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PENGUIN COMPUTING

No Dummies in These Rollovers

RESEARCHERS USE COMPUTER SIMULATIONS AS A WAY TO EVALUATE LARGER NUMBERS OF VEHICLE CRASH SCENARIOS AND UNDERSTAND WHAT FACTORS MAY CAUSE INJURIES.

BY PETE BARTOLIK

Researchers have used crash test dummies in vehicle rollover tests for years to help them determine why these events have a higher fatality rate than any other type of crash. Now they are turning to high-performance computers, which researchers say are more practical and cost-effective when it comes to pinpointing elements in future automobile designs that could reduce injuries and deaths.

According to the U.S. National Highway Traffic Safety Administration (NHTSA), automobile rollover accidents account for 33 percent of passenger vehicle fatalities, resulting in more than 10,000 deaths annually. Any auto is potentially subject to rollovers, most of which occur when a vehicle is "tripped" by striking something low, such as a ditch or a curb.

NHTSA publishes annual rollover ratings data that indicates which vehicles have a higher propensity to trip. But determining how the vehicle performs in the event of a rollover and pinpointing design factors that contribute to the actual cause of death and injury are more complex. Physical testing of the vehicle can be costly and time-consuming, so researchers are turning their attention to computer simulations on relatively low-cost, massively parallel computer systems, which enable them to evaluate a significantly larger number of crash scenarios.

Such a system is in use at the University of Virginia (UVA) Center for Applied Biomechanics, where researchers are using a NHTSA-funded 10-node cluster of systems, each powered by two Dual Core AMD Opteron™ 2218 CPUs and running on Red Hat Linux. "Rollovers are increasingly a crash safety target," says principal engineer and graduate research assistant Dan Parent. He notes that much work has already been accomplished with front- and side-impact issues, but rollovers are becoming more statistically significant.

"Our goal is to take whatever information we have available, including full-vehicle models of various SUVs and cars, and run rollover simulations to figure out what the important injury-causing factors are," Parent says. "We use data from each physical test, which represents a single input condition, to validate models. In other words, we try to ensure that the model's prediction of the vehicle roof deformation as well as the motion of the test dummy is accurate. Then the model can be used to predict the roof deformation and dummy response in a much larger range of possible input conditions. For instance, we could run one rollover test at one velocity, ensure that the model accurately predicts the results, and then use the computer simulation to predict the results at different velocities."

"THIS (SOLUTION) ENABLES US TO ACCEPT RESEARCH CONTRACTS WE COULD NOT PREVIOUSLY ACCEPT."

—MARK MCCARDELL, COMPUTER SYSTEMS ENGINEER
UNIVERSITY OF VIRGINIA CENTER FOR APPLIED BIOMECHANICS

The center is using a system configured by Penguin Computing and running LS-DYNA software created by Livermore Software Technology Corporation (LSTC). According to LSTC, "LS-DYNA is a general-purpose transient dynamic finite element program capable of simulating complex real-world problems."

At the UVA facility, researchers use full-vehicle finite element models—complex descriptions of the geometry and material properties of a vehicle—and LS-DYNA to analyze parameters such as how fast the vehicle is rolling, how fast it's travelling when it starts to roll, the rate at which it drops before it hits the ground and so forth, says Parent. They're able to model how much a roof will deform and intrude into the occupant space, which is a crucial element in determining cause of injury.

"The next step is to take results from the finite element models and build full multibody automotive models," he adds. The center uses MADYMO software developed by TNO Automotive Safety Solutions (TASS), which includes models of physical test dummies and human body models that have been developed through biomechanical research conducted at universities around the world to predict the human body's response in an automotive collision.

SIMULATIONS IN HOURS RATHER THAN DAYS

Running these types of visualization simulations on high-powered individual PCs would take more than a week, according to Parent and Mark McCardell, a computer systems engineer at the center and de facto administrator of the cluster. An earlier "small test cluster" of five workstations proved disappointing, mainly due to latency issues with Gigabit Ethernet connectivity.

Although Gigabit Ethernet technology is fast for general business computing needs, "when you're doing massively parallel processing, you have a lot of communication going back and forth, and the latency of Ethernet was causing us to not achieve any type of time advantage whatsoever," McCardell recalls.

With funding from NHTSA and the UVA School of Engineering and Applied Sciences, the center was able to purchase a more robust cluster solution featuring InfiniBand switched fabric networking cards and switches, which McCardell says accounted for one-third of the total system cost. Penguin Computing was selected because of the company's familiarity with LS-DYNA and its ability to deliver a turnkey implementation. "All the other companies we dealt with would handle pretty much only the hardware aspect; when it came to actually installing applications and providing a turnkey solution, they kept on wanting to hand us off to another company."

The solution implemented by Penguin Computing called for a cluster with 24 processor cores encompassed in six nodes and utilized the high--speed InfiniBand networking. Each node is a rack-mounted server incorporating two dual-core CPUs and 8 gigabytes of system memory. The cluster also incorporates five 500-gigabyte hard drives in a RAID 5 configuration, for a total storage capacity of 2 terabytes. According to McCardell, the Penguin implementation was able to reduce the time needed to run these rollover simulations to three to six hours, due in part to the system's ability to use remaining nodes for smaller-scale analyses, such as modeling individual test dummies.

LEARNING AND GROWING CURVE

It wasn't all smooth sailing. McCardell says few people at the center had any experience with Linux, so he initially installed VMware so that researchers could run a simulation on a virtual machine within Microsoft Windows. But performance did not meet expectations, and the team realized that it needed to dedicate more of the cluster's nodes to a rollover simulation rather than divvying up computational resources among multiple projects.

The center's staff members hope to increase the size of the cluster in the course of the coming year. "We definitely need to expand; it's just a matter of funding," says McCardell.

That's not to say they're not pleased with what they've got. "This enables us to accept research contracts we could not previously accept because we didn't have the computational power to conduct these projects," said McCardell. Those projects are contracted with a range of clients, from auto manufacturers to parts manufacturers, to the military.

Adds Parent, "In the past, if we could run only one full-scale simulation a week, it was kind of hard to do any sensitivity studies. Now we can run several different cases under several different conditions to look at a wide range of inputs to figure out which variables are significant and which variables we can target to improve safety."

And that will save lives in future rollovers, even if there's a dummy doing the driving.

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