A Virtual Geant4 Environment

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Abstract We describe the development of an environment for Geant4 consisting of the application and data that enables users a faster and easier way to access the Geant4 applications without having to download and build the software locally. The environment is platform neutral and offers the users near-real time performance. The environment consists of data and Geant4 libraries built using the LLVM tools which can then result in bitcode that can be embedded in HTML and accessed via the browser. The bitcode is downloaded to the local machine via the browser and can then be configured by the user. This approach provides a way of minimizing the risk of leaking potentially sensitive data used to construct the Geant4 model and application in the medical domain for treatment planning.

Particle Therapy Simulation

The Particle Therapy Simulation Framework (PTsim) was developed as a Geant4-based simulation framework for radiotherapy of cancer treatment with a special focus on proton and carbon therapy.

The PTsim contains a software application for modeling a treatment port consisting of a beam delivery system and a treatment head with patient data obtained from CT images. The PTsim provides a class library for geometry description, material definition, optimized physics process setting, scorers, event level parallel processing, and so on.

The PTsim had already supported three Japanese proton and ion therapy facilities as well as three more in other countries. The PTsim allows particle therapy clinicians or researchers to simulate their own facilities or envisaged facilities without requiring Geant4 expertise or programming skills.

Virtual Geant4 Environment

A PTsim-based common platform for Monte Carlo dose calculation in Grid distributed computing systems has been developed. This platform allows medical physicists to separate dose large-calculations into many small-calculations and process them in parallel over the distributed systems. As a result of this approach, significant performance improvement in turn-around-time for dose calculation has been achieved while medical physicists are inside the clinical facility. It is, however, concerned that patient's personal information might be obtained by unauthorized or unexpected users in the cause of staging data on the distributed systems.

A Virtual Geant4 Environment consists of the application and data that enables users a faster and easier way to access the Geant4 applications without having to download and build the software locally. Therefore medical physicists do not need to copy data to the external storage systems. This approach results in more secure dose calculation.

In order to run applications with this environment, Geant4 class library has to be compiled by LLVM based toolchain, which is set of a compiler, a linker, and other tools, in advance. Then applications are statically linked and translated into the bitcode executable, which is an OS and architecture independent format. A bitcode is distributed as an embed object in the HTML. When users open the HTML and applications are downloaded, application code is verified, and translated into the hardware-specific code, which is able to run on Windows, Mac, and Linux, with nearly 90% of native speed.

Conclusion

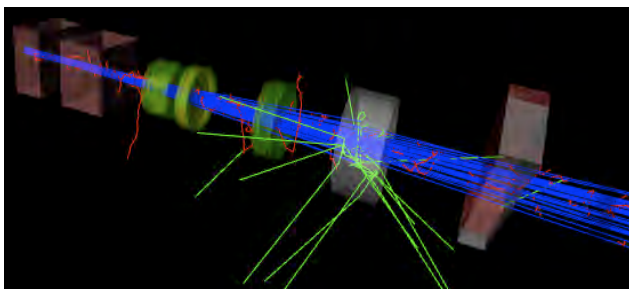
Existing Geant4 applications run in a web browser (Google Chrome™) without special modifications to existing code. Virtual Geant4 Environment allows medical physicists to run their applications securely on multiple platforms, i.e. Linux, Mac, and Windows, with near-native speed, which is 84% of regular 32-bit applications.

Future Works

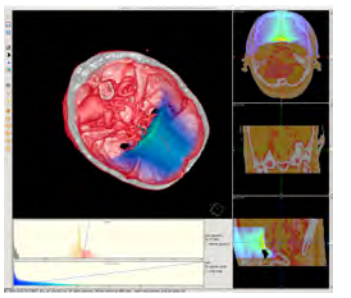
1. Multi-threading support
2. ROOT support
3. Better interface and visualization

Acknowledgment

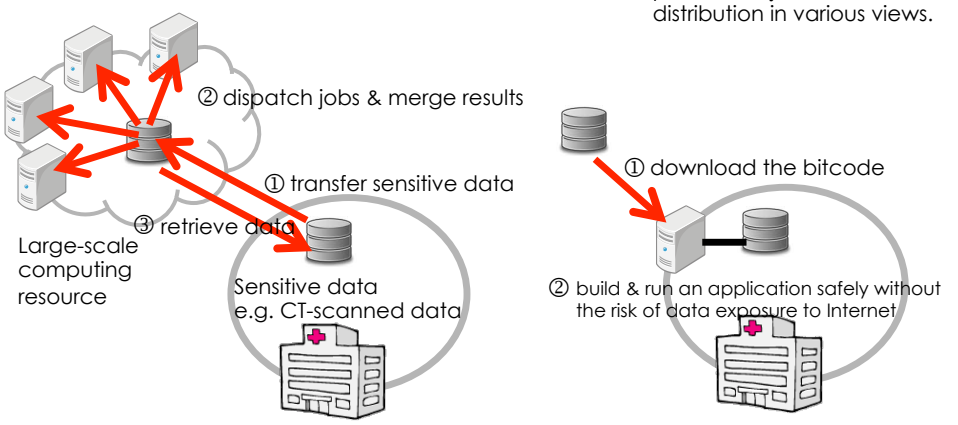
The Author would like to thank Adil Hasan, Centre for e-Research, King's College London, for his advice on English expressions.



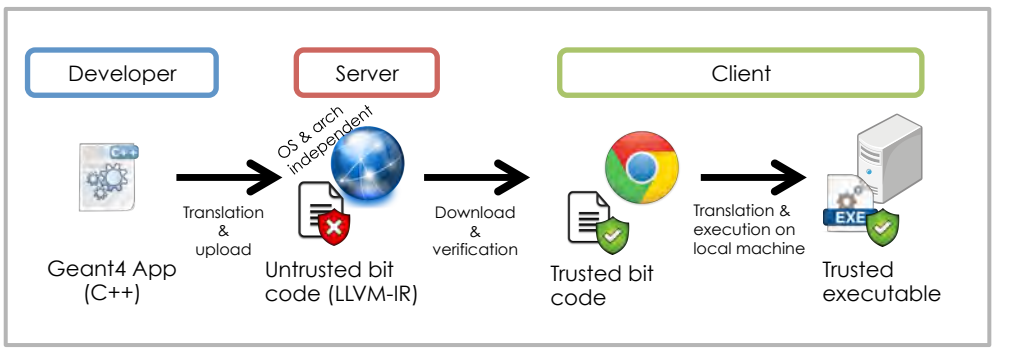
Treatment port modeled in the PTsim for the Hyogo Ion Beam Medical Center, Japan.



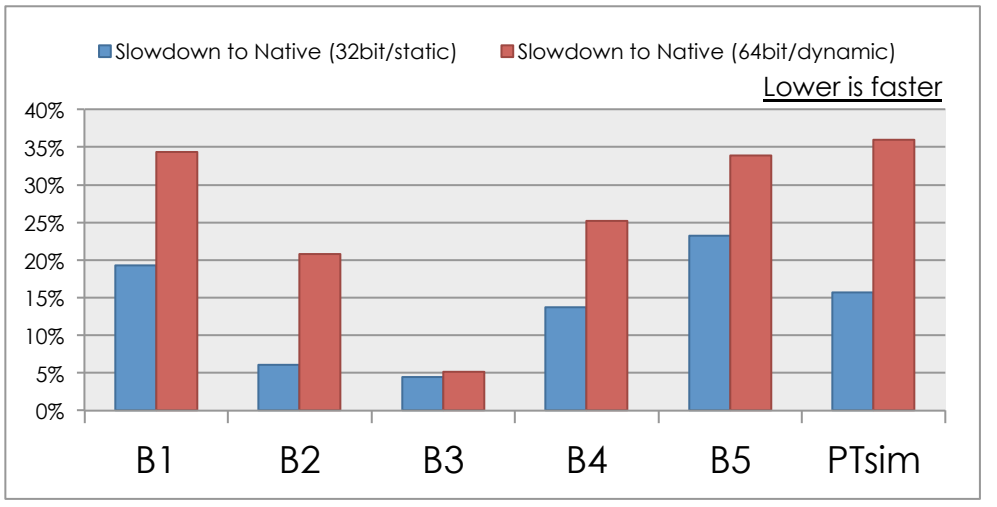
gMocren visualizes CT-scanned images and overlay particle trajectories and dose distribution in various views.



(a) PTsim Grid Platform (b) Virtual Geant4 Environment



Applications Delivery Sequence in the Virtual Geant4 Environment The environment consists of data and Geant4 libraries built using the LLVM tools which can then result in bitcode that can be embedded in HTML and accessed via the browser. The bitcode is downloaded to the local machine via the browser and can then be configured by the user.



Performance Evaluation Figure shows the benchmark result of Geant4 basic applications B1-B5 and PTsim. The blue bar shows the performance degradation of Virtual Geant4 applications to native applications statically built for i386 architecture and the red shows the performance degradation of Virtual Geant4 applications to native 64-bit applications dynamically linking to shared libraries. Average of performance degradation is 14% for static linking applications.