

White Paper  
Intel Labs

# ScienceSim

A virtual environment for  
collaborative visualization and  
experimentation

## Introduction

*If you want to explain the solar system to a child, a book or video is a good start. But it would be more fun, and more instructive, simply to take a trip around the planets.*

*Imagine lifting off from your rooftop and soaring into space, beyond the Earth's atmosphere. As you fly through the solar system, you zoom in and out between planets, viewing them from different angles, observing their size, orbits, and relative distance from one another, and watching as the Earth makes its annual rotation around the sun, compressed in time to a matter of minutes.*

The scenario above illustrates the potential of [ScienceSim](#), a virtual environment that can be used as a tool for visualization, education, training and scientific discovery. ScienceSim was launched in January 2009 by the ACM and the IEEE Computer Society community for the [Supercomputing 2009 conference \(SC09\)](#). Intel is collaborating with the conference organizers to develop the hardware and simulation infrastructure behind this world. One goal of this technology industry initiative, which Intel is sponsoring, is to provide a turnkey kit that researchers and others can download for free and use to develop innovative applications involving collaborative visualization.

## Beyond traditional simulation

Collaborative visualization goes beyond traditional simulation. "In the past, we've been able to do what might be called remote visualization, whereby one person creates a simulation and another person takes the output and creates a video that others can watch in order to observe what happened to the data," says Mic Bowman, the Principal Investigator from Intel who is leading Intel's research in support of ScienceSim. "Collaborative visualization takes that concept one step further, enabling several people to participate in building a simulation, connecting different sources of data in real time. Each person can have a different perspective of the simulation, enabling collaborators to focus only on the parts of a scene that are most relevant to them." While collaborators can develop a simulation jointly in real time, they also can contribute to the simulation at different times. In either case, the contributions accumulate on ScienceSim.

*ScienceSim enables researchers to conduct experiments that require visualization and analysis of large, complex data sets —the kind of "big data" that is the focus of supercomputing.*

ScienceSim is an ideal platform for researchers to conduct experiments that require visualization of large, complex data sets that are not easily understood or analyzed in a spreadsheet or report—the kind of "big data" that is the focus of supercomputing research. "The output of many supercomputing applications — from astronomical simulations to medical models — is complex and

often highly visual," says Justin Rattner, Intel's Chief Technology Officer. "Creating a persistent, standardized environment where these models can reside will make it easier to share and explore these data sets with other researchers."

The supercomputing community—specifically, the committee of the SC09 Conference—is leading the ScienceSim initiative. "This is a very sophisticated community that is accustomed to being on the leading edge and will push the boundaries of what's possible in virtual environments," says Jim Held, Intel Fellow and Director, Tera-Scale Computing Research. "We believe they will be pathfinders in understanding how to combine the 3D visualization, simulation and collaboration aspects of ScienceSim."

## Toward immersive connected experiences (ICE)

ScienceSim is part of an evolution toward online 3D experiences that look, act and feel real. Sometimes dubbed the "3D internet," Intel labs refers to this technology trend as *immersive connected experiences*, or ICE. This emerging category of computing usage models will enable people to share experiences and information online within highly intuitive, interactive visual interfaces.

The emergence of ICE applications in domains such as social networking, online gaming and online retail, is being driven by the convergence of five trends in Internet-based computing: widespread broadband connectivity and the visual data (photos, video, 3D movies, etc.) it enables; the rise of social networking; the emergence of user-generated content; the spread of mobile

## White Paper ScienceSim: A virtual environment for collaborative visualization and experimentation

computing and devices; and the growing popularity of visual, immersive virtual worlds.

Initial examples of ICE fall into two main categories: *simulated environments* such as virtual worlds, online multiplayer games and 3D movies; and *augmented reality*, which combines real-world images with digital information to provide an enhanced experience (Google Earth\* is a familiar example).

Intel is taking a leading role in advancing ICE technology and removing the technical barriers to its widespread adoption. To that end, we are conducting research in four key areas: platform optimization for the unique aspects of these workloads; technology that makes it easy for users to generate, use and share 3D content; improved architectures that make the distributed computation more scalable; and how to use mobile broadband connectivity, together with the camera, location and other sensors in handheld devices to make the mobile experience more immersive.

ScienceSim is one step along the path to this immersive technology future. "ScienceSim will help us to understand what's possible and needed as we move to larger scales and tackle bigger problems related to ICE applications that involve greater complexity and more data," says Held.

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## OpenSim: the engine driving ScienceSim

ScienceSim is differentiated from most virtual world environments by its open source architecture. Unlike proprietary virtual world platforms, such as Second Life\*, ScienceSim leverages open source building blocks (installation utilities, management tools, client viewers, etc.) based on [OpenSimulator \(OpenSim\)](#) software. "We're trying to leverage components that have already been built, such as identity, authentication and authorization, and storage of digital assets," says Bowman. "We want to bring to ScienceSim as many existing Internet standards and technologies as possible, and provide them as the core of a common set of technologies developers can use to build applications."

ScienceSim's open architecture enables developers to share modules, connect their virtual worlds with other worlds that run on the platform, and to leverage existing building blocks when

developing new applications, rather than having to build each component from scratch. "The OpenSim core team has been very successful in creating a modular interface, so it's relatively straightforward to swap out components," says Bowman. "That means, for example, that if I want a virtual space that's driven by n-body gravity or has different notions of how collisions act, or if I want a space that is highly specialized for the evolution of ferns [an existing application on ScienceSim], I can build those spaces. And I think that flexibility is critical to the success of ScienceSim."

*OpenSim's modular, open source architecture makes it easy to swap out components, change the behavior of objects and avatars, and leverage previous work to build new applications.*

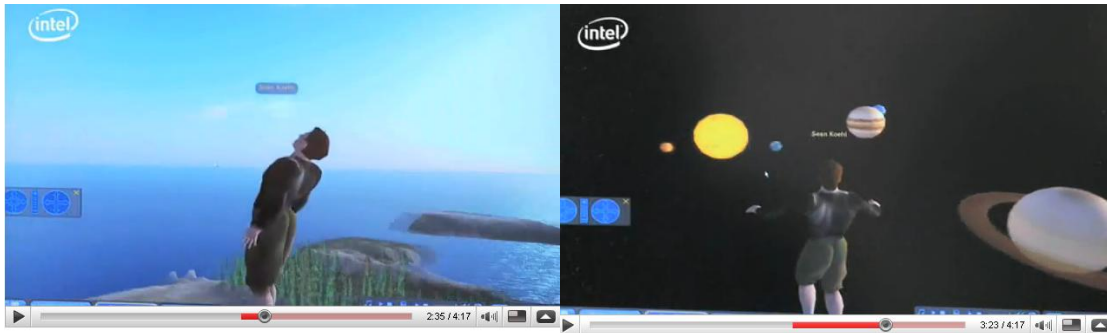
There are a variety of contributors to OpenSim; the diverse development community includes Intel, IBM\* and Microsoft\* as well as virtual world service providers and a large number of small companies. The fact that OpenSim is downloadable for free enables a broad range of developers to experiment with new applications and explore the innovations in distributed system scaling and interoperability required to support ScienceSim.

## A range of applications

ScienceSim could enable the development of a broad range of virtual world applications in domains as diverse as public policy, education, healthcare and business. One promising application area is serious games, such as training and "what if" scenario planning. For instance, Intel is collaborating with Sandia National Labs to build a game in which various constituents (developers, farmers, environmentalists, etc.) can visually explore the impact of different water management policies. The simulation provides realistic results that educate the players about the complex issues associated with water management, and offers insight into potential policies that address the needs of the various groups.

On a smaller scale, cities could use ScienceSim to simulate traffic patterns, or to bring together experts and data from different locations to solve problems that affect a range of constituents. For example, an urban planning group wants to combine the rich data about its neighborhood, including both structured data from the city and data from various residents, with traffic generating models, in order to examine the impact of different architectural models of buildings and other structures on noise reduction.

## White Paper ScienceSim: A virtual environment for collaborative visualization and experimentation



Screen shots from a simple educational application on ScienceSim—a model of the solar system.

**(Left):** An avatar prepares to launch himself into space from the rooftop of a building.

**(Right):** Avatars can fly around the planets, observing their relative sizes, movement and relationships to one

Education is another key application area for ScienceSim. Educators can leverage this interactive 3-D environment to explain complex concepts such as gravity, or the composition and movement of the solar system, as illustrated in the opening scenario. Such immersive educational experiences have the potential to engage students and enhance learning.

If the simulation models were sufficiently robust, ScienceSim might even be used to conduct complex virtual experiments in physics and chemistry, reducing the cost and eliminating the potential danger associated with real world experimentation.

The potential for other types of applications is far-reaching. In the healthcare arena, for instance, physicians might use ScienceSim to simulate the outcome of reconstructive surgery or visualize medical concepts, such as the impact of asthma or smoking on lung function, or how diet affects the circulatory system. Businesses could use ScienceSim to conduct highly realistic virtual conferences, or to collaboratively develop cars or other complex products. They also could leverage the platform to educate and train employees. For instance, the Fashion Research Institute\* has established several regions on ScienceSim and is using the platform to train students in fashion design.

We can only imagine what other applications will be developed on ScienceSim as the platform advances. This immersive environment, and the modular architecture of OpenSim, will support a broad range of usages. Just as the Internet spawned applications that could not have been foreseen years ago, such as the emergence of Facebook\* and Twitter\*, we cannot yet anticipate all of the potential uses for ScienceSim.

## Enhancing performance and scalability of OpenSim code

One of Intel's most important contributions to ScienceSim is our work in enhancing the OpenSim code to improve performance and scalability. Although OpenSim is functionally quite complete and stable, Intel's performance work is fine-tuning areas of code based on their actual impact on simulator performance. "We've contributed a number of patches back to the core OpenSim group that have made it run much more efficiently," says Bowman. "For instance, we've "increased the number of objects that can appear in a scene by a factor of 10. We have also reduced the memory footprint significantly, and we've made the packet processing more efficient, and many of the inner loops more efficient."

***Intel's work in enhancing OpenSim provides information about how virtual world applications affect our platforms —information we can use to optimize performance on Intel hardware and guide the development of new technologies for virtual worlds.***

Many performance improvements have to do with streamlining how, and how often, data is stored and accessed—a critical factor as scale increases. Much of the Intel team's analysis led to linearly iterated lists which created problems when the number of items grew into the thousands. The team replaced several of the core simulator data structures and operations, which had radically slowed performance, with more efficient approaches.

This performance improvement work has yielded a collection of design tools for building highly scalable virtual worlds. While most public virtual worlds are limited to thousands of objects and tens

## White Paper ScienceSim: A virtual environment for collaborative visualization and experimentation

of participants in an area, OpenSim can now support hundreds of thousands of objects. These scalability design tools are applicable to any virtual world implementation.

These OpenSim performance enhancements have a side benefit for Intel, according to Bowman. "Our OpenSim code work makes ScienceSim a more stable platform we can use to conduct other technology research," he says. "It not only allows us to test our ideas for improving performance and scalability, but it gives us information about how virtual world applications affect Intel's platforms, including their impact on power management and memory architectures. These applications have a very different compute signature that we want to understand and optimize for Intel hardware. We can also use that understanding to guide the development of new Intel technologies for virtual worlds."

## Building an architecture for decentralized virtual worlds

In addition to improving the OpenSim source code, Intel has launched a research initiative called Cable Beach, to build an architecture for decentralized virtual environments with multiple virtual worlds, such as ScienceSim. The goal is to promote interoperability—to enable sharing of authorization, content delivery and services across virtual worlds, based on common web protocols.

"Our goal isn't to create interoperability standards," says Bowman. "We're trying out new ideas and architectures, see how they fit together, then provide our key learnings to the organizations that are building out the standards work."

## The need for sustained collaboration

Since the launch of ScienceSim, a great deal of progress has been made, with many developers contributing applications and the OpenSim code much improved. "We now have a set of demonstration regions that capture some very complex sets of interactions and content," says Bowman. "And from Intel's perspective, we've learned a lot. We've been able to test some key ideas and develop relationships with other organizations that are trying to deliver similar kinds of immersive connected experiences around what standards are needed, and how to achieve interoperability."

As technology advances, we can expect to see ScienceSim applications enriched by the development of new, more intuitive

interfaces, including haptic interfaces, which convey a sense of touch, enabling users to "feel" the virtual 3D objects they are manipulating. Researchers are already experimenting with haptic interfaces for OpenSim.

In the meantime, Intel is continuing its active collaborations with the OpenSim and ScienceSim communities. "Just as the internet could not have evolved without an enormous amount of collaborative innovation, ScienceSim will require a broad, sustained collaborative effort," says Held. "I hope that this initiative will spark the imaginations of a large number of scientists, that they will realize the potential of ScienceSim to move far beyond today's virtual worlds, and will become engaged in advancing this initiative and other ICE experiments. We invite researchers and developers around the globe to explore, use and contribute to ScienceSim, and to participate in the OpenSim community. Having a global community of contributors will be essential to the success of these efforts."

## Learn more

For more information about ScienceSim, visit [www.sciencesim.com](http://www.sciencesim.com) and [www.intel.com/go/sciencesim](http://www.intel.com/go/sciencesim).

To learn more about OpenSim, visit [www.opensimulator.org](http://www.opensimulator.org).

For information about Intel's Immersive Connected Experiences (ICE) initiative, visit [www.intel.com/go/ice](http://www.intel.com/go/ice).

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