Motivation:
ADCIRC, a multi-scale, multi-physics coastal circulation model, is used to predict the effects of large storms approaching the coast. Under development for twenty years, the software has a large community of users including the US Army Corps of Engineers, NOAA, and FEMA.

With the recent availability of petascale compute resources and the introduction of new architectures, the ADCIRC community has recognized the need to revamp the underlying parallelization paradigms to take full advantage of the growing and quickly changing resource landscape.

By leveraging the scalability harnessed by HPX, an open source C++ runtime system, and improving the algorithms which provide the foundation of the model, the researchers will update the code base to be faster, more flexible, and sustainable for years to come.

Our Goals:
We aim to create a sustainable software infrastructure that will allow us to:
• Scale to at least 256k compute cores on modern HPC systems by utilizing HPX, a next-generation parallel runtime system
• Separate the tasks for load balancing, boundary value exchange, and IO from the scientific computations by using LibGeoDecomp
• Use multiple solution algorithms, such as discontinuous Galerkin methods, which promise to increase accuracy and fidelity in ADCIRC simulations.

Our Goals:
• Separate the tasks for load balancing, boundary runtime system
• HPX: a next-generation parallel runtime system
• ADCIRC: a coastal circulation and storm surge model. Used to predict flooding to hurricanes, simulate oil spills, and other applications

Broader Impacts:
STORM will have a large impact on the communities that it comes in contact with:
• The fundamental research in discontinuous Galerkin methods will be dispersed to the broader unstructured mesh and coastal modeling communities.
• In addition, other scientific communities which consume the hydrodynamic output of ADCIRC, such as biologists, ecologists, and coastal engineers, stand to benefit from the improved fidelity and resolution that these new methods can bring.
• This project also increases ADCIRC’s presence in Louisiana, as daily runs of ADCIRC are planned as part of the model’s ongoing development. Data from these runs will be made available to emergency managers and others working in the coastal zone including local fishermen and wetlands researchers.

Outreach:
• STORM Website
• Computer Science impacts: Presented novel technique for C++/Fortran integration at CANDAR’15, Sapporo, Japan in December 2015.
• HPX and LGD are both open source and available online (GitHub and Bitbucket, respectively)
• Presented a workshop for early dissemination of our goals and results with the AMS workshop Second Symposium on High Performance Computing for Weather, Water, and Climate, January 14, 2016.

Work so far:
• DGSWEM/HPX Code: Working DG version of ADCIRC using HPX and LGD libraries for parallelization. Scales well on a single compute node. Fortran physics kernels remain largely unchanged, interact with C++ libraries efficiently (no need to recreate complicated data structures in C++)
• Future work: Expand execution to multiple compute nodes, enable more physics features.

Community Engagement:
ADCIRC/HPX software stack

ADCIRC/Physics Modules
Application Code
LibGeoDecomp
HPX
ADCIRC
LGD: LibGeoDecomp, an auto-parallelizing library for computer simulations
HPX: a next-generation parallel runtime system
DG Methods: discontinuous Galerkin solvers for the shallow water equations
ASGS: ADCIRC Surge Guidance System, a software system for the automation of ADCIRC simulations
CERA: Coastal Emergency Risks Assessment. Website which presents ADCIRC results in an intuitive, interactive format.

Contact us:
Hartmut Kaiser, Joannes Westerink, Rick Luettich, Clint Dawson
1 Louisiana State University, 2 University of Notre Dame, 3 University of North Carolina, 4 University of Texas at Austin