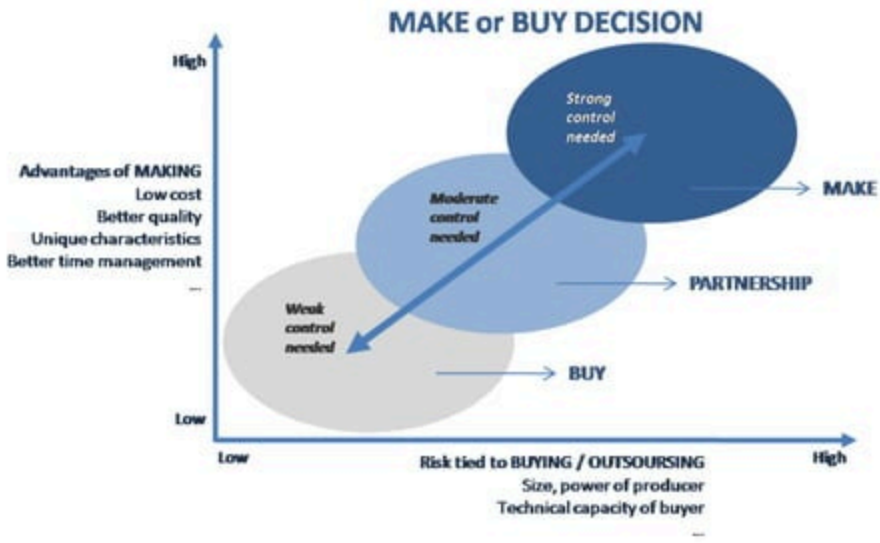
Buy or Make?



Identifying What is on the Market?

- **Construct a long list of available tools** (to ensure nothing is missed)

- **Classify common tool features according to your needs and constraints** (mandatory, desirable, do not care, fully implemented, partially implemented or not implemented).

- **Construct a short list of available tools** (2 or 3 options).

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Evaluating Tool Short List

- **Compare features**
  - Collect information about the tools
  - Consult industry reports
  - Ask for and contact previous customers
- **Ask for in-house demo day**
  - Pre-supply vendors with test (easy and nightmare tests)
  - Do additional tests on the demo day
  - Do post-demo analysis
- **Test script maintenance**
- **Do a pilot**

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Making the Decision

- **Assess versus the ROI**
- **Stop evaluation** when there is one clear winner or based on consensus when there are close candidates and all selection team member are happy w/ an option.
- **Document the decision** for future need if any.
- **Get necessary approvals and inform the vendor.**

Implementing Tools

- Once a tool has been chosen, the real work starts.
- Careful choice does not necessitate success in the tool's use.
- According to industry reports, 70% of purchased t[illegible]ually as shelfware.

Tool Implementation Team

Champion

- Focal point
- Evangelist
- Driver for implementation
- Do not mind giving others credit for his own ideas
- Necessary but not sufficient for successful implementation

Change Agent

- Plans and manages change
- Day-to-day progress
- Experienced in testing, doer, decisive, practical with strong analytical mind

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Tool Implementation Team cont'd

Angel

- Management sponsor
- Critical for implementation success
- Focal point and may be regarded as the tool champion

Custodian

- Technical support, mentor and coach
- Technical interface with vendors
- Tool process/guidelines owner

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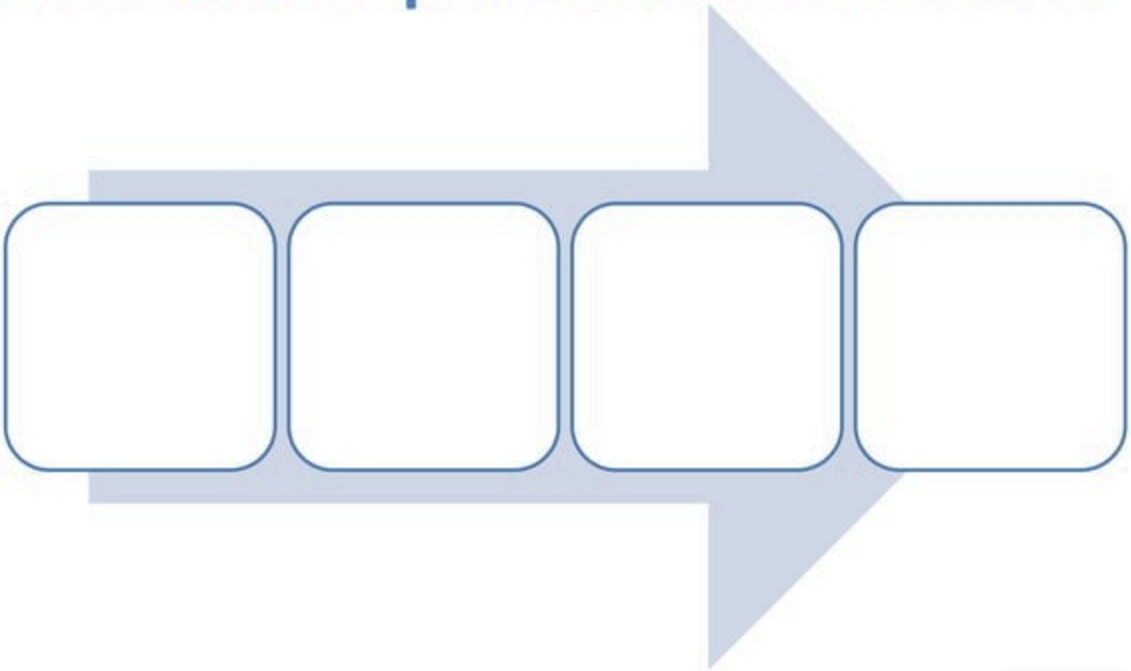
Tool Implementation Team cont'd

Team

- Tool users representatives
- Meet regularly to gather information and to disseminate information

Test Tool Implementation Process



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Management Commitment

- **Not one time** during tool selection and purchase
- Must **continue during implementation** especially when things goes wrong
- Commitment is in the form of **visual backing** to the implementation team from high-level managers as well as **adequate resources, budget and time.**
- **Realistic e:** ı gain.
  - The silv

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Preparation

- **Publicity** (do not surprise those will be impacted by the change, give the message several times)
- **Raising internal interest** (internal demos, side talks, advocacy)
- **Continuing publicity** (value small victories throughout the implementation realistically)
- **Test the demos** (failed demos destroys credibility)
- **Use evaluation licenses to confirm suitability** (make the best out of it before purchase)
- **Internal market research** (find your right audience)

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Pilot

- If you don't know what you're doing, don't do it on a large scale ☺.
- **Assess the changes to your testing processes**
- Set up and **trial your automated regime** (experiments)
- **Evaluate results**

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Phased Deployment

- **Plan gradual deployment and roll-out**
- Identify and conduct any needed **training**
- **Monitor automation results**

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Good Scripts

Attribute	Good	Poor
Number	<< test cases	1 script = 1 test case
Size	< 2 pages w/ annotation	> 2 pages
Function	single, clear	> 1 function, unclear
Documentation	clear, up to date	Unclear, outdated
Reuse	many	limited or none
Structured	yes	spaghetti
Maintenance	Easy	hard

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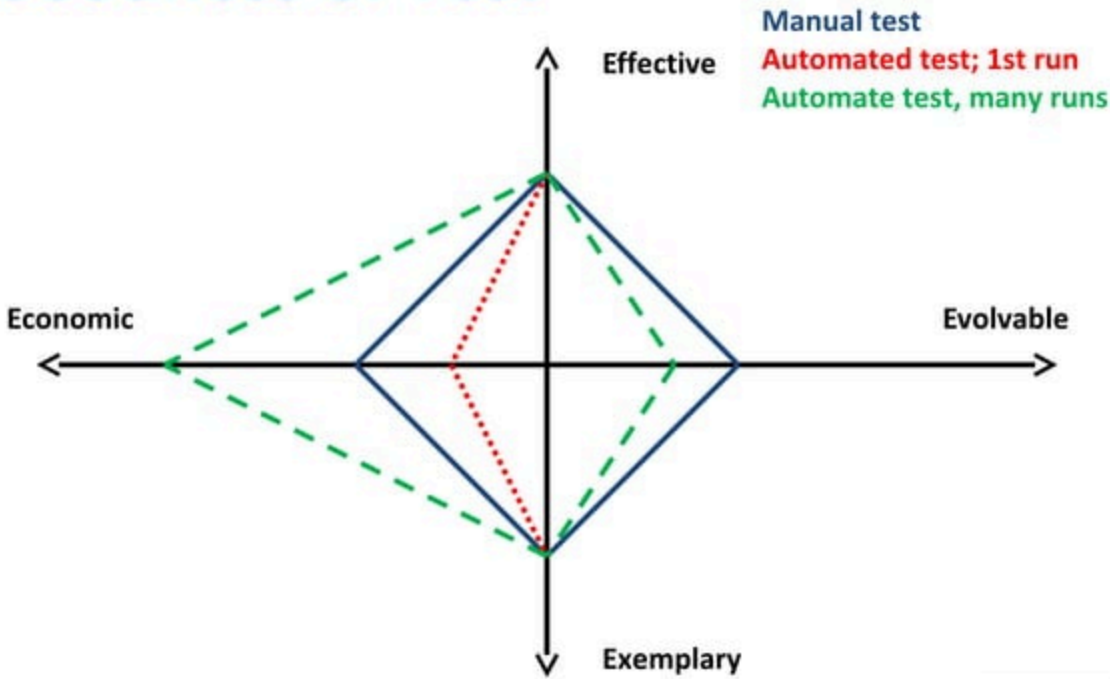
Test Case vs. Test Script

vs.

Goodness of Test



Script Pre-processing

- Script manipulation techniques that make writing and maintaining scripts easier and therefore less error prone
  - Pre-compilation techniques
- Tool or scripting language supported; more or less automated
- Examples include:
  - Beautifiers
  - Static analysis
  - Substitution

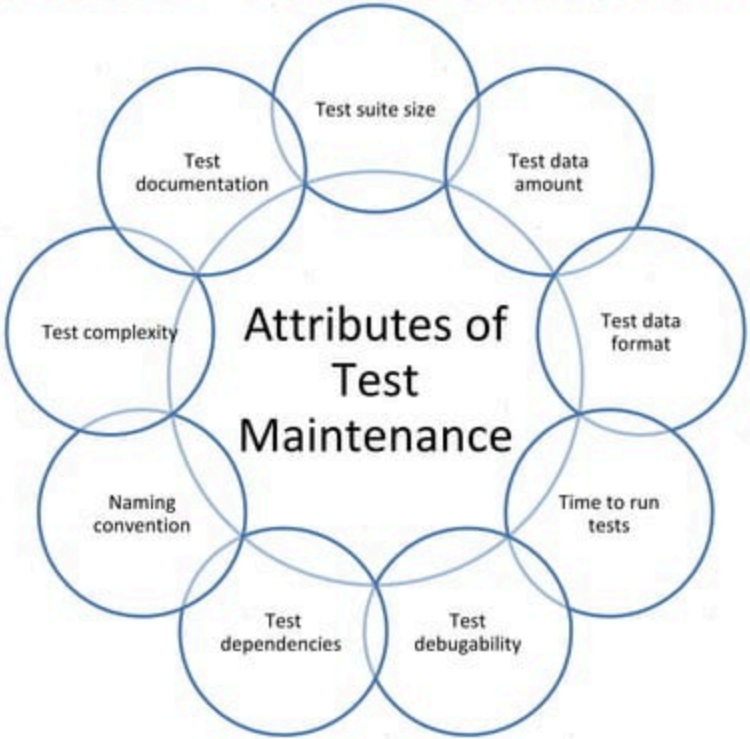
Outline

- Introduction
- Test Automation Process
- Test Automation Frameworks
- Test Tools
- More about Test Scripting
- *Maintainable tests*
- Metrics
- Automation Issues

Problems in Maintaining Automated Tests

- Changes in SW imply need for new tests and changes in old ones.
- Tests might become redundant.
- Maintenance is standard in any SDLC but little given to test automation.
- Maintenance costs are higher for automated testing than manual testing.
  - Testers have the reason and context and can apply changes on the fly; unlike tools.

Attributes of Test Maintenance



Be Aware of

- Tools help you do the wrong thing.
- Easy approaches result in higher maintenance costs.
- Initial enthusiasm
- ROI is maximized at the end of automation effort not the start.
  - 80% of effort gives 20% of gain; while truly 80% of gain is achieved by the remaining 20% effort

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Strategy and Tactics

- No single solution will work. It is a matter of tradeoffs and compromises.
- Justify maintenance efforts (measure attributes to take informed decisions)
- Tactics include:
  - Define processes and standards
  - Provide tool support
  - Automate updates
  - Periodic weeding
  - Acquire maintenance utilities

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Why We Measure?

- To decide whether the automobile was a good investment
- To evaluate choices, compare alternatives, and monitor improvement
- To have early warning of problems, and to make predictions
- To benchmark against a standard or in competition

What can We Measures?

- Gilb's Law: “Anything can be made measurable in some way, which is superior to not measuring it at all”

- This does not say that anything can be made measurable in a perfect or even adequate way, simply in a way that is better than no measurement.

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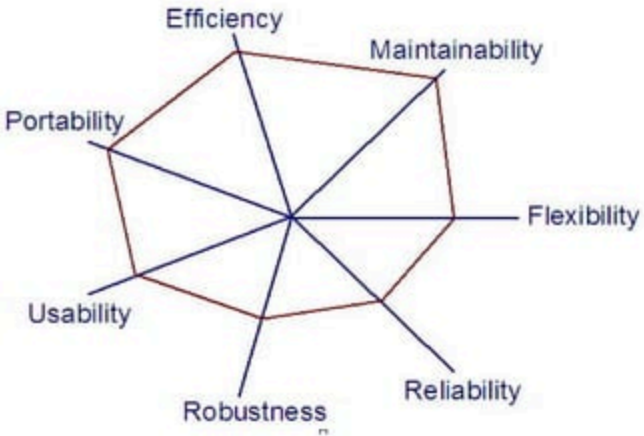
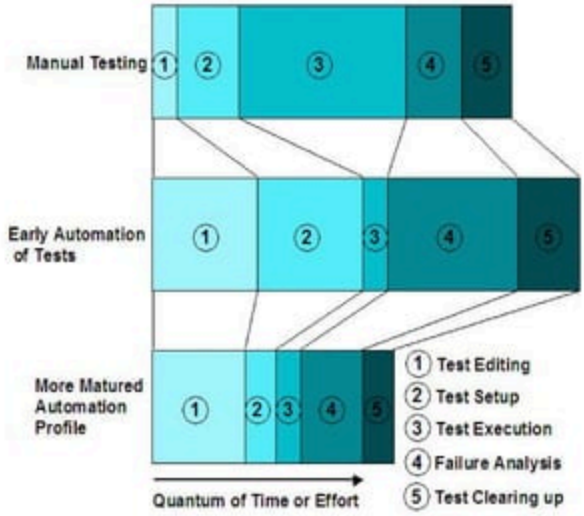
Attributes of Test Automation



Efficiency

- Efficiency is related to cost.



- Scales of measurement of efficiency can be:
  - Elapsed time (hours) to perform certain tasks
  - Effort (working hours) to perform certain tasks

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Maintainability

- Ease of updating the testware when SW changes

- Scales of measurement of maintainability can be:
  - Average elapsed time in hours or effort in working hours per test to update the tests
  - How often software changes take place.

- It is important to make the tests easier to update for the most frequent changes in SW.
  - UI changes, business rules, formats, communication or functionality

Reliability

- Reliability is related to test ability to give accurate and repeatable results.

- Scales of measurement of reliability can be:
  - Percentages of tests that fail due to defects in the tests i.e. either test design defects or test automation defects
  - Number of additional test cycles or iterations required because of defects in the tests
  - Number of false negatives and false positives

Flexibility

- Flexibility is related to the extent to which it allows us to work with different subsets of tests.
  - A more flexible profile will allow test cases to be combined in many different ways for different test objectives.

- Scales of measurement of flexibility can be:
  - Time to test emergencies fix on an old release.
  - Time taken to identify a set of test cases for a specific purpose
  - Number of selection criteria that can be used to identify a subset of test cases
  - Time or effort needed to restore a test case that has been archived.

Usability

- Must be considered in terms of the intended user profiles of the regime

- Scales of measurement of usability can be:
  - Time taken to add new test cases of a similar type to a test suite
  - Time or effort required to ascertain the results of running a set of automated test cases
  - Training time needed for a user profile of the automation suite to become confident and productive.
  - Time or effort needed to discount defects that are of no interest for a particular set of automated tests
  - How well the users like the suites, their perceptions of how easy it is for them to use it.

Robustness

- Ability of testware to cope with unexpected events without tripping up

- Scales of measurement of robustness can be:
  - Number of tests which fail because of a single software defect
  - Frequency of failure of an automated test
  - Mean time to fail
  - Time taken to investigate the causes of unexpected events that result in the test failure

Portability

- Portability is related to ability to run in different environments.

- Scales of measurement of efficiency can be:
  - Time or effort needed to make a set of automated tests run successfully in a new environment
  - Time or effort needed to make a set of automated tests run using a different test tool
  - Number of different environments in which the automated tests will run.

Should We Measure All?

- Just pick what suits your purpose

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What is an Automation Issue?

- A problem that testers and/or test automators encounter when trying to do test automation.
  - They take longer than they should.

- An Issue can also be a task that has to be done when automating.

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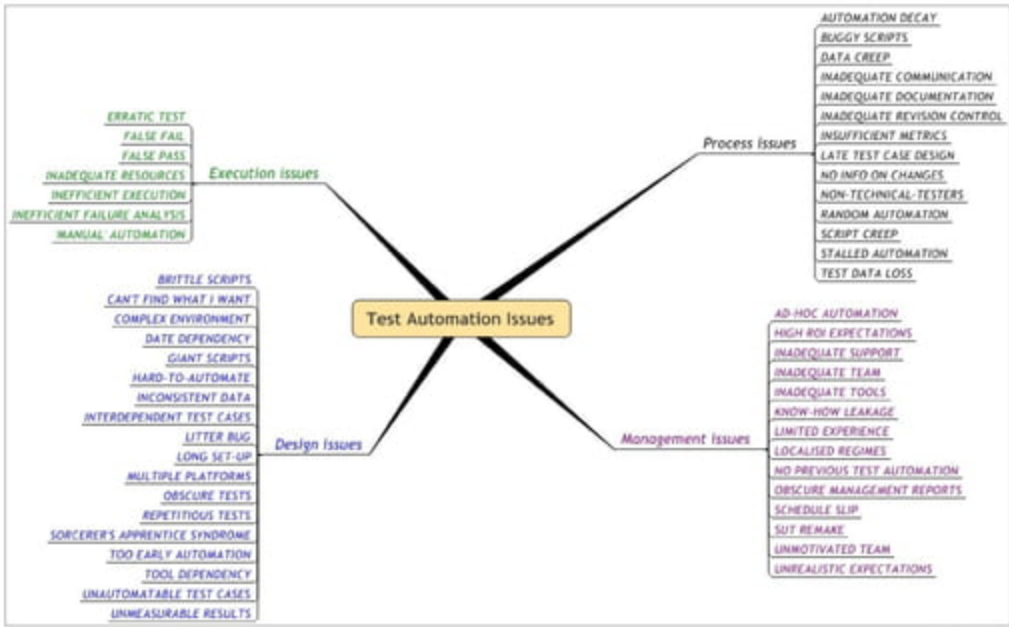
Issues Classification

- General issues: generalized issues that direct you to the more specific issues
- Specific issues:
  - Process issues: the way we work with automated tests and tools
  - Management issues: issues of management, staffing, objectives (need time, money or people to fix)
  - Design Issues: testware architecture, including maintainability
  - Execution Issues: the running of tests in their automated form

General Issues

Issue	Description
EXPECTATIONS NOT MET	Test automation is not meeting the expectations of managers, testers or developers
NO PREVIOUS TEST AUTOMATION	You are just starting with automation and have never done it before
NO DIRECTION	Test automation is stumbling along with no specific goal or no clear strategy
MISSING RESOURCES	Test automation is being hindered by lack of automators, testers, tools, hardware etc.
MISSING KNOWLEDGE	Automators or testers don't know how to do good automation, how to use the tools, have limited experience in the SUT or new team members take too long to become productive
MISSING SUPPORT	Test automation is not supported by managers, testers or developers
UNSATISFACTORY QUALITY OF TEST AUTOMATION	Test automation kind of works, but constant problems afflict it

Specific Issues



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Relation between General and Specific Issues

- A full mind map is in here.

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What is an Automation Pattern?

- A general reusable solution to a commonly occurring problem within a given context.
- A test automation pattern is a way of solving an issue or problems in test automation that has worked in practice for many people.
- Patterns do not exist in a void: each is a solution to an issue that occurs under some particular conditions.
- Also patterns are often associated with other patterns, either because they can only be implemented using other patterns or because they can only be applied after other patterns have been put into practice.

What is a Pattern is Not?

- A finished solution that you can just "plug in" directly to your situation
- Prescriptive (you must do this)
- A step-by-step procedure (do this first, then that)
- Patterns are ideas that you can adapt and implement in your own context and which will hopefully help solve some of your issues.

Pattern Template

- Pattern summary: Write here a short summary of the pattern
- Category: Process / Management / Design / Execution
- Context: Explain in which context(s) this pattern is valid and in which it isn't
- Description: Describe what the pattern does
- Implementation: Describe how to implement the description. Eventually specifying the differences from context to context.
- Potential problems: List here potential problems or general remarks
- Issues addressed by this pattern:
  - Issue 1
  - Issue 2
  - Issue 3
- Experiences
  If you have used this pattern, please add your name and a brief story of how you used this pattern.

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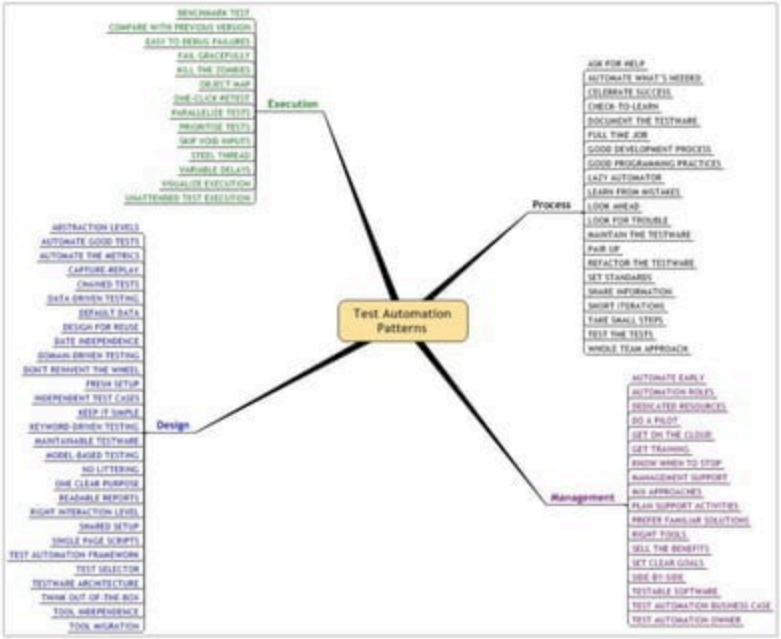
Test Automation Patterns



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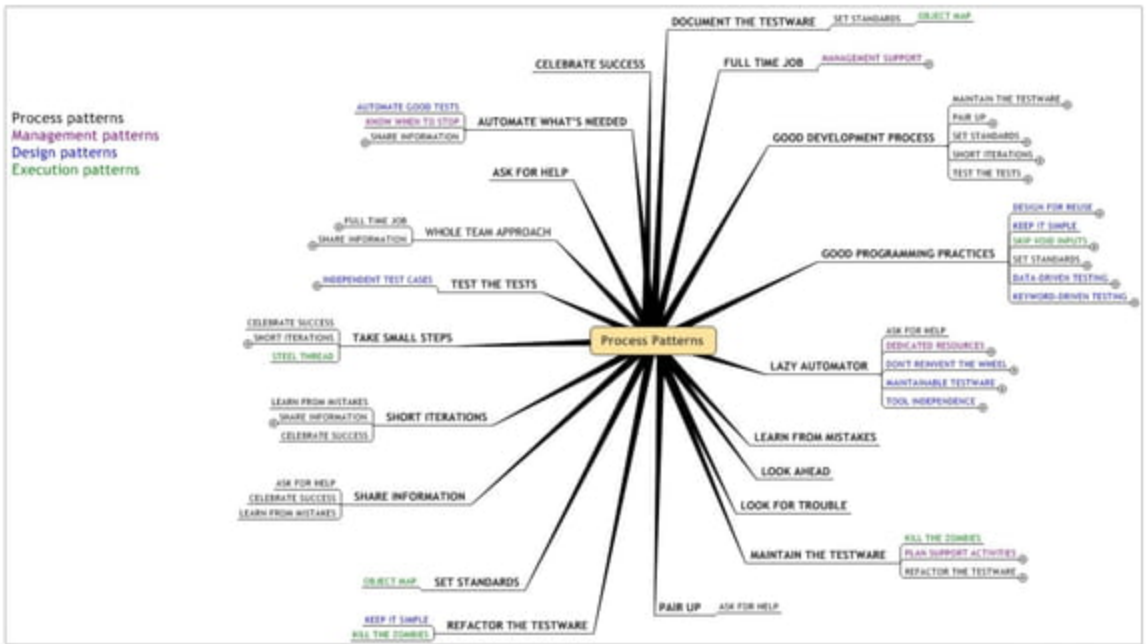
Process Patterns



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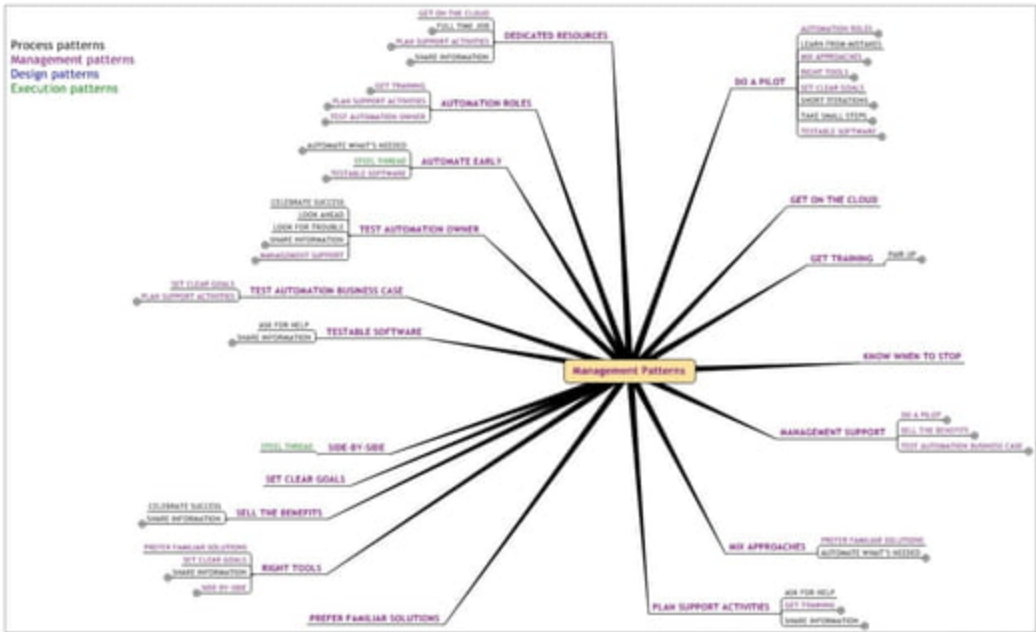
Management Patterns



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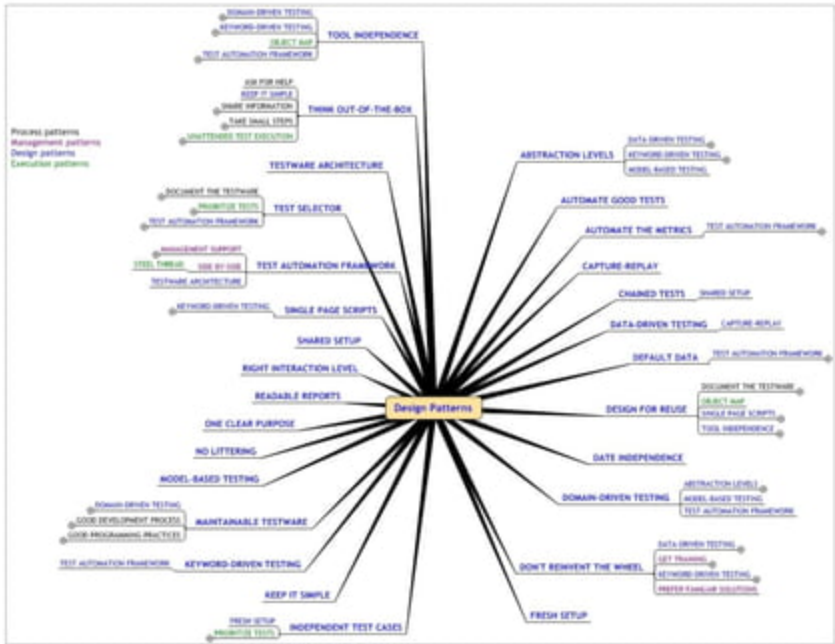
Design Patterns



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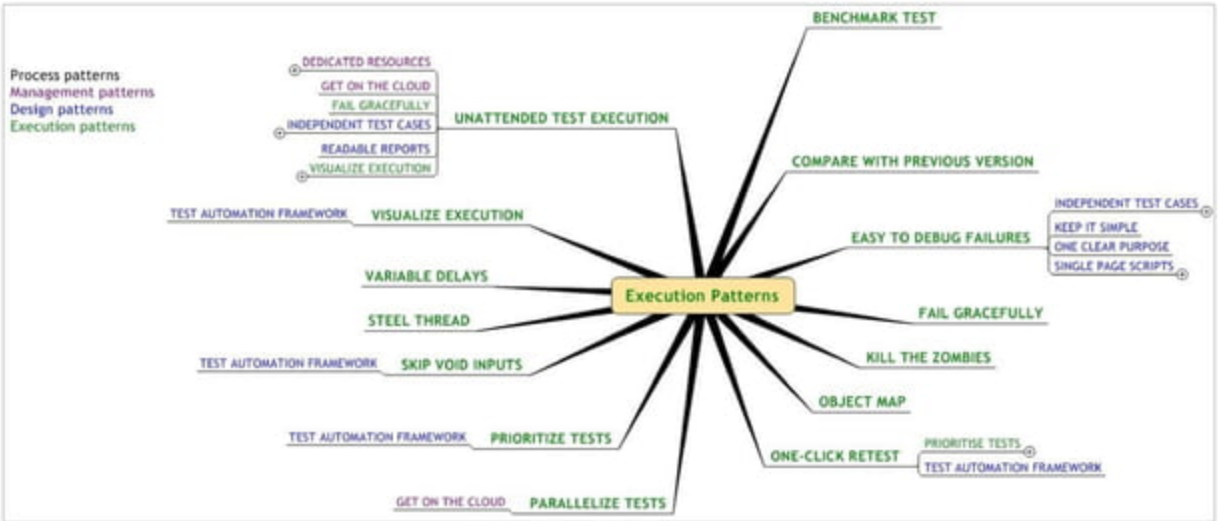
Execution Patterns



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Failure Patterns

- Failure patterns show how behaviors that start well can end up as costly failures.

- Help recognize if an automation project is heading in the wrong direction at a time when countermeasures can still enable a turnaround