Bringing Thermal and Integration Expertise to ATCA Systems

Radisys Platform Services Harden Systems, Reduce Risk and Accelerate Time-to-Market

Overview

Realizing all the benefits from using standards-based Advanced Telecommunications Computing Architecture (ATCA) components requires a combination of telecom and ATCA expertise. Two key benefits, improved modularity and multi-vendor compatibility, are predicated on solid thermal design and system integration practices, often derived from years of industry experience. Such best known methods (BKMs), complementing the modularity and capability guidelines built into ATCA specifications, enable developers to achieve higher levels of system performance, robustness and reliability.

PICMG 3.0 provides one-stop shopping for ATCA specifications, including detailed support material to enable more choice and interoperability of components at multiple levels of the solution stack. However, there's no guarantee that multi-vendor ATCA components will flawlessly work together for all applications and targeted conditions. As a result, equipment manufacturers need to conduct thorough thermal characterization and perform rigorous integration testing to ensure system stability.

As telecom companies transition from proprietary to standards-based architectures, some are now saving resources and capital by outsourcing critical design and validation tasks. Radisys is providing these services and helping telecom equipment manufacturers (TEMs) reduce risk and ramp up on ATCA, decreasing development cycles that can take up to three years down to just 12 to 18 months. This paper reviews many of the thermal design and system integration practices developed by Radisys over the last 20 years.

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Thermal Integration

ATCA is founded on a comprehensive set of specifications aimed at promoting interoperability, including requirements for thermal engineering such as the parameters under which vendors should measure airflow. It provides a range of values for acceptable board impedance, a measure of a board's resistance to airflow, which is useful information when conducting performance tests. The PICMG 3.0 defined airflow direction and distribution provides assistance to board designers seeking to maximize board cooling. In support of ATCA, the Communications Platforms Trade Association (CP-TA) publishes thermal guidelines and develops interoperability test tools that enable vendors to speed up design and increase their confidence in interoperability.

However, these specifications and guidelines alone don't ensure that all components will work together perfectly. Sometimes there are unforeseen challenges, as each chassis configuration has unique thermal dynamics. For example, the airflow volume through a specific slot depends on the impedance of the board it supports as well as the boards in nearby slots.

Although airflow across actual system boards is turbulent, some vendors publish commercial airflow data that is based on unrealistic laminar flow test boards with minimal impedance. When specifying performance, most vendors only list results for the maximum achieved airflow, which is actually a transient operating condition that isn't necessarily indicative of normal operation. Despite the comprehensiveness of the ATCA thermals specification, TEMs still need to characterize their system as a whole under real world conditions. They should also consider using simulation tools to assess worst case conditions and system response to faults.

Simulation Tools

Boards and chassis performance are tightly coupled and it's important to address their thermal requirements from the perspective of system-level interoperability. Simulation tools are critical for modeling thermal interactions between various components at the board, chassis and system-level.

Function	Thermal Design and Simulation Tools
Mechanical CAD	• PTC Pro/Engineer • Windchill (Content and Process Management)
Thermal Simulation	• FloTherm (Mentor Graphics, formally from Flomerics)
Thermal Testing	• DegreeC Blade Profiler (Wind Tunnel) • DegreeC Chassis Scan (Airflow Characterization) • Flir Infrared Camera • DegreeC Airflow Measurement Systems • Multi-Channel Thermocouple Data Loggers • Thermal Test Chambers

Table 1. *Thermal Design and Simulation Tools*

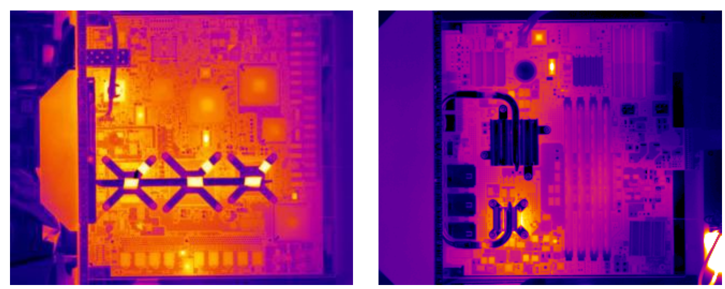

Figure 1. *Board-Level Thermal Simulation*

During board and chassis development, Radisys uses a suite of the thermal design and simulation tools, including those listed in Table 1.

Board-Level Thermal Simulation

Thermal simulation tools, such as FloTherm from Mentor Graphics, are essential for optimizing component placement on a board. The FloTherm simulation results in Figure 1 show two design placement iterations of a 13U board. The initial simulation run, left board, indicates multiple components are too hot (in red) while others are receiving more airflow than needed. The airflow is bypassing hot components and flowing instead through other sections of the board, and/or the airflow is being preheated by other parts. This component placement is disrupting airflow and concentrating high powered parts in too small a space. Following some board layout changes, right board, a subsequent simulation run shows the improved placement balances airflow and heat dissipation, leaving a smaller number of devices requiring additional attention.

Chassis-Level Airflow Simulation

Simulation tools can model chassis thermal characteristics from various angles, as the 14-slot 12U chassis loaded with uniform impedance blade models in Figure 2 shows. The front chassis view (left side) shows the airflow is relatively uniform even across the blades, except at the outer slots, where blue indicates a relatively low level of airflow. The side chassis view (right side) again indicates the airflow is mostly uniform through the chassis; however, the rear of the front blade has more airflow than the faceplate side. This information identifies the worst-case locations that warrant the majority of the analysis time and is taken into account during system-level simulations.

System-Level Thermal Simulation

The greatest payback from system-level thermal simulation occurs before the chassis and blade components have all been designed, because expensive redesign iterations can be prevented. Typically, once the chassis and blades exist, it's easier and more efficient to test the physical system-level configuration in the lab and then use simulation tools to help analyze the test results.

With its models of the boards and chassis, Radisys can assemble a chassis (in CAD) with CPU blades installed. Blade-level thermal models are 'installed' in a chassis model, and the simulation computes the airflow through the assembled chassis, as shown in Figure 3. The simulation allows the developer to walk through the chassis as a slice, represented by the purple plane going through the chassis, and look at any particular location within the chassis. This detailed and comprehensive perspective helps developers optimize component placement on the board—while it's being designed and before it's built—and see how it will run in an actual system. Simulations may be used to predict system behavior under different operating conditions, like full board power and decreased airflow to reduce system noise.

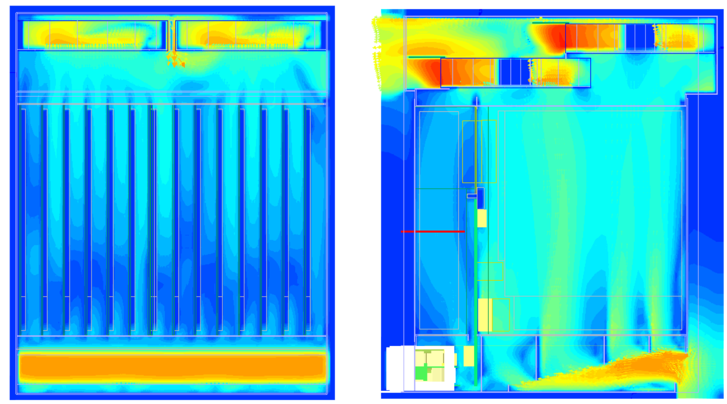

Figure 2. *Chassis-Level Thermal Simulation*

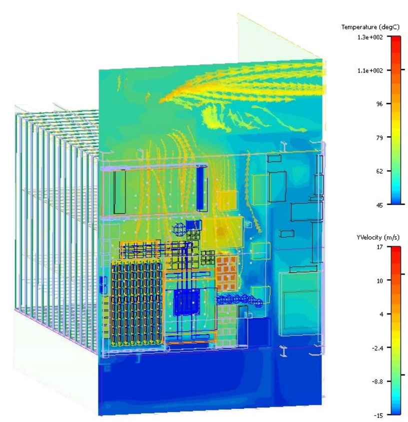

Figure 3. *System-Level Thermal Simulation*

Simulating Various System Conditions

The previous section discussed how airflow across the board is affected by the chassis structure and board topology, but it's also important to simulate system behavior under more difficult conditions. Some of these conditions may have been identified during the board and chassis simulations, like the highest power board, the worst chassis slot and the worst interacting neighbors. Various conditions, such as maximum power consumption, may be difficult to reproduce in the lab, but they can easily be simulated. It's also possible to simulate a component failure, like a faulty fan, or service procedures like rear transition module (RTM) removal and fan tray replacement.

A simulation of a fan failure on a computing blade is shown in Figure 4, where the temperatures of two CPUs are monitored. The simulation models the entire service procedure, from fan failure through to the fan tray replacement, including opening the chassis service door, which drives the temperatures to their highest levels.

Generally, determining the absolute worst case conditions can be difficult because of complicated component interactions; however, simulation tools usually enable developers to evaluate a wide range of system configurations and operating conditions more easily than through lab testing. With their board and chassis models, Radisys can simulate most combinations of their board sets, chassis and operating environments.

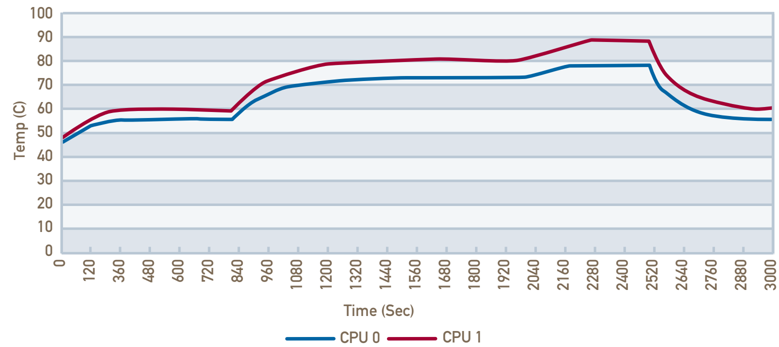

Figure 4. *CPU Temperatures During Service Procedure*

Thermal Testing Lab

As developers transition from design simulation to prototype testing, the Radisys onsite environmental lab is used for board-level and system-level testing. Figure 5 shows three of Radisys' chambers, including one that's large enough to test a 16 slot system and manage the heat produced by a system running at maximum power. The chambers support full environmental testing at the shelf-level over all temperature and humidity ranges.

Figure 5. *Radisys Testing Chambers*

System Integration

System integration testing, like thermal integration testing, is essential for ensuring component modularity and multi-vendor compatibility. System integration is more than simply standards-based compliance testing, because system engineers must understand the entire system in order to identify interoperability and compatibility issues and coordinate resolution with partners.

How does system integration testing differ from plugfests? Plugfests primarily address basic interoperability from electrical and management perspectives, whereas integration testing covers more functional areas, such as security and resource provisioning and other system behaviors, like performance and throughput. Additionally, system integration testing must be capable of testing large configurations, systems too big for plugfests.

Developed over a number of years, Radisys system integration capabilities are particularly applicable to standards-based architectures like ATCA. System engineers and experts at Radisys come from different disciplines and have hundreds of years of combined experience. They can track down and fix unexpected interactions between hardware, drivers, operating systems and middleware, even if this means coordinating the necessary vendors to find the underlying problem. They have worked with ATCA since its infancy and contributed to the foundation specifications. This integration and interoperability experience is invaluable for identifying and resolving issues early in design phase. The team is constantly improving test coverage, increasing test efficiency and lowering cost, and their broad perspective enables them to view systems like a TEM.

System Integration Methodology

Finding and fixing defects requires a robust integration test methodology, capital intensive test tool infrastructure and resident system engineering expertise. The Radisys methodology meticulously tracks defects and subsequent reconciliatory actions and reduces risk by quickly identifying reliability, performance and compliance issues. The Radisys system product verification (SPV) team focuses on many system aspects, including feature/function validation and reliability, and also on standards-based requirements affecting the system like interface specifications from PICMG, IEEE, SAF and IETF.

The verification methodology ensures the interoperability between Radisys, ecosystem and custom TEM products. In addition to verification, Radisys performs stress testing and performance characterization in a manner that fully comprehends custom configuration requirements. Table 2 lists the Radisys integration testing focus areas.

A typical ATCA system test cycle lasts four to eight weeks, depending on product content, and comprises 30 to 50 tests. The release features are defined well in advance and managed through a formal release management process. The tests are executed in two phases, a full test suite followed by regression testing, and focus on four areas: release stability, functionality, compatibility and upgrades. The test cycle is process driven and the formal exit criteria are developed by a multi-functional team that includes Radisys quality, operations, service, engineering and marketing personnel.

Test Infrastructure

Radisys test infrastructure provides a framework of utilities and modules that promote the rapid development of system test cases and scripts, maximize system test coverage, guarantee repeatability and support ecosystem products and custom features. The modules, written in Perl, are complemented by a substantial suite of test cases. Many test cases are automated, using companion test scripts, and some tests are manual for cases when automation is not a practical option. Some of the scripted test cases include Ethernet traffic and storage (e.g., Fibre Channel). Overall, the Radisys suite of system tests covers over a dozen categories of functional, performance and reliability tests, with specific examples listed in Table 3.

Integration Testing Focus Areas
• Functional verification of system features • Performance verification and characterization • System stress and system stability • Customer configuration and use cases • Third party compatibility • Software upgrades • Customer deliverables (distribution CD, documentation, etc.)

Table 2.

System Test Case Category	Examples
Power, Mechanical and Cooling	• Verify cooling characteristics across blades and throughout chassis
Shelf Management	• Exercise IPMI, HPI, hot swap and failover mechanisms
Networking (Ethernet) and Storage (SAS/SATA, Fibre Channel, iSCSI)	• Check network links and verify all components can operate storage pool
Network Timing System	• Verify components are reporting status
Layer 3 Routing	• Test Layer 3 routing of ATCA switches
Third-Party Interoperability	• High-availability managers
Reliability	• Reliable boot, operability, failover and switchover
Performance	• Latency, throughput, benchmarking, virtualization
Customer Deliverables	• Compatibility, documentation, upgrade process
Datapath Test Cases	• IPsec, NAT, tunneling
Use Case Scenarios	• VoIP, streaming server

Table 3. *System Test Case Examples*

System Test and Interoperabilty Lab

Radisys has a specialized lab to serve the demands of rigorous testing and tight deadlines. There are over a dozen racks filled with a mix of 2, 6, 14 and 16 slot ATCA chassis, from both Radisys and ecosystem partners. Remote lab access permits off-site test monitoring, and during system test cycles, environ-mental chambers are used to further evaluate and characterize system performance.

Radisys can build unique configurations and recreate custom environments during test cycles. Their lab has a full complement of industry standard test equipment, including traffic generators, Ethernet, clocking, fibre channel storage and a host of analyzers. The test lab also has an up-to-date selection of ecosystem ATCA products, including switch blades, chassis and shelf managers, CPU blades, advanced mezzanine cards (AMCs), high availability system managers and customer propriety equipment. This wide assortment of test equipment and ATCA components represents a significant capital expenditure, one that TEMs can fully leverage when they partner with Radisys to meet their platform requirements.

Faster Equipment Deployment

TEMs are finding that equipment based on open-standard architectures typically costs less to deploy because it makes sound economic sense to design scalable platforms that can be employed across multiple applications. Yet, to fully realize the true benefits of ATCA equipment, manufacturers have realized it takes a combination of telecom and ATCA expertise to bring all the elements together—chassis, blades, operating system, middleware and platform management software—and make these components play together better.

With over 20 years of experience in standards-based architecture, Radisys offers testing services that can speed up the development and deployment of telecom equipment and allow TEMs to focus on higher value-added areas. Radisys is helping TEMs get to market faster and at less cost by finding and resolving problems early on, enabling cleaner lab trials, absorbing capital costs and substantially reducing risk. As telecom companies transition from proprietary to standards-based architectures, some are now saving capital, resources and time by leveraging Radisys thermal and system integration testing services.

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