

White Paper: The Importance of Automated Testing in Set-Top Box Integration

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1 What is Automated Testing?

Automated product testing is widely used in the production of both hardware and software. It allows a sequence of tests to be run at the push of a button, and a log to be generated showing which tests passed and which failed. This log can then be reviewed manually or processed automatically to determine whether all the test results are as expected for the current state of the product.

Generally, the same tests can be run manually, but running these is usually a laborious and time-consuming process not to mention prone to human errors. A manual testing model makes testing on any level of scale very costly and time consuming. This is particularly so if the production process requires tests to be run frequently and repetitively, for instance for regression testing when changes are made to the product under test.

Automating a set of tests can be expensive in terms of the purchase of test equipment, and also for the design and implementation of the tests themselves which are typically coded in software. However, the return-on-investment in a testing solution can be seen quite rapidly particularly if tests are run many times over. Test cases only have to be created once, and the incremental cost of each test run can become very low compared to the cost of a manual test run. Typically the design and implementation of tests themselves, which are coded in software, can mean an investment of resources at the set-up phase however after this time the benefits of full automation can be enjoyed.

It's important to remember however that the value of an automated test system will be affected by the degree of automation that it supports. If there remains a very large subset of tests which cannot be automated, then the cost advantages of having the automated test system are eroded. This will depend on the nature of the product under test and the sophistication of the automated test equipment being used. In cases where an appropriate subset of the tests can be automated (generally 70% or greater) and especially in cases where it is necessary to run the full set of tests very frequently, the argument in favour of investing in an automated testing system is compelling.

2 Why Automated Testing for Set-Top Box Integration?

In S3 Group, we have completed several projects which involved the full software integration of a Set-Top Box (STB) for various Digital TV networks worldwide. Such projects are generally very complex and involve the integration of multiple software components from third-party software suppliers. Our preferred way of working in such projects is to integrate early and then gradually build up the functionality and stability of the software. For a long time S3 Group has worked with an automated nightly build process which ensures that the integrity of the build is maintained at all times. This is particularly useful in projects where we are responsible for some of the main components of the build, for instance the low-level drivers. Having a nightly build verifies that any new code or bug fixes added to the head of development in our software repository have not broken the build.

S3 Group had a desire to take this nightly build to the next level, by not only building the software each night but *also running it*. An automated test system for STBs would allow this. The build is automatically generated by our Configuration Management system and could then be loaded into a STB in a test system which would then run through a sequence of tests, checking that the output of the box matches the result expected for each test case.

In the case of a STB, the minimum requirement for such a test system would be a device that allows Infra-Red (remote control) key-presses to be sent to the box under test, and collection of debug output from the box via the serial log. The log could then be examined the next morning for any abnormal events.

Such an automated testing system would be a huge step forward from a system that only provides integrity checking of the build itself, and would provide at least the ability to verify that the basic operation of the STB is unaffected by any recent code updates. However, it would fall a long way short of a fully automated testing system outlined in Section 1 above. Therefore, we in S3 GROUP began to consider what that fully automated test system might look like for a set-top box product.

In order to have any chance of achieving a suitable level of automation of a set of tests for a set-top box, some way of automatically capturing the video output of the box and comparing it to a pre-defined video capture would be essential. We realized that we would also need some way of programming the set of test cases, so that the degree of flexibility required to run a full range of test cases for the product would be supported. Finally, to be able to simulate real-world

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duration tests (stress tests) of the box, we wanted to be able to run tests on several boxes at the same time, possibly quite a large number of boxes, rather than just on one single box.

3 Automated STB Testing in Practice

The following picture illustrates at a high level the kind of automated test system S3 Group began to build.

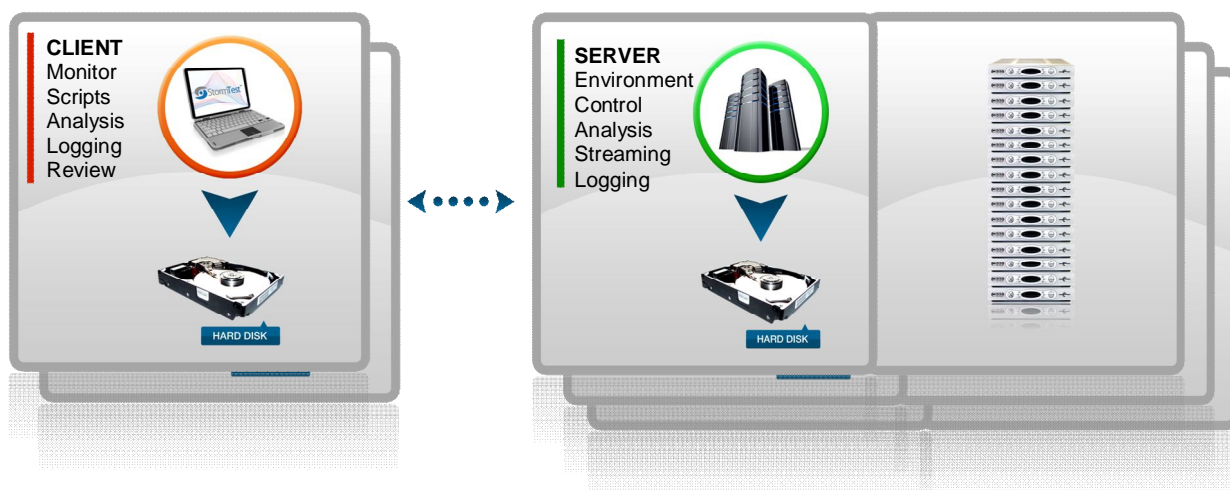


Figure 1: An automated test environment for set-top boxes

Here is how it works.

The devices under test are installed in a rack with multiple slots. Each slot in the rack can be individually controlled so that the same test can be run on many boxes (useful for stress testing) or different tests can be run simultaneously on different boxes (useful for high throughput of functional tests).

The server controls the communication with the devices under test, for instance sending IR commands to the set-top boxes under test and capturing the audio/video output of each box for further analysis.

The client machine is used by the test engineer. It contains all the test scripts which have been created for the particular product under test. The test engineer can configure the test rack with the sequence of tests to be run on each set-top box, and the client machine will gather and store all the relevant logging information during the test run. When the run has completed, the test engineer can review the results to see which tests have passed or failed.

In the early stages of an integration project, it may well be the case that certain tests are not expected to pass. Such a test system allows the full set of tests for the product to be run automatically and the results recorded to show the status of the integration project at any given time, in terms of the percentage of tests that currently pass.

In the early stages of such an integration project, the focus is typically on functionality, adding a little new functionality each day, until eventually all the functional requirements of the product are implemented. As the project progresses, the overall stability of the product increases and towards the end of the integration work, stress testing becomes very important. For a set-top box, many different stress test scenarios can be devised, but the most basic ones involve repeated channel changes, or in the case of a PVR box, repeated pause and playback cycles.

As the software becomes more stable, stability problems occur less frequently. In order to observe failures, the tests have to be run for extended periods, maybe several days, and this is where the multi-slot rack becomes essential. Running stress tests simultaneously on multiple boxes greatly enhances the likelihood of detecting a single failure within a reasonable time, and of capturing an associated debug log which might enable the software developers to understand the likely cause of the problem.

But this is not all that is needed to truly experience the breadth of capabilities and benefits of a comprehensive testing solution.

4 Features of an Automated Testing System for STBs

In the previous section we mentioned some features of an automated testing system that are essential to provide a high degree of automation. However, there are many more features that would be required in order to achieve a high degree of automation of the test regime of a digital set-top box. The following features are those which S3 Group regard as mandatory for an automated testing environment and which have been included in S3 Group's StormTest STB solution discussed below:

Client/Server Architecture

A client/server model which supports physically separate tester and STB locations – client can be anywhere with a good network connection.

Remote Control of Set-Top Box

Each box in the test rack must be individually controlled by means of an IR device attached to the box. The IR commands are sent to the box under software control by the client machine, where the test engineer has selected the test case(s) to be run for each box. We also need to be able to remotely power cycle each box individually, since some test cases can require this.

Programmable Test Cases

The test system must be easily programmable using a scripting language that can be easily learned by a typical test engineer. This will allow the test engineer to create new test cases when this is required.

Audio/Video Capture

As mentioned above, this is essential to automate testing of the basic operation of the box.

Logging of serial output

Typically a set-top box, particularly during the integration phase, will deliver debug output via its serial port. This will often provide useful information when a fault condition occurs that will allow the developers to understand the cause of the problem. The test system must capture and store the serial log from each box in the rack during testing, for possible later analysis.

Image Analysis and OCR

It must be possible to capture full resolution images from the live video stream for each STB and compare it against either images taken from other boxes or reference images previously stored. The image comparison must be fast and dependable. UI text recognition through an

integrated OCR engine is also required, and this should support the majority of worldwide languages.

Transport Independent

S3 GROUP is involved in the development of digital STB's for OEMs and Operators worldwide, consequently an automated test system will have to support cable, satellite and IPTV transport networks.

Offline Review Mode

Use of an automated test system means there is an increased quantity of test results which require human post-analysis. Provision of support to ensure that this can be done efficiently would be a very valuable feature of the automated testing system.

User Interface

The user of the system (typically a test engineer) should have a user interface on the client machine that allows at least the following:

- Start-up of sequences of tests on each slot in the rack individually
- Monitoring of the status of tests in progress and completed
- Screenshot comparison (for automatic detection of deviations from expected behaviour on the video output)
- Automatic motion detection on the video output (lack of motion may indicate a box under test has stopped responding to IR commands)

Configuration Management Integration

The testing system should integrate tightly with the Configuration Management system in use on the development/integration project so that it is, for instance, possible to configure the system to do a nightly build of the latest code and then load it in some of the boxes in the rack and run a chosen set of tests. These tests would most likely be a standard set of stress tests, so that project management continually has a measure of the stability of the current build throughout the integration work of the project.

Integration with Defect Tracking system

The testing system should integrate tightly with whatever defect tracking database is in use in the STB integration project. In particular, it should be possible for the system to automatically raise or update a defect when a test is found to fail.

Stream Carousel control

STB integration projects often have a need for a stream player that can play a recorded MPEG stream for purposes of testing the box. This may be because there is no 'live' satellite or cable stream available in the geographical location of the test site, or it may be because a particular stream (with data or characteristics not generally available in the 'live' stream) is required to provoke a particular fault condition. The automated testing system should have direct access, via the local network, to the stream player so that it can dynamically select from the available library of recorded test streams, while running tests.

5 StormTest™ – S3 Group's solution for STB testing

S3 Group developed an automated testing system initially for use in our STB integration projects internally and subsequently invested product resources to increasing the functionality and features of what is now commercially known as StormTest™ – an intelligent automated set-top box testing system. The product has all of the features outlined above and has been deployed by a number of S3 Group's customers across the Digital TV Value Chain including BSkyB, Irdeto and others.

S3 Group has over 15 years experience of developing advanced digital STBs for the world's leading OEMs and Operators. StormTest encapsulates much of the learning which S3 Group has accumulated in the area of STB testing and the new features on the StormTest roadmap will benefit from S3 Group's continuing involvement in complex STB developments. Full details of the feature set currently implemented and our future roadmap for the product are available by emailing tvtech@s3group.com.

6 Conclusion

Manual testing of STBs is time-consuming, expensive and error prone and most routine STB testing can be automated. An obvious use of automated STB testing is for final QA cycles and approvals at the Operator's site prior to product launch, but significant cost savings and project efficiencies can also be generated by the correct use of automation throughout the STB integration phase. Additionally the automated test cases developed during STB integration can be re-used during testing at the Operator's site as part of the final test cycles pre-launch and again in testing during legacy maintenance.

S3 Group's experience has shown that there is significant benefit to be gained from automating tests as early as possible in the STB integration cycle. It is not feasible, nor advisable, to attempt to automate all of the tests, manual testing never goes away, but that effort can now be focused on more rigorous manual tests. Integration of the automated test solution with the other elements of a development and test environment further improves the automation outcome.

The benefits of identifying and resolving problems as early as possible in a product development lifecycle are well known and applicable to STB integrations. Use of automated testing throughout the STB integration can greatly reduce time and cost and ultimately increase the end product quality.

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