ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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- **WEDNESDAY 9 DECEMBER 2015 - ROOM MA A1 10 - 16h15**

Dr. Fabien DELALONDRE (Blue Brain Project, EPFL, Geneva) will present a seminar entitled:

"Brain simulation: Review of used numerical methods and challenges for reaching extreme scale."

Abstract:
The Blue Brain Project (BBP) of the École Polytechnique Fédérale de Lausanne (EPFL) aims to build detailed reconstructions and simulations of the rodent and human brain.
At the cellular scale, the BBP uses the NEURON simulator [1] to model the electrical activity of large networks of morphologically detailed neurons. Each individual neuron is typically described by a model that couples the actions of localized membrane mechanisms with an electrical system described by the cable equation on a network derived from the neuron's dendritic tree. NEURON discretizes the electrical problem with a scheme derived from finite volumes. The system is then solved in time with an implicit Euler or Crank–Nicolson scheme, using Strang splitting to decouple the evolution of the mechanisms from the membrane potential [2]. Outside of gap junctions, neurons are coupled chiefly by spike exchange taking place at network minimum delay time, which allows for excellent weak scaling at large scale (786 thousand cores and 3.1 million threads) [3]. At the subcellular level, the BBP uses the STEPS simulator [4] to model the reaction-diffusion of systems in complex geometries. STEPS uses a new operator splitting scheme that couples the exact Gillespie SSA algorithm for the reaction Markov-jump processes with a distributed diffusion, allowing the modeling of stochastic reaction–diffusion process in large tetrahedral meshes. The first parallel implementation has been shown to scale up to approximately one hundred cores [5]. As the next generation of supercomputers are expected to present an additional order of magnitude of node-level parallelism, it is necessary to review the numerical schemes used in both NEURON and STEPS in the context of petascale and exascale computing. In this presentation, we will first present a detailed review of the methods used in each simulator before describing the challenges associated with extreme scale computing. Finally, based on this analysis we will propose future areas of research and development in the field of numerical methods as applied to computational neuroscience.

[1] N.T. Carnevale, and M.L. Hines, The NEURON book, Cambridge University Press, 2006.
[2] M. Hines. "Efficient computation of branched nerve equations", International journal of bio-medical computing 15.1 (1984): 69-76.
[3] A. Ovcharenko, P. Shivaj, M.L. Hines, F. Cremonesi, T. Ewart, S. Yates, F. Schuermann, and F. Delalondre, Simulating Morphologically Detailed Neuronal Networks at Extreme Scale, ParCo15 Conference, Edinburgh, Scotland, 2015.
[4] STochastic Engine for Pathway Simulation (STEPS) website, http://steps.sourceforge.net/STEPS/default.php
[5] C. Weilang, I. Hepburn, S. Yates, Parallel STEPS: Simulating reaction-diffusion and electrical field on distributed systems, Human Brain Project Summit, Madrid, 2015

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