

# Technical Innovation

## Architectural Requirements for Adaptive Test

Adaptive Test is a term that describes a broad range of methodologies that may be used to improve test efficiency and effectiveness. Long before the term became popular, Salland was delivering real solutions into high volume production. Today we are happy to report that we are clearly the world's leading commercial supplier of real-time adaptive test solutions. The reason for this success is that our software has been architected to allow us and others to build a growing family of applications on top of a real-time foundation that is portable to most modern commercial models of ATE.

To understand what Adaptive Test is, it is useful to observe what it is not. The historical role of test has been supported by tools built on an antiquated database schemes that support file-based, post-processing solutions. Most engineers in the industry don't even question these approaches because "it's the way we have always done it."

Of course, the whole process of test engineering can be called "adaptive." If an engineer analyzes his production results for the last month and manually "tunes" his test program to run faster or provide better test coverage, he is performing a conventional form of "adaptive test." Today, a new generation of software is becoming commercially available that allows for these decisions to be made "dynamically" during production. This is increasingly important as variations prevalent in the test hardware and modern deep-submicron processes are getting worse and static designs and static test programs will be unable to achieve the most efficient yield, quality and test times in the future.

An important result of being able to perform adaptive test dynamically (on-line and in real-time) is that test now takes on a more proactive role in improving the quality, yield and cost of modern semiconductor

devices. Recognizing this, Salland has developed a core technology based upon a revolutionary way of accessing and processing data in real-time directly from the tester.

### **Disadvantages of post-processing approaches**

On-line, post-processing approaches have the following drawbacks:

- Data is delayed. The time for problem identification and resolution is extended.
- Production testing cannot adapt to variations in material, tester stability or operations. This forces the engineer to design the test program for worst case conditions which in turn leads to lower yield and higher cost.
- Data storage requirements are high. All data must be collected and stored in order to support comprehensive post-processing.
- Off-line decisions and adjustments will not be reflected in test logs. For example, if post-processing routines mark additional failures due to proximity algorithms, outlier algorithms, and so forth, the STDF will not contain accurate results unless exceptional back annotation is performed. This back annotation consumes additional time during volume production.

### **Architectural Requirements for Adaptive Test**

Since first deploying adaptive test solutions in 2004, Salland has developed a very clear concept of the architecture required to support a comprehensive adaptive test environment. There are five components.

#### **1. Device Profile**

There needs to be a mechanism to tell the test stations what parameters to use and action to take for a particular device under test. The Device Profile is

sometimes referred to as the “recipe.” The Device Profile will typically be released and maintained in sync with the test program. The Device Profile will need to be able to be distributed over the users network and easily accessible be the test floor using it.

## 2. Real-time Data Acquisition

A mechanism to capture test results in real-time from the tester is required. This capability needs to be implemented so that the tester is not slowed down and normal operation is not changed. Test results will typically include all parametric measurements.

## 3. Local (On-line) Decision-making Engine

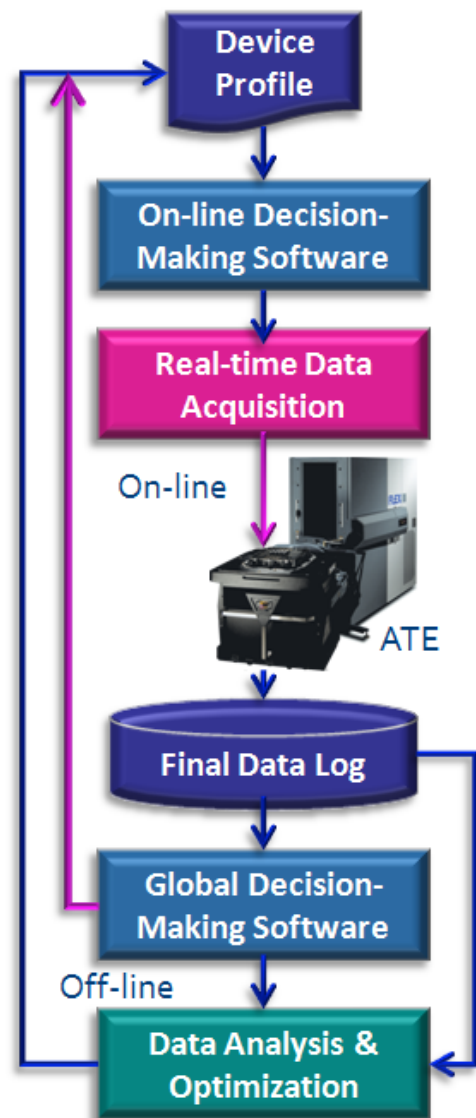
Peter O’Neill of Avago Technologies describes adaptive test very eloquently when he states “it is the ability to change flows and/or test limits on-the-fly.” We describe “local decision-making” from the point of view of the ATE system itself. Local decisions affect the silicon currently on the tester, whether it is a packaged part or uncut die on a wafer. The ability to compare IDDQ at multiple spots on the same device is an example of a local decision. Changing the test flow on the next device based upon results of the prior device is another example. In general, local decision making must not slow the tester down and therefore, no database interaction can occur during test runs.

## 4. Global Decision-making Applications

Global decisions are those that compare data over time or space. Example are comparing yesterday’s yield to today’s yield, or comparing the performance of a tester in Singapore to a tester in California. Global decision-making is also the basis for “continuous learning” applications. For example, as production matures, one may want to tighten up certain measurement thresholds or yield metrics. To do this, a full scale DBMS is usually required in order to compute long term trends.

## 5. Data Analysis & Optimization Tools

Finally, in order to create the Device Profile with the “adaptive test plan,” a unique data analysis and simulation toolset is required. All adaptive test is based upon an examination of recent historical production data. The analysis tools need to assist the user in determining the optimum test plan while avoiding any unwanted side effects. For example, when deploying outlier detection, the user needs an analysis tool that will assist in selecting the proper tests and screen



parameters that will produce the best quality while minimizing yield loss. The output of the analysis tool will be the recipe stored in the Device Profile. Typically a Device Profile Editor will be required as well.

## Other Requirements for a Successful System

In addition to the five main architectural components described above, a good foundation for Adaptive Test needs to meet other requirements in order to become a commercial success:

- Must be easy to deploy and integrate into your existing production environments.
- Should not displace the current data logging or data archiving that your organization has invested in.
- Should be easy and intuitive to use.

- Should be open to interface with other tools and databases.
- Adaptive algorithms should be programmable by the user.
- Should be supported on a wide variety of tester platforms.
- Should be scalable from single tester installations to hundreds of testers.

**Salland’s Architecture**

Salland has developed several product lines that fulfill the above requirements for a comprehensive adaptive test infrastructure. SwiftTest is the family of products that run in real-time on the tester and monitor test data and can change flows and thresholds dynamically. TestScape is a powerful DBMS that support off-line applications capable of interacting with SwiftTest for complex, global decision-making.

Both SwiftTest and TestScape are licensed in a variety of configurations depending upon what applications the user is interested in.

TestScape and TestVision are data analysis tools that assist the user to define the optimum adaptive test plans and release them via a well-defined Device Profile. TestVision is our desktop tool for customers not committed to the full TestScape test data management and analysis system.

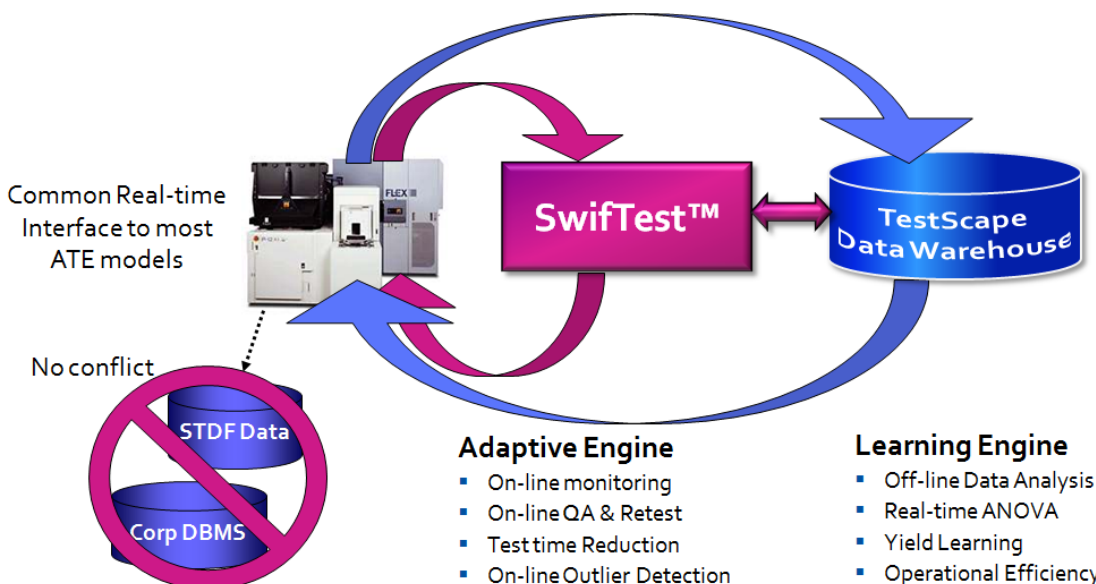
**Salland’s Advantage**

By capturing data on the tester in real-time SwiftTest can pre-process important parametric results such as counts, averages, Cp and Cpk. This reduces data

storage requirements and enables real-time decision-making. Real-time, on-line decision-making is critical to reducing interruptions, scrap and lost test time.

SwiftTest can perform real-time decision-making at three levels of hierarchy regarding the device: On-DUT (“device under test”), DUT-to-DUT and Wafer level post processing (“WPP”.) **On-DUT** means that multiple measurements can be made on a single device and used to form decisions as to how to complete processing the current or subsequent DUT. **DUT-to-DUT** algorithms change the test plan on subsequent devices based upon measures made on earlier devices. **Wafer level post processing** is used when all of the data for a lot (wafer) needs to be analyzed and back annotated into the test results. Since SwiftTest has already preprocessed most of the data, even post processing is faster with Salland as there is no need to locate and load inefficient STDF files.

SwiftTest operates at a highly granular level, with far great control than possible using convention manual techniques. During sampling for example, SwiftTest-MX suppresses only those tests within a test program that are adhering to the user-defined criteria for sampling in true real-time. Immediate notification can be provided through triggers and alerts of production issues related to test program stability, ATE operations and maverick lots. Real-time, temporary suppression of tests that are in statistical control achieves a more optimal balance of time versus quality than possible using traditional manual optimization techniques. The result is shorter test time that reduces cost of test and improves product margins.



Real-time processing with SwifTest is unique in that it is equally effective at wafer probe and final (packaged) tests. It supports single-site, multi-site, and dual-head configurations. In addition, the products are highly configurable by the user to ensure that corporate standards for quality assurance and DPPM rates are satisfied. Finally, since the algorithms “adapt” to changing silicon variations, results get better as your yield improves and your products mature.

Finally, Salland’s solutions can be deployed into your production operations in modular phases. You may begin with a single tester only and grow into multiple test floors supporting numerous tester models. We do not require massive changes to your central test databases and most of our on-line software operates transparently to your test floor operators.

### Applications for Adaptive Test

The range of possible adaptive test applications is vast and growing with the imagination of our users and industry visionaries. A few are described here.

- **Test Time Optimization**

Salland’s most popular product is SwifTest-TTO that performs real-time statistical sampling to achieve significant reductions in test time. It has been in production since 2004 and billions of devices have been shipped by leading semiconductor manufacturers using the software.

- **Zero Defects via Outlier Detection**

If your market demands zero defects, one way of increasing reliability of your tested devices is to include outlier detection and rejection. Dynamic parts average testing (“DPAT”) and nearest neighbor rules (“NNR”) are very simple forms of this. Salland’s SwifTest-FOX (Fast Outlier Extraction) supports a wide range of sophisticated outlier detection and rejection algorithms that find the optimum balance between yield and desired quality.

- **Production Monitoring**

SwifTest-MAX offers the user a variety of user programmable triggers and alerts that may be used to perform complex monitoring and binning analysis on-the-fly. Equipment issues like site-site variance can not only be quickly identified but dynamically corrected as well.

- **Yield Improvement**

Historically, most of use believed that yield was “what it is” and could not be improved by test. Today that is no longer true. Salland has customers today who are using SwifTest to dynamically change test limits and flows compensate for variations that are external to the device under test. More ideas are brewing in this area.

- **Data Feedback**

When a database system like TestScope is integrated with SwifTest, feedback from earlier production can direct adjustments to subsequent testing. This may be done either automatically or with user intervention and approval. The possibilities of continuous learning algorithms become obvious.

- **Data Feed-forward**

Industry visionaries are working with Salland on methods to use data from an earlier manufacturing step to adjust the test plan so as to achieve improved yield or test efficiencies. Perhaps knowledge of the PCM data can be used to optimize wafer probe. Likewise, knowledge of what testing occurred at probe can be used to optimize final test plans.

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