



TeraSci - Test Philosophy

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Introduction

TeraSci Industries Inc. is an Automated Test Equipment (ATE) provider. We have been in the business for over 30 years and have provided test solutions to many computer screening and repair companies as well as mobile device (phone, pads and tablets) screen and test facilities. Our basic approach is to provide a lease based full turnkey solution.

This document will cover the overall architectural concept of our test systems and does not include details about specific commodities. We have individual manuals on the Portal for each commodity. Our basic system architectural is worldwide centric not site centric. We will cover several areas of interest including: the basic layout, advantages of leasing, a fully interconnected test approach, database driven testing, and rapid capability scaling.

This is not a “possible solution” but one that has been deployed for over 20 years. As we outline the capabilities keep in mind these are real world installations that have used our solutions for 2 decades and have helped us make improvements and cost reductions every year. Because each installation and customer have unique requirements our systems have built-in flexibility that has allowed us to add new customers, new sites and new commodities in real time. We can add a new worldwide customer with multiple sites in weeks not months. Each site will have exactly the same process controls, test procedures, test equipment and reporting at deployment time. We add new commodities to this architecture every month (sometimes weekly).

We do not like to be thought of as only a test equipment company (yes we do that) but we are much more than that. Hopefully after reading this document you will agree. At TeraSci we believe our test platforms are data collection stations as well as “test equipment”. Today data is as important to any company as the units you yield in the test process. This document will emphasize the data we collect as much as the units we test. Doing high volume testing with low skilled labor is today’s test environment. Without data, quality is not controllable. You must be able to share that data with many parties including: the test sites, your engineering staff, your procurement and logistics staff, management, your vendors that provided



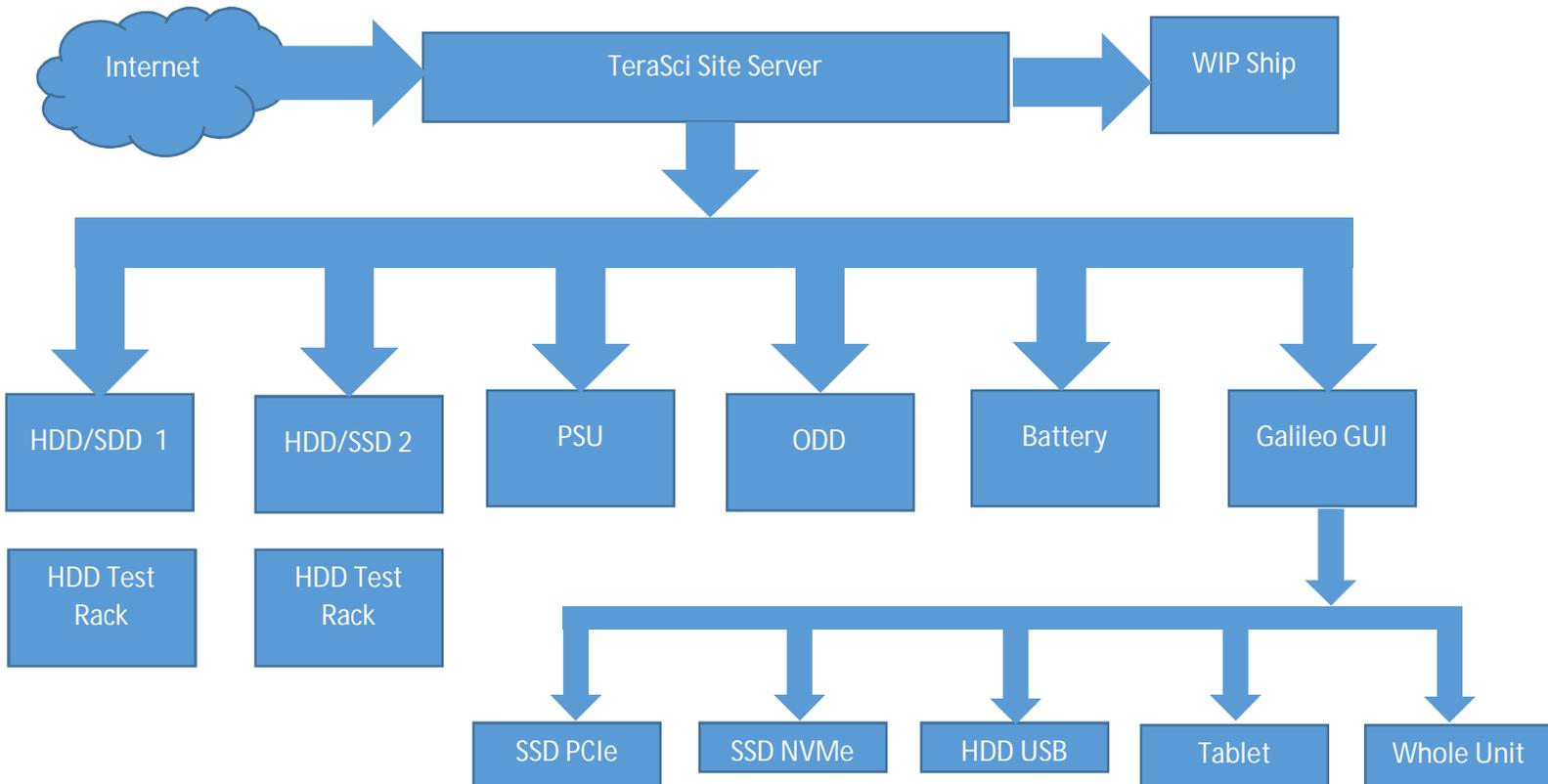
the sub-assemblies, and of course TeraSci that helps you keep all of this secure and in real time.

Today storage is virtually free and the Internet is fast. We believe you can never collect too much data. All of that data is the answer to the question no one has asked so far. That unasked question is solution to one of the hidden problems that are buried within the ever increasing complexity of today's technologies. Solving those problems is one of main the reasons for TeraSci's existence.

Basic Layout

Our solutions always have an Internet connection from TeraSci to every site. Figure 1 below is an example of one of our sites.

Figure 1.





Sites all have a Site Server and 1 to many test platforms. The test platforms are specific to each commodity we test. The commodity could be a computer peripheral or a mobile device (phone, pad or tablet). Each of the sites have several things in common independent of the commodity being tested. This basic approach adds to the quick deployment of new sites and new commodities. First we will discuss the common hardware and software deployment at all sites.

Site Server

Each site has a Linux based computer that is Internet connected to our Headquarters in Huntington Beach, CA. (hereafter referred to as HQ). The site server provides basic functions and several common software components. Most site servers are deployed in a server room on the customer site. It comes fully configured with all of the necessary TeraSci software. The site must provide two capabilities.

First the Internet connection. This is quite often a security concern for the sites. We use an approach that minimizes the security concerns called SSH reverse tunnels. Using this approach doesn't require opening any inbound firewall ports to our site server. We use only an outbound port and the port number is not a standard number like port 22. We establish an SSH connection, back to HQ, using secure keys that are unique to each site Password authentication is explicitly disabled, so only connections using valid SSH key can connect back to TeraSci HQ. This approach has been accepted by all of our sites and has satisfied the requirements of our most secure customers. We also use dual NIC site servers so we can isolate the Internet Traffic to a single NIC.

Second the site must provide a LAN (usually a VLAN) that connects to all of the test platforms. More on test platforms later. This is from a second NIC on the site server. These 2 NIC's do not share traffic. One side is for the test equipment and the other for the Internet connection to HQ.

The Site Server performs several functions at the site. First it handles the reverse tunnel. Second it is a MYSQL database that keeps all of the test records for each unit tested. Third it hosts a TeraSci software package called ts_Tracker. Fourth it is file server for all of the test equipment and holds all of the test software and control files.

The Database

The MYSQL database is synced in real time to a mirrored copy at our HQ. As units are tested they upload the test data and results to the site server that is synced to HQ in virtually real time. This provides one data backup for your results (there are more).

Having all of the site data moved to HQ allows TeraSci to provide data reports via our Portal - www.terasci.com/portal - to any authorized party using the Internet from anywhere in the world. So at your headquarters your engineers can gather reports from any or all worldwide sites very quickly. The data from each site for a specific commodity is identical. Different commodities do have completely different data. Reports will give accurate and the same results from all of your sites. This does not need to be designed, it is operational at deployment and we have been doing this for decades. It is also a major part of how we can bring up sites so quickly. We can see training and other issues on day one. We know what to expect for various commodities because we are testing those same commodities at other sites and for other customers. Your engineers can participate from their office (anywhere in the world) in bringing up sites and deploying new commodities by observing the raw data or custom reports provided by TeraSci. Our data engineers are experts on our DB layouts and in selecting the data that you need. You do not have to spend money and programming time to get information to solve your problems.

File Server

The File Server function of the site server is also very important. All of the test platforms mount to the site server as soon as they boot. The test software is on the site server not on the platform. That means all of the test platforms run the exact same code and use the exact same configuration files. When we do a code or configuration file update all of the test platforms are at the same level. If we need to do a worldwide software update it can be accomplished in a few minutes (about as quick as copying the files to the sites via the tunnel). For example if you need to do a FW update on a commodity like: an HDD, an SSD or a Smart Phone, all of the sites can be up to date in minutes. Once we copy the software to each site



server all of the test platforms are up to date even when we are talking about 100 test platforms.

Ts_Tracker Software

This software package is a major key to our quality control. This package provides a function we call work-in-progress (WIP) Ship. As units leave the TeraSci test area we use WIP Ship as the final quality check. An operator scans the serial number of the unit and ts_Tracker software will look up that number in the database and pull the last record. Then it will run a software function called a CSR (customer specific requirement). Each commodity can have a different CSR and even different processes for the same commodity can have a different CSR. This CSR basically checks certain fields in the DB. For example the simplest check is Pass or Fail. Other checks can be for Firmware Revision. Many CSR's are very complex and allow us to validate lots of things. TeraSci programmers write all of the CSR for you. All you do is define the criteria.

One of the primary functions of the CSR is to set the disposition. Here are a few of many possible dispositions:

Pass – route to Finished Goods

Fail – route to RTV (return to vendor).

Fail – Scrap

Fail – route to OOW

Fail – Route to FW update

Hold – Hold for engineering

Incomplete – Route back to test

We find that our customers have many more possible dispositions.

WIP Ship will also upload the test record for the tested device to the customer shop floor and inventory system. This insures the test data is accurately sent via electronic transfer to the sites DB systems. We have



supported many different ways of getting the data from our system to yours all electronically. We understand the importance of this.

It does no good to accurately test a unit only to have that unit entered into the inventory system incorrectly via a manual system. In fact this could be an extremely expensive mistake. For example, HIPPA is the US governing body for health records. If a unit with customer data was to ship out of your test facility with health records the cost could be \$50,000 dollars for each patient record on that device. Similarly GDPR in Europe has much higher fines. That could happen if a unit that failed the test was incorrectly entered as a PASS. Quality is more than just equipment and a few spreadsheets.

DB Central

The term DB Central refers to a collection of servers in Huntington Beach, CA, our HQ. Since it is not just a single server TeraSci named it DB Central. This section will define the roles of this collection of servers that keep each site server alive as well as up to date.

Each site server has a corresponding mate at TeraSci HQ. The site server is of course the backbone of all of the testing at each site. But it cannot be a standalone function. It requires real time support in several areas. Without all of this support it will become obsolete in a few days.

Reverse Tunnel

We have already mentioned the SSH reverse tunnel. This function requires a connection at the opposite end of the tunnel from the site server. So each site has a Linux Container (in effect another server) that resides in DB Central. One of the container's main functions is to run the MYSQL slave DB which replicates from the site server master DB in real time. We have a software function that collects the data from the Container DB and uploads it into a Central SQL database. There will be more information on this process below in "ETL".

Since we have many reverse tunnels (many sites) we use a dashboard to see which tunnels are active and which are disconnected. The site server constantly "pings" the tunnel to keep the Internet connection open. Those pings allow us to see when the last time the tunnel pinged. If it has been too long we can alert the site that the site server is "down". This ping feature is also nice for a new install. As soon as the new site server is powered on and connected to the Internet we will see the ping. At that point we can connect to the site server and assist in bringing up the site. The IT department at the site has only a few standard IT functions to perform and they do not need to "configure" our server. As soon as the ping appears we can inform the site that their IT configuration is operational.

Mirrors and Security

Linux is an open source OS and as such it does not require any licenses. This saves the cost of both buying and maintaining those licenses (OS license, Virus Scan License...). Both our site servers and all of the test platforms are command line based and do not have a GUI installed. These systems do not have a browser and cannot connect to the Internet port 80. This significantly removes the possibility of them getting a virus, worm.... This means they are one less headache for your IT department in terms of security.

But we do have to maintain these systems at the current revision level. We have standard configurations for each of the platforms. They are all based on a Debian release. Occasionally we need to Upgrade that release or add new packages. These installs and upgrades are built in functions within the Debian OS. But in order to get new software they must connect to a Debian Mirror. This is normally via standard open ports on the Internet. But our sites have all of those ports closed for security so that is not possible. Linux is quite flexible so mirror access is provided through the reverse tunnel.

DB Central has a copy of the latest Debian Mirrors. This is a vital part of our software test architecture. Linux drivers are part of the Kernel. Periodically we need to upgrade one or more of those drivers to improve the tester. The same goes for installed packages. We may need to upgrade an existing package or install a new package.

Part of the installation of a new server or a platform is the configuration. That means which packages need to be installed. We accomplish this with a TeraSci script called Setup. We can run Setup at any time on any server or platform. One of the functions of Setup is to connect to the DB Central Mirror and make sure all of the proper packages are installed and up to date.

This is a fully automated step and insures all of the servers and platforms are at the latest software level. This not a small point with dozens of sites and 100's of platforms we need automated ways to insure all of the software is at the latest revision. By putting all of the software configuration information into each test record in the DB reports can flag software issues. So we have a way to see the revision of each test platform in real time.



Setup gives us a way to quickly and accurately update to the latest revision level. Updates can take many minutes (think Windows update) so we can do this after the sites stop testing for the day. Most Linux updates do not require reboots to take effect. In fact we can log into the site and start the updates in parallel for all of the platforms. We usually tell the site supervisor to leave the platforms powered up overnight. The next day the site is fully updated. This is what allows us to meet your QUALITY standards.

Extract Transform Load (ETL)

We have mentioned that the site server has a MYSQL DB that holds all of the platform test records. That data is synced to DB Central to a corresponding site container. This way DB Central always has a current copy of the site server data. Periodically we need to move that data to the Portal for everyone to access. More on the Portal and security concerns next, here we will explain how that data moves to the Portal.

The Portal is a collection of all of the data from every site for every one of our customers. DB Central has a job that runs daily and moves the data from the containers to the Portal. We call the job ETL because it must Extract the data from each container (MYSQL) and Transform it to Microsoft SQL Server and Load into the Portal DB. The importance of this step is that the site data is available for reports within 24 hours of testing a unit.

Portal

The Portal is one of the most important functions we support. The Portal has two main functions: it is the way to get reports or view raw data. It is also a library of the documents you need to understand our processes, reports and our data.

Most of the TeraSci software architecture is designed just to be able to get accurate and complete data to the Portal. There are several manuals on the Portal that explain the reports and the organization of the data. That is beyond the scope of this document.

Portal Security

We have built security into the design of the Portal. We use credentials to define who has access to which data sets. For example it is valuable to you to be able to share data with your vendors especially the fail codes for the units you return to them. But that means vendor X for a certain commodity can only see their data and not the data for Vendor Y for the same commodity. These are typical issues. Your engineering team needs to see all of data from all the sites, but the engineers at your site A may be restricted from seeing the results at a different one of your sites. Our security model is built into the Portal and you can define the roles for each log in.

No one has access to the Portal without a user name and password. James Meece our VP of Customer Service (jmeece@terasci.com) will provide you with a username and password. We provide access to the document library for anyone with a need to review our processes. Once you are a customer and you have data on the Portal we allow you to have access to your reports and your raw data. The contract you signed with TeraSci designates one individual in your organization that can grant access rights to your data to other individuals, customers and vendors. We do not allow just anyone in your organization to grant access to your data.

Canned Reports

After 2 decades of doing this we have a number of canned reports. There is a document on the Portal that defines all of the current reports. It also explains how to see the "Data Freshness". It is important to know when the



data was last updated from each source. You can have many sites and it is important to know the last time the data from each site was updated.

Custom Reports

As a TeraSci customer we will support you with custom reports free of charge. That is part of the contract you sign with us. Our data engineers are experts on the schema for our DB and they can quickly create new reports. We will work with your managers and engineers to help organize data into meaningful reports that fit your needs.

Portal Library

This area of the Portal contains documents that help you understand: our process, the platforms, the commodities tested, the database field definitions, the canned reports, and specific areas of concern such as industry standards for Data Sanitation and other areas. There are things like work instructions for training your operators, Linux cheat sheets to help understand the Linux OS, and specific instructions for your IT department to understand our security model. Again our VP of Customer Service James Meece can assist you in finding the documents that best fit your current needs.

Platforms

Our platforms are what most people think about when picturing test equipment. But in our view a test platform does not stand alone. It must be part of a larger overall system to be most effective. We have very low cost sites with as few as one platform that tests around 100 units per month. But everything that is explained in this document supports that single platform. It is this full infrastructure that allows that single low cost platform to be as accurate and effective as sites with hundreds of platforms and large engineering staffs.

Of course it is fundamental and extremely important for the platform to be precise and high quality. We build platforms for many commodities and we add new platforms almost monthly now. We are in the technology business and migration is ever accelerating. Computers have become Chromebooks, pads, tablets and phones. Storage has moved from hard drives to solid state and solid state has evolved from ATA or SAS to USB, NVMe, IPM, SD, EMMC and more. The same is true for most other commodities.

20 years ago test platforms were Intel computer based desktops. A decade later those were replaced with small form factor Intel systems. Today both of those are too large, too power hungry, and too expensive. They take up space, consume hundreds of watts, and those things cost you money. Today we don't need keyboards and monitors on every platform. Again too much power and space.

We need the processes to run unattended. Low cost means operators that make few to no decisions and can be trained in minutes not days. That is part of the key to cost savings while still maintaining high quality standards.

Our platforms are migrating to ARM based systems. These are very powerful computers, very small form factors, very low power consumption, with a full Linux OS, Gigahertz processors, gigabytes of memory, EMMC boot storage and Gigabit Ethernet connections. Many of these system are 2 inches wide by three inches long and 1 inch high. They consume less than 5 watts and don't need fans for cooling. There low cost means we don't fix them in the field (and neither do you) we replace them with a spare that is kept at your site. Our update model explained above means they



can be configured on site in minutes and upgraded to the latest level (run the Setup script).

Keep in mind our model is that the platform computer (this time an ARM SOC) mounts to the site server at boot time. This means these ARM systems do not need HDD or SSD storage. Data is retrieved from and stored on the site server. Many of these ARM systems do not have keyboards, scanners or Monitors. They boot and run the software automatically. A single station (could be another ARM system) with a monitor, keyboard and scanner can control a dozen ARM platforms. The primary role for the operator is logistics. Moving test units onto and off of the platform.

Some of these ARM systems have: a USB bus, a PCIe bus, SM Bus, GPIO bus and many other connection options. We take advantage these standard interfaces to build connections for new commodities. When testing computer based peripherals and subsystems (storage, PSUs, batteries, plug-in cards and many other commodities) we have a single software package called “test”. This package tests all of our existing commodities and adding a new commodity is made much simpler by having this basic structure. Everything outlined in this manual is commodity agnostic, most of the software in our “test” program is commodity agnostic. We already support many commodities with various interfaces so adding a new commodity can be as simple as a few changes to one of the existing interfaces. This is how we can rapidly add new devices to our testing portfolio.

Our engineering team regularly designs a new schematic, does a new PCB layout, sends this out for FAB and gets back a new board in less than a week. Our software teams take advantage of the existing software infrastructure we have outlined and can add the new PCB to our system in a few days. We can then ship this to the sites for implementation. This can be something as simple as a new “connector adaptor board” or as complex as a new interface. This is not a discussion of possible – we have been doing this for years.

Advantages of Leasing

Having outlined our approach it should be obvious that our system is not a static solution. There are not parts we can “break out” and sell. Our systems are holistic and requires our support and software engineers. We believe “data” is the only way to manage complex systems, especially when the goal is low cost and high quality. We also believe, because of 30 years of experience, that ATE equipment is transitory. It becomes obsolete very quickly. Sometimes even before you can amortize the purchase price.

Just as important as obsolescence are scaling issues, you may be testing a commodity with a given interface today at high volumes and tomorrow your volumes are higher but the interface has migrated to different tester. The old testers are still needed but that volume is now quite low while your incoming units need a new tester with different interface. This discussion could be about a plug-in card, a battery, a storage device or a Smart Phone. It’s all the same. You need to keep up with the ever changing world of technology. Even 20 years ago we recognized this model. We started out with the approach outlined back then. Now we have a couple of decades of experience in this area. It is not hard to see that the migration is even accelerating.

Leasing lowers your cost of entry, it isolates you from obsolescence, and just as important it allows you to scale up and down as needed. Cost of entry is both the equipment cost and the engineering and software development side. It is not hard to see all of the investment we have made in software infrastructure over the years. You may not duplicate our scheme in its entirety, but you will need most of the functions to support low cost and high volume processes.

If you go out and purchase the equipment and software you will need expensive engineers to set it up and maintain the system. But this will not isolate you from: loss of contract, changes in volume, and product migration.

In our model you lease what you need. If your volumes change you can change the mix of equipment (platforms). We can ship you a new platform and you can be operational very quickly. You do not have to bring up “new” hardware or create new software. Our hardware is plug and play.

These are a few of the advantages of a lease based model.

Fully Interconnected Approach

Standalone test systems are still quite common. There are many available on the Internet. They have the advantage of low cost, most are “programmable” and many provide an output (generally text files). For most of these support is sketchy at best and spares may or may not be readily available. You will need someone to maintain and repair them. If you intend to do any volume of substance they will wear out (our systems are the same – connectors have only so many insert and remove cycles). You are generally testing defective parts and that means they can short out and blow up a tester. This is all a normal part of the game. As new generations of devices ship there is always the NPI (New Product Introduction) issues. This means the interface has been altered in some subtle way. You will have to figure out why these units are all failing.

We have addressed these issues for years. The ability of our support team to log into your site and connect directly to a platform allows us to run special built in diagnostics and trouble shoot the equipment quickly. It’s not that your team can’t do this, we will train you how, but it’s about the best use of your time. Each platform has its own set of complicated diagnostics. A lot for your team to learn and remember. It’s just faster for us to do this. Once we have identified the issue we send an email telling the engineer, a supervisor or in many cases the operator which part to replace with an onsite spare.

Our DB reports are automatically generated and some of them are intended to address just these issues. We run yield reports looking for specific problems. For example NPIs generally do not hit in big volumes immediately and so no one notices that a specific part number has 100% failure rate. Our reports notice this and are designed to look for other issues such as spikes and trends. Sometimes these show up in only some regions at first, but the fact is this is normal. If you are testing 10,000 units a month and a few part numbers have zero or low yield a general yield report will not see this. The idea is to get this problem resolved before the



large volumes hit your site.

The same is true for operator reports. These can show operator training issues. A new operator can alter the yield but if they are only 1 in many operators you may not see the immediate consequences. This can cause both yield and quality problems. We can log into a platform and watch an operator run the system. They are not aware we are watching and this helps us once a report has flagged an operator issue. Sometimes this is the only way we can figure out exactly what they are doing. Once we know we send an email to the site engineer or supervisor to re-train that operator.

Whether you are a single site or a collection of worldwide sites all of the above pertains to you having a low cost, high volume, high quality process.

Database driven testing is the key to success with today's complex technology.

Summary

We hope that the information we have supplied here shows that we are committed to forming a long term partnership with our customers. We are not in the business of making a short term sale. We have been in business for decades with this model. We believe we are experts in our area and we look to partner with experts that need our services. Together we hope to form a business model that is profitable for both of us.

Our contracts are very simple. We do not have upcharges, the monthly lease costs are all you pay. The monthly lease costs cover all the items we laid out in this document including spares, upgrades, new interfaces and adaptors, effectively everything you need to keep the testing side of your business viable.