

# ppOpen-HPC

**Open Source Infrastructure for Development and Execution of Large-Scale Scientific Applications on Post-Peta Scale Supercomputers with Automatic Tuning (AT)**

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**Software Engineering for Computational Science & Engineering**  
**SC15 BoF, November 18, 2015**  
**Austin, Texas, USA**

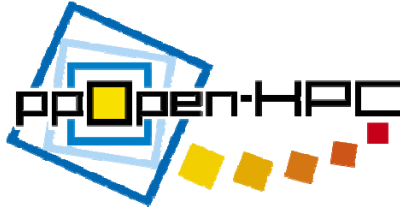
# Post-Peta CREST

## Development of System Software Technologies for Post-Peta Scale High Performance Computing

<http://www.postpeta.jst.go.jp/en/>

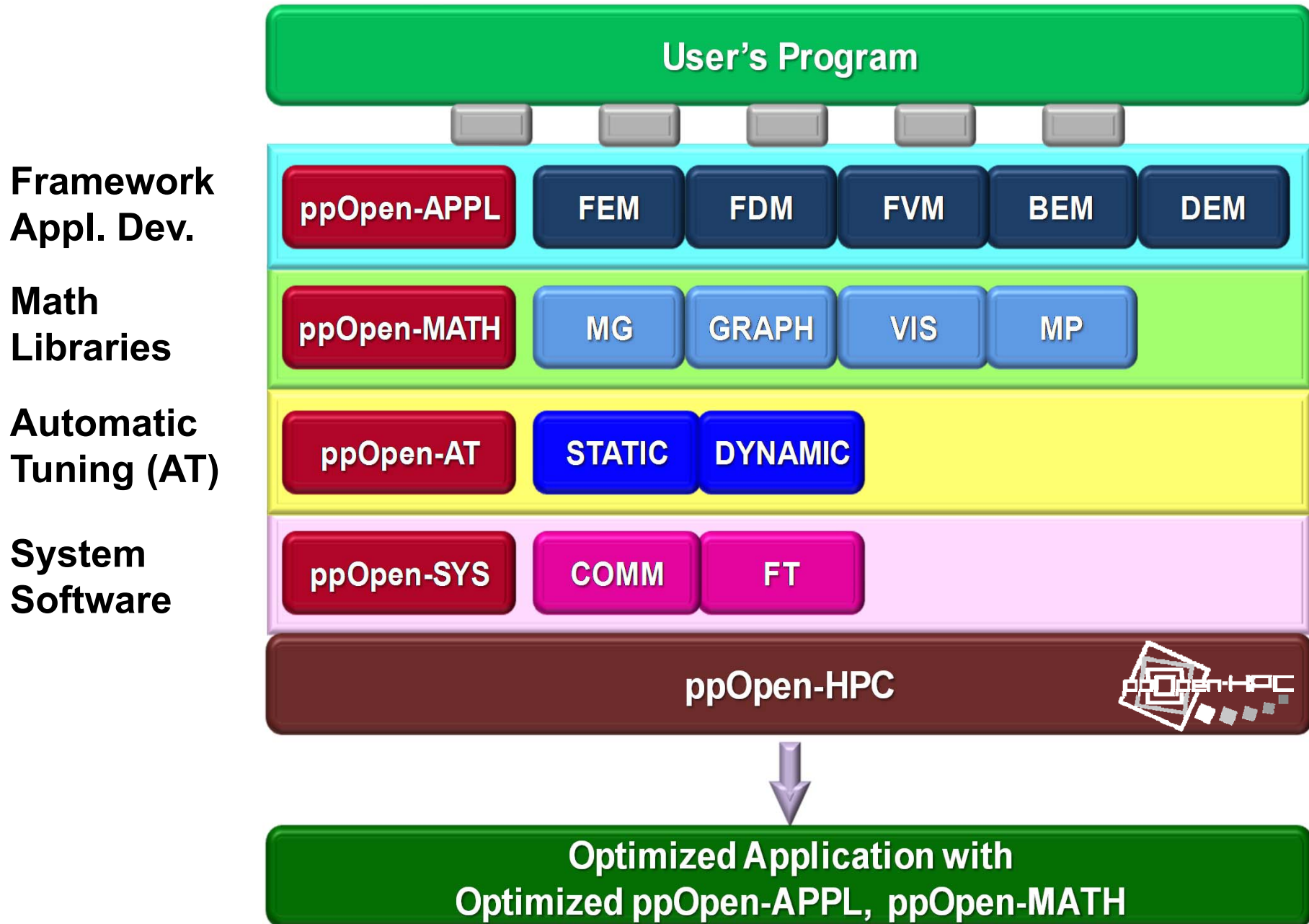
- Objectives
  - Co-design of system software with applications and post-peta scale computer architectures
  - Development of deliverable software pieces
- Research Supervisor
  - Prof. Mitsuhsa Sato (RIKEN AICS)
- Run by JST (Japan Science and Technology Agency)
- Budget and Formation (2010 to 2018)
  - 55M-60M \$ in total
  - Round 1: From 2010 for 5.5 year (5 Teams)
  - Round 2: From 2011 for 5.5 year (5 Teams)
  - Round 3: From 2012 for 5.5 year (4 Teams)

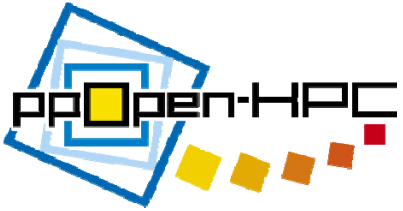




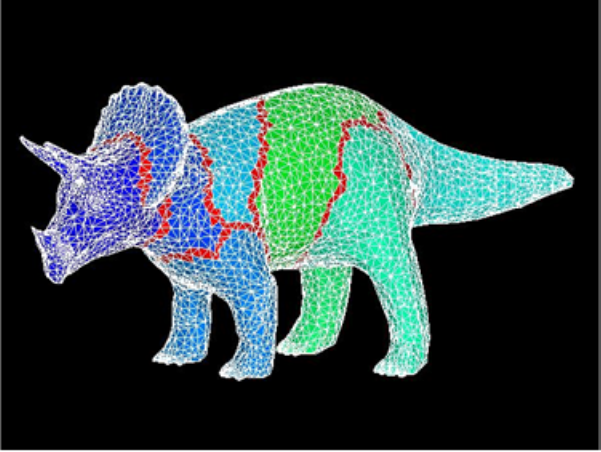
# ppOpen-HPC: Overview

- Application framework with automatic tuning (AT)
  - “pp” : post-peta-scale
- Five-year project (FY.2011-2015) (since April 2011)
  - Lead P.I.: Kengo Nakajima (ITC, The University of Tokyo)
  - Part of “Development of System Software Technologies for Post-Peta Scale High Performance Computing” funded by JST/CREST (Supervisor: Prof. Mitsuhsa Sato, Co-Director, RIKEN AICS)
- Team with 7 institutes, >50 people (5 PDs) from various fields: Co-Design
  - ITC/U.Tokyo, AORI/U.Tokyo, ERI/U.Tokyo, FS/U.Tokyo
  - Hokkaido U., Kyoto U., JAMSTEC

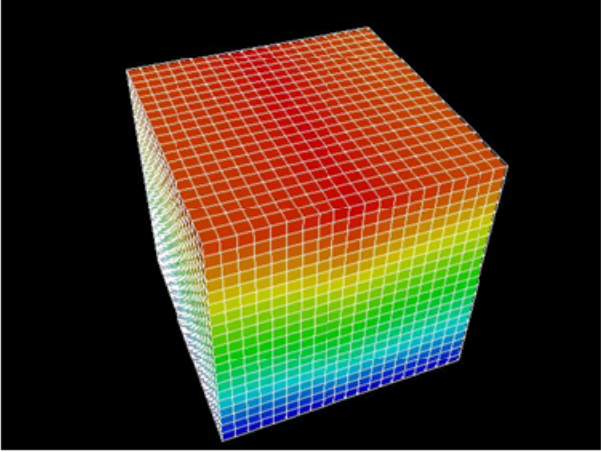




# ppOpen-HPC covers ...



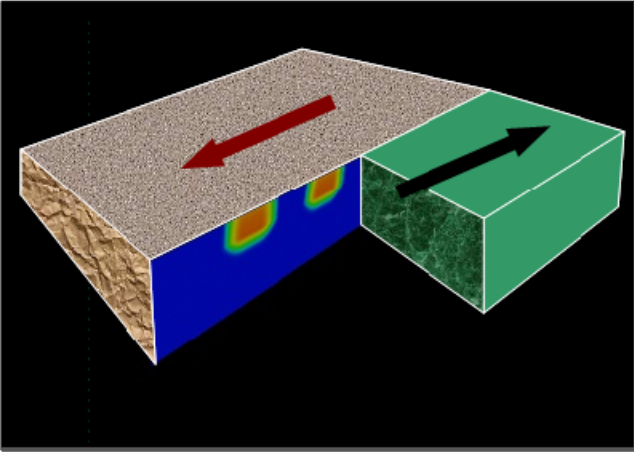
**FEM**  
Finite Element Method



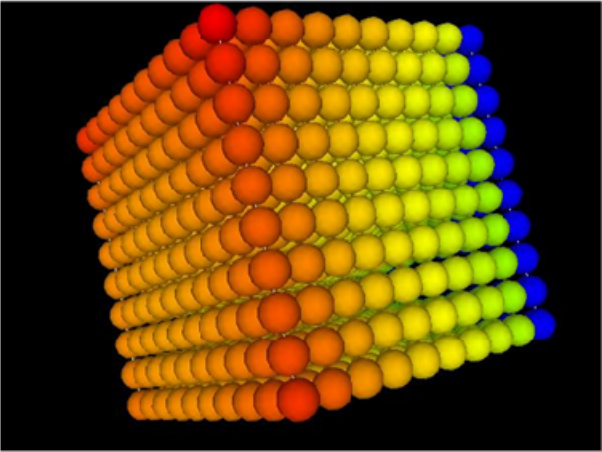
**FDM**  
Finite Difference Method



**FVM**  
Finite Volume Method



**BEM**  
Boundary Element Method



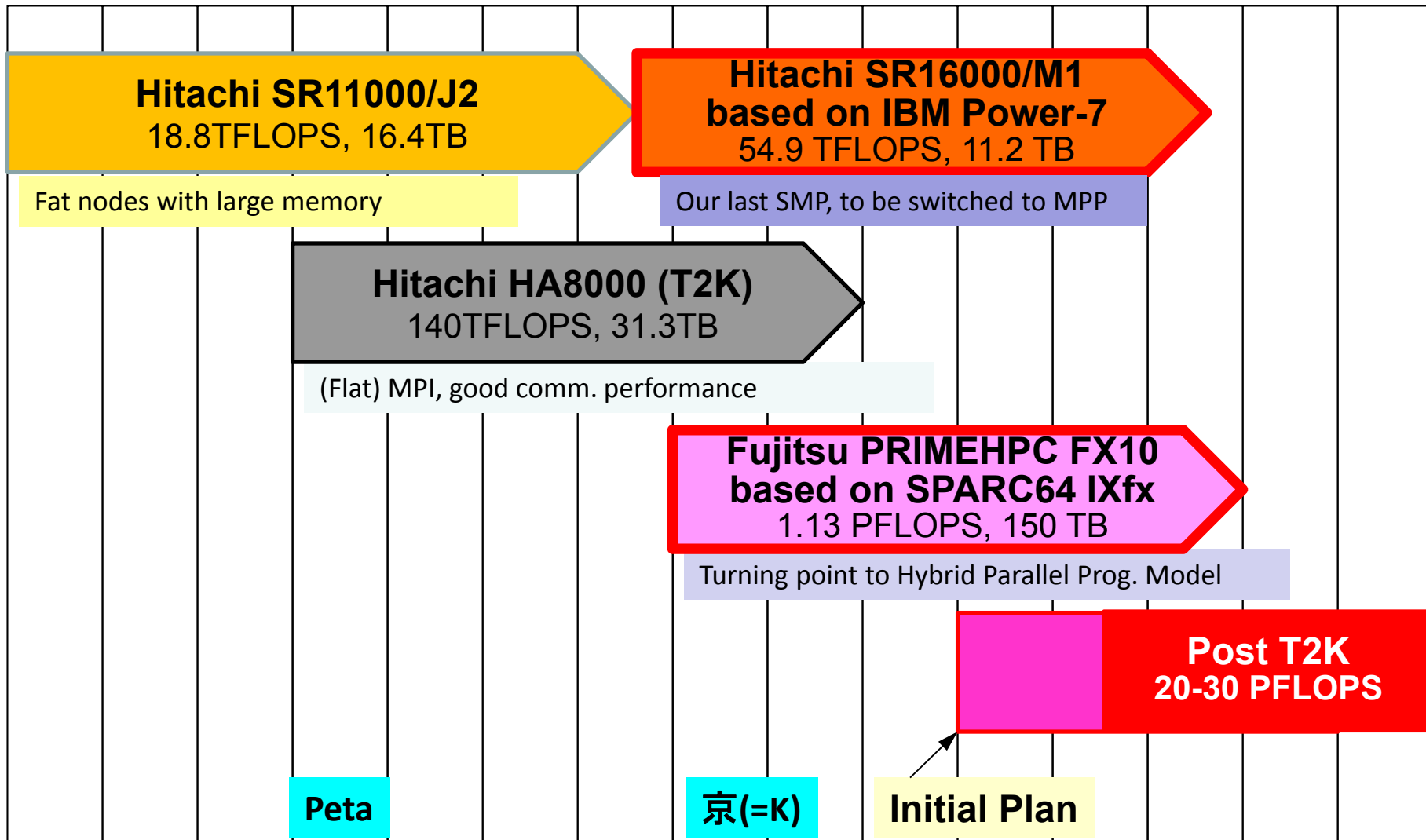
**DEM**  
Discrete Element Method

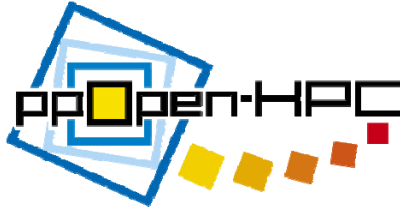
# Supercomputers in U.Tokyo

## 2 big systems, 6 yr. cycle

FY

05 06 07 08 09 10 11 12 13 14 15 16 17 18 19





# Target of ppOpen-HPC: Post T2K System

- Target system is Post T2K system
  - 25+ PFLOPS, FY.2016
    - ✓ JCAHPC (Joint Center for Advanced High Performance Computing): U. Tsukuba & U. Tokyo
    - ✓ <http://jcahpc.jp/>
  - Many-core based (e.g. Intel MIC/Xeon Phi)
    - ✓ MPI + OpenMP + X
  - ppOpen-HPC helps smooth transition of users (> 2,000) to new system
- K/FX10, Cray, Xeon clusters are also in scope



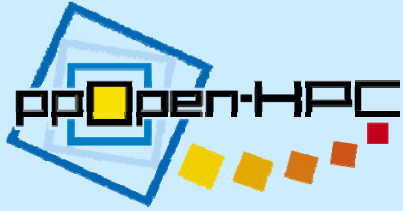
# Schedule of Public Release

(with English Documents, MIT License)

<http://ppopenhpc.cc.u-tokyo.ac.jp/>

- Released at SC-XY (or can be downloaded)
- Multicore/manycore cluster version (Flat MPI, OpenMP/MPI Hybrid) with documents in English
- **We are now focusing on MIC/Xeon Phi**
- **Collaborations are welcome**
  
- History
  - SC12, Nov 2012 (Ver.0.1.0)
  - SC13, Nov 2013 (Ver.0.2.0)
  - SC14, Nov 2014 (Ver.0.3.0)
  - SC15, Nov 2015 (Ver.1.0.0)

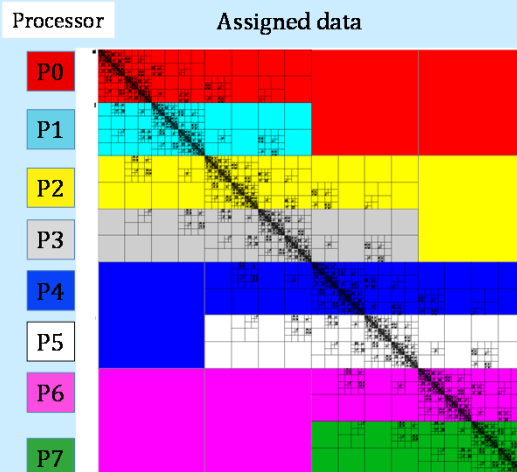




# New Features in Ver.1.0.0

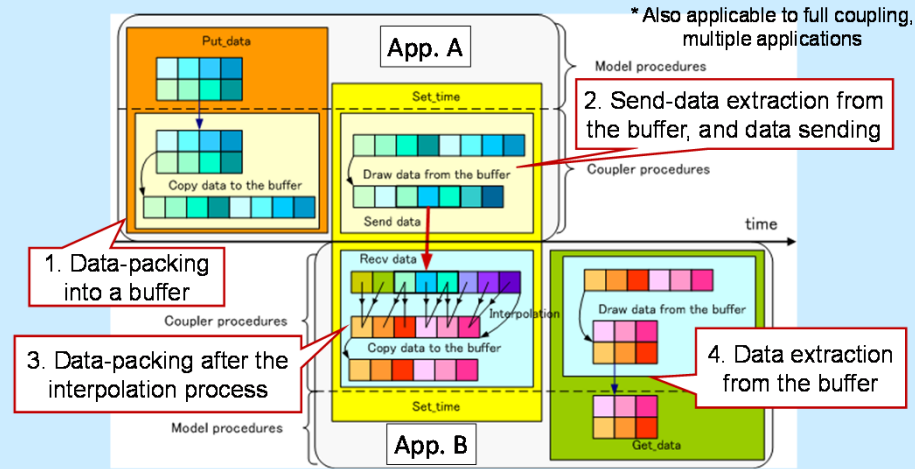
<http://ppopenhpc.cc.u-tokyo.ac.jp/>

- HACApK library for H-matrix comp. in ppOpen-APPL/BEM (OpenMP/MPI Hybrid Version)
- ppOpen-MATH/MP (Coupler for Multiphysics Simulations, Loose Coupling of FEM & FDM)
- Matrix Assembly and Linear Solvers for ppOpen-APPL/FVM



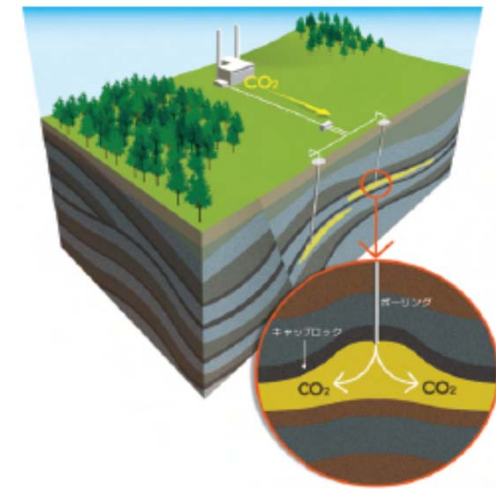
Assign  $a^c$  to  $P_k$  if  $S(a^c_{ij})$  in  $R(P_k)$

$A$  : Whole matrix  
 $A_{IJ}$  : The entry in the  $I$ -th row and the  $J$ -th column of  $A$   
 $a^c$  : A small submatrix of  $A$   
 $a^c_{ij}$  : The entry in the  $i$ -th row and the  $j$ -th column of  $a^c$   
 $N$  : Number of rows of  $A$   
 $n$  : Number of processors  
 $P_k$  : The  $k$ -th processor  
 $l_k : 1 = l_0 < \dots < l_k < \dots < l_{n+1} = N + 1$   
 $R : R(P_k) = \{i \mid l_k \leq i < l_{k+1}\}$   
 $S : S(a^c_{ij}) = I$  when  $a^c_{ij} = A_{IJ}$



# Collaborations, Outreaching

- Collaborations
  - International Collaborations
    - Lawrence Berkeley National Lab.
    - National Taiwan University, National Central University
    - ESSEX-II/SPPEXA/DFG, Germany
    - IPCC (Intel Parallel Computing Center)
- Outreaching, Applications
  - Large-Scale Simulations
    - **Geologic CO<sub>2</sub> Storage**
    - Astrophysics
    - Earthquake Simulations etc.
    - ppOpen-AT, ppOpen-MATH/VIS, ppOpen-MATH/MP, Linear Solvers
  - Intl. Workshops (2012,13,15)
  - Tutorials, Classes



# Next Stage of ppOpen-HPC

- FY.2016-FY.2018
  - JST/CREST & DFG/SPPEXA (Germany) Collaboration
  - ESSEX: Equipping Sparse Solvers for Exascale
    - <http://blogs.fau.de/essex/>
    - Leading PI: Prof. Gerhard Wellein (U. Erlangen)
  - ESSEX II: ESSEX, Sakurai-T, Nakajima-T
    - Iterative Solver for Quantum Chemistry: pK-Open-SOL
      - Multgrid/Low-Rank Approximation
      - DLR (German Aerospace Research Center)
    - Performance Model for Stencil Computation: pK-Open-AT
      - U. Erlangen
      - kerncraft: Loop Kernel Analysis and Performance Modeling Toolkit
        - » <https://github.com/cod3monk/kerncraft>

