Thermal Simulation Helps Redback Networks Create First Million-Subscriber Platform for Triple-Play Broadband, Phone and TV Services

Redback Networks sets out to create the first million-subscriber platform for triple-play services such as high definition television (HDTV), high density video on demand (HD VoD) and broadband mobility. To obtain this improvement in performance and functionality, power dissipation of the line cards increased twofold relative to the previous generation. This created a thermal management problem since key application specific integrated circuits were already close to their junction temperature specifications. Redback Mechanical Engineer Wendy Lu overcame this challenge by simulating airflow and heat transfer within the enclosure. By optimizing plenum geometry and using a higher performing fan, she was able to double the system airflow. The new platform is just going into production but it has already been selected by one of the top 20 telephone carriers in the world, ChungHwa Telecom (CHT) of Taiwan.

Fifteen of the world's top 20 telephone carriers use Redback's SmartEdge router platform to deliver a mix of broadband, phone and TV services to more than 50 million subscribers. AT&T, British Telecom, China Telecom, China Netcom, ChungHwa Telecom, eAccess (Japan), France Telecom, Korea Telecom, Telefonica, and Turk Telecom are among the more than 200 carriers deploying SmartEdge worldwide. The new SmartEdge 1200 provides twice the capacity for new video upgrades, extending triple-play services to broadband mobile networks and integrating up to six network applications in a single router. The new network applications include deep-packet inspection for peer-to-peer traffic management, advanced session border capabilities and network security for carriers and their customers.

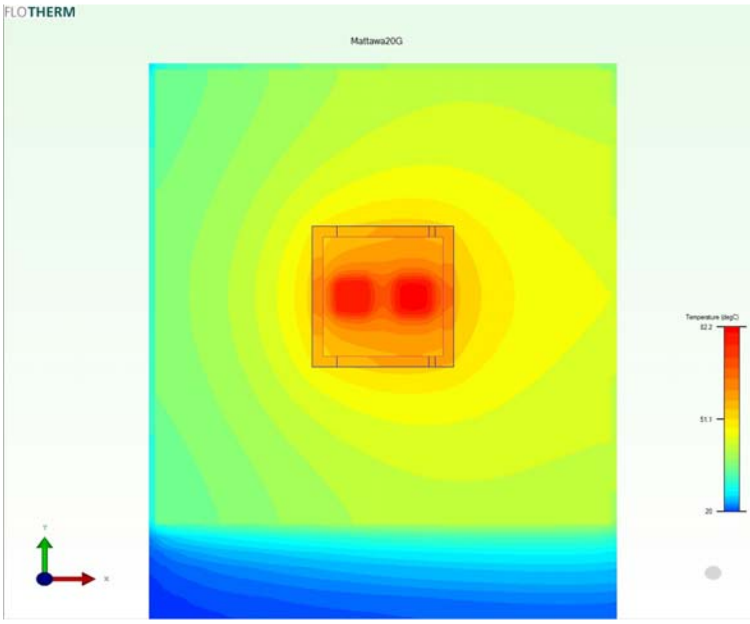

Figure 1: A typical surface temperature plot in FloTherm.

Thermal management challenge

The SmartEdge 1200 platform comprised 12 line cards total. Because of the substantially increased functionality of Redback's latest generation ASIC & hardware technology, the thermal profile for these new line cards are that of the previous generation. Since these routers are used in central offices, they have to meet strict National Equipment Building Systems (NEBS) reliability standards. Higher power dissipation translates to a necessary increase in airflow in order to maintain the same system thermal performance. The traditional approach to this type of thermal management problem would be to build prototypes then perform physical tests to determine system airflow and temperature. A major shortcoming with this approach is that thermal design can not began until after the first prototype becomes available. Each design iteration substantially increases the amount of time and money for modification and prototype testing. This approach runs the risk of delaying product introduction and higher development costs.

Redback Networks uses FloTherm, thermal simulation software from Flomerics, as part of the thermal design process. Due to the critical importance of thermal management in leading edge network equipment, Redback Networks engineers begin thermal simulation as early as possible during the design process. In the case of a new platform, a feasibility study is performed during the concept stage. A model of the enclosure, circuit boards, and system fans are created in FloTherm to estimate system airflow and temperature distribution within the enclosure. In the board design stage, a detailed model of critical components and heat sinks are created in FloTherm to ensure component thermal specifications are met.

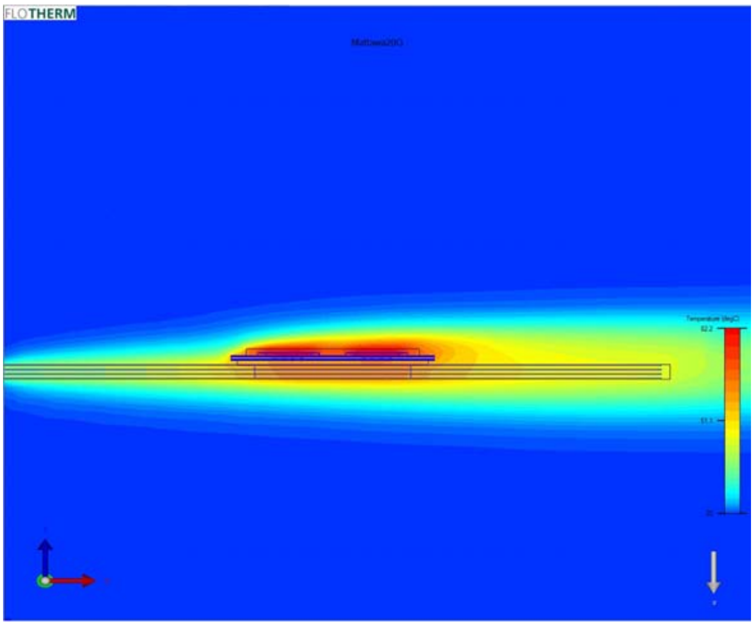

Figure 2: A typical side temperature profile in FloTherm.

Feasibility Study

It is of utmost importance during early design stages to create models and evaluate alternative designs quickly in order to provide timely results that remain relevant to the fast-changing design process. Redback's thermal engineer, Wendy Lu accomplished this goal by using simplified system and compact models.

To determine how the new generation line cards will perform in the previous-generation router enclosure, Lu performed a "virtual wind tunnel simulation." This wind tunnel model consists of a single line card in an air stream that matched the boundary conditions extracted from the system enclosure model. Critical components are modeled as compact models. These models are created using FloPack, a software from Flomerics that creates compact models using FloTherm modeling templates called SmartParts. Lu used a combination of 2-resistor and Delphi models for critical integrated circuit components. She modeled the printed circuit board (PCB) using the PCB SmartPart which allows the user to specify board size and layer count. Example, PCB layers are entered as FR4, signal, FR4, signal, FR4, power and ground. Based on this information, the PCB SmartPart will estimate the in-plane and through-plane thermal conductivity of the board.

The simulation revealed that more airflow is required for the critical components to stay within their thermal specifications. Moreover, it uncovered a problem with the component placement. A column of hot components created the chimney effect, in which an upstream component preheats the airstream before it reached the downstream component. Lu worked concurrently with the PCB designers to come up with a placement that improved thermal performance. But even with the improved board layout, Lu's model indicated that the junction temperatures were still too high based on the airflow conditions in the previous-generation product. The system airflow volume needed to increase twofold in order to bring component temperatures down to acceptable levels.

System level simulation

Lu began creating a system level model leveraging off the model from the previous generation of router. The system level model included additional compact models such as six 185cfm axial fans. These models were created by the fan manufacturers and posted on www.smartparts3d.com web site. Instead of using the detailed board model, a simplified resistance model based on measured airflow data of an existing board is created using FloTherm's modeling template called WebPart. Lu first tried improving the design by using a higher performance fan at 250cfm. Substituting this fan increased the system airflow by 50%, but it was not good enough.

Lu next looked at the enclosure geometry to determine if any improvements could be made. On the previous generation, the fan tray is located at the inlet creating a pressurized cabinet. Lu moved the fan tray to the exhaust side to pull a vacuum in the cabinet. This prevented the fans from preheating the air upstream from the line cards. It also provided a more balanced and streamlined airflow. The improvement in airflow is good but was still not enough.

Figure 3: Redback's SmartEdge 1200.

Optimizing the design

Next, Lu looked at the plenum geometry changes. The idea was to provide a bigger area for the air to expand into in order to reduce pressure drop in the chassis. Increasing the plenum area meant increasing the overall size of the chassis. The width and depth of the chassis are defined by the standard rack form factor so the only dimension that can be adjusted is the height. However, Lu also wanted to maximize the number of chassis per rack. By using FloTherm's Command Center, she quickly evaluated several different plenum geometries. The objective is to obtain the necessary airflow while minimizing the height of the chassis. The simulated results showed the optimized chassis plenum increased the system airflow 100%, the target level.

The detailed board model is now included in the system model simulation to verify that this volume of airflow can adequately bring critical junction temperatures to under maximum operating specifications. To meet NEBS standards, the router must operate safely with one fan failure. Lu performed additional simulations to evaluate different failure modes. The simulation showed that a fan failure caused airflow recirculation, which resulted in overheating over the affected region. Lu added a louver assembly to each fan, which automatically close the fan opening in case of fan failure. This effectively eliminated the recirculation problem. Lu then commissioned a foam core model of the new plenum so physical tests could be performed quickly in order to meet the tight schedule. The lab measurements closely matched the simulation results so no thermal design changes were required during the prototype phase. The resulting SmartEdge 1200 platform is expected to jumpstart a new category of megabit mobility devices.

For more information, contact Flomerics Inc. (US Headquarters), 4 Mount Royal Ave., Suite 450, Marlborough, MA 01752. Tel: +1 (508) 357 2012, Toll-free: 866.799.6147, Fax: +1 (508) 357 2013, E-mail: info@flomerics.com, Web site: www.flomerics.com