Real World Applications on Massively Parallel Environments

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Introduction

**Aims**
- Effective utilization of HPC
- Broaden the possibilities of HPC
- Practical applications

**Application Areas**

**Industry**
- new product
- new material
- energy saving

**Environment**
- prediction and prevention of disaster
- prepare for and protect against disaster

**Health care**
- aid diagnosis
- personalized therapy
- efficient drug trial
Industry: Electromagnetic field simulator

i. Design of Motor
ii. Efficiency Improvement of Magnet
Energy Saving Design of Motor

- Motors consume almost half of the generated electric power
- The same tendency is also observed globally

- In Japan
  (2009, Fuji-Keizai)

- 56% motor
- 14% light
- 10% heater
- 5% IT
- 15% other

570 TWh

1% more efficient

Saving
One thermal plant
Coupling of Simulation of Two Scales

- Highly precise magnetic field analysis for design of products realized

**micro-magnetics hysteresis model**
(material property)

**EM analysis: FEM**
(deformation & current)

- weakly coupling

hysteresis loop
magnetization

FEM analysis result
Rare Earth Magnet Analysis

- Magnetic reversal* process of rare earth magnet analyzed with 3-D micromagnetics simulation

* magnetic reversal: the phenomenon which direction of magnetization reverses by direction of an external magnetic field.

mesh size < 1nm

BY USING HPC, THE REALISTIC STRUCTURE AND PRECISE PHYSICAL PROCESS OF CRYSTAL GRAINS CAN BE SIMULATED.
Environment: Tsunami simulator

This whole project is a collaboration with Prof. Imamura of IRIDeS, Tohoku University
Prevention of Tsunami Disaster

- Mar., 11th, 2011
  - M9 earthquake & historic tsunami
  - Over 19,000 victims

- Target
  - Tsunami-proof design of buildings
  - Escape planning
  - Preliminarily enlightening on the danger
  - City planning
  - Tolerability of evacuation cites or public buildings

This movie is for the demonstration of the simulation technique, not for prediction of actual tsunami damage.

The Digital terrain data is provided by GEO Technology Laboratory Co., Ltd.
1. Calculation of wave stress
   - Formulation of tsunami-proof intensity standard
   - Tsunami-proof design

2. Inundation analysis w/o overdamping
   - Re-examination of dikes
   - Escape planning
   - Hazard analysis
   - Preliminarily enlightening on the danger
   - Tolerability of evacuation cite or public building

The hydraulic experiment is performed by Prof. Murakami of Univ. of Miyazaki.
Combination of 2-D & 3-D Simulations

Seamless 3-D simulation from the epicenter to an urban area

- **SPH method (3-D) for small area**
- **Shallow-water model (2-D) for broad area**

**tsunami simulator**

- Calculation of wave stress to buildings
- Inundation in urban areas
- Tsunami propagation from epicenter

The Digital terrain data is provided by GEO Technology Laboratory Co., Ltd.

Simulation performed by Prof. Imamura of Tohoku Univ.
CG made by the collaboration with Bosai Tech Consultants.

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Healthcare:
Heart simulator [UT-Heart]

This work is a collaboration with Prof. Hisada and Prof. Sugiura of the University of Tokyo and Fujitsu Limited
For Personalized Therapy

- **CVD (cardiovascular disease)**
  - One of the leading causes of death

- **Computer aided therapy**
  - Personalized therapy
  - Efficient drug discovery
Electrocardiogram (ECG)

- Comparison of ECG measurement
  - between heart simulator and human heart
Ventriculoplasty

- Virtual surgical treatment

<table>
<thead>
<tr>
<th>Diseased heart</th>
<th>Virtual operation</th>
<th>Following virtual therapy</th>
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<tbody>
<tr>
<td>modest</td>
<td>excision</td>
<td>sutura</td>
</tr>
<tr>
<td>radical</td>
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Ventricular aneurysm after myocardial infarction

- EF: Ejection Fraction. EF represents the strength of pumping function of heart. Defined as (end-diastolic volume – end-systolic volume) / (end-diastolic volume).

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<thead>
<tr>
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<th>EF</th>
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<tr>
<td>1</td>
<td>34.9</td>
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<td>2</td>
<td>46.6</td>
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<tr>
<td>3</td>
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</tbody>
</table>
Multiscale Analysis

- For the personalized therapy in medical domain
- As a bridge between molecular biology and clinical application

**multiscale simulation**

- EC-coupling metabolism, sarcomere dynamics
- structural dynamics by FEM contraction force
- homogenization method
- FSI by FEM circulation

molecule  |  cell  |  tissue  |  organ
---|---|---|---
EC-coupling metabolism, sarcomere dynamics | structural dynamics by FEM contraction force | homogenization method | FSI by FEM circulation
Scalability and Performance on "K computer"

- Succeeded in simulating 1.5 heartbeats lasting about 17 hours and using 602,112 cores.

- Achieved more than 90% of the ideal scaling and 27.7% of the peak performance using 20,736/41,472/82,944 nodes with 659,456 embedded numerical cells of and 49,248 DOFs.

Present results were obtained by early access to the "K computer" at RIKEN AICS as a "grand challenge application" under the "R&D of Next-Generation Integrated Life-Science Simulation Software" program supported by MEXT.
Conclusion

- FUJITSU has been developing the HPC applications for practical use
  - Effective utilization of HPC
  - Broaden the possibilities of HPC
  - Practical applications

- Some of these were introduced.
  - Tsunami simulator based on article method for disaster prevention
    - From the epicenter to the urban area
  - FEM based Electromagnetic field simulator for industry
    - Coupled with micromagnetics simulator
    - Optimization in macroscopic quantities possible, taking into account of the effect of micro magnetics
  - FEM based human heart simulator (UT-Heart) for personalized medical therapy
    - Multiscale & multiphysics heart simulator
    - Possibilities of use to aid diagnosis not only in surgery but also in a medical domain for personalized medical treatment
    - Achieved more than 90% of the ideal scaling and 27.7% of the peak performance on "K computer"
Thank you for your attention.