Development and Collaboration of NSCC-TJ

Meng Xiang-Fei

Leader of HPC Application from NSCC-TJ

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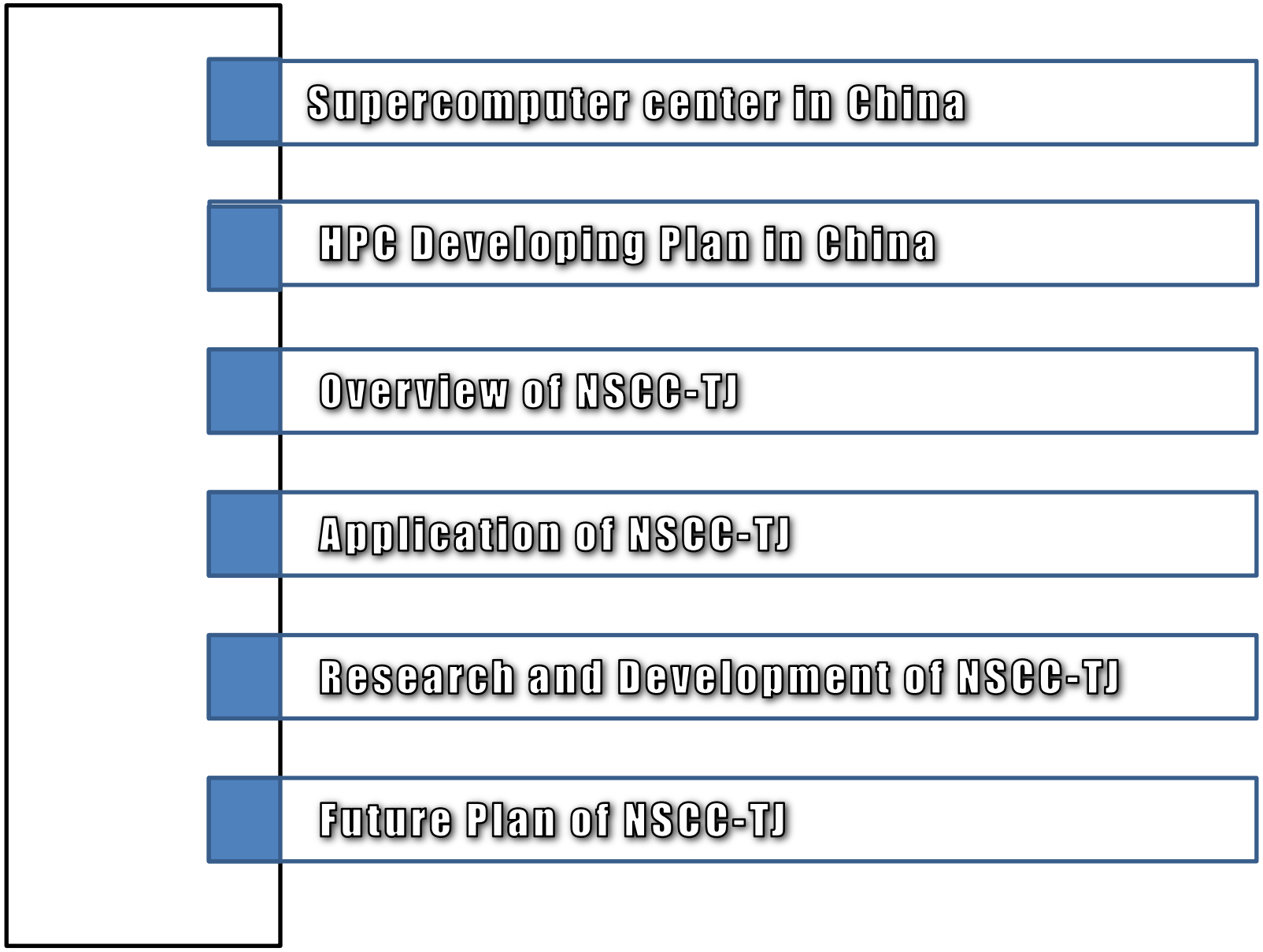
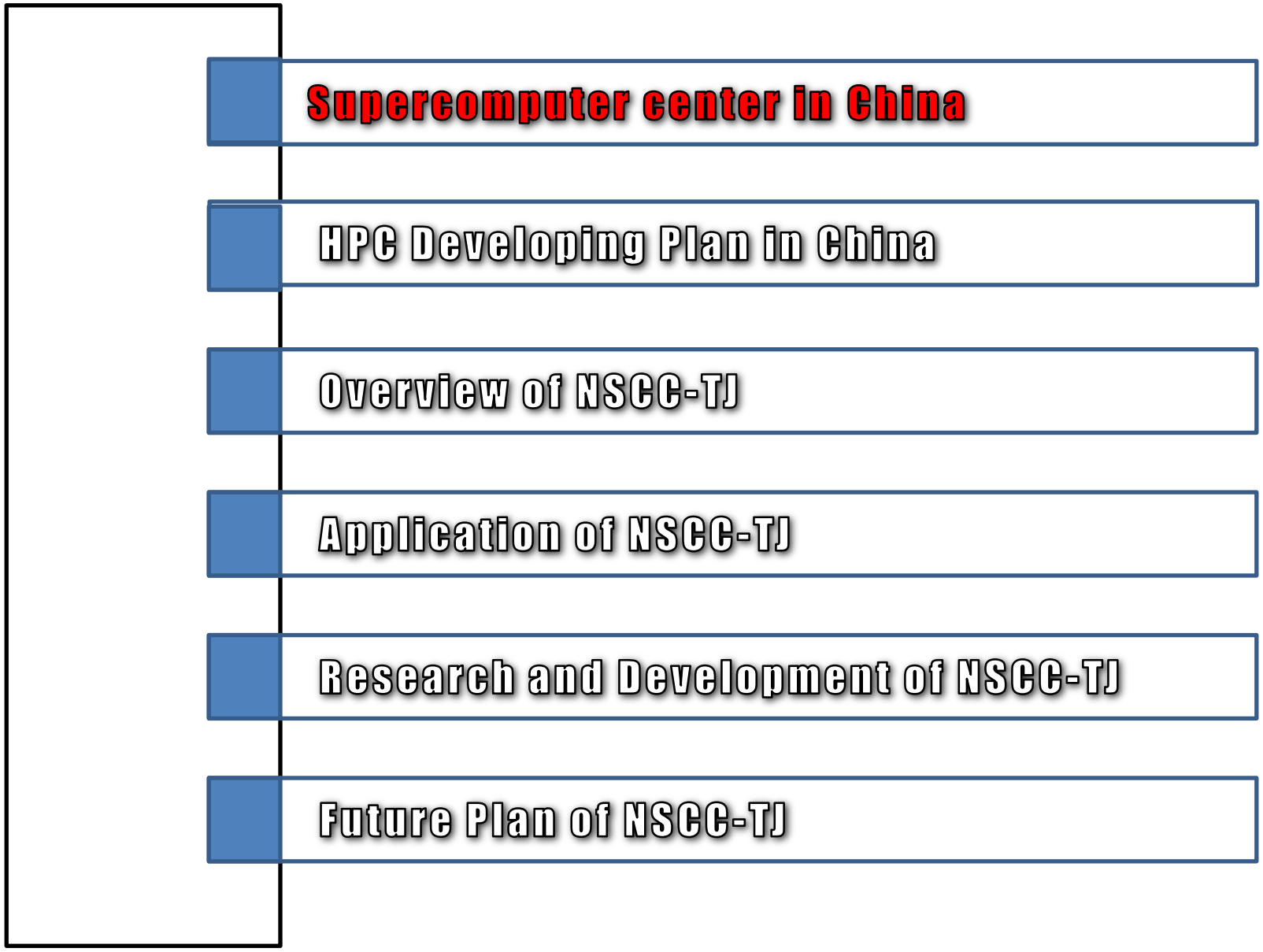

Supercomputer center in China
HPC Developing Plan in China
Overview of NSCC-TJ
Application of NSCC-TJ
Research and Development of NSCC-TJ
Future Plan of NSCC-TJ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Supercomputer Center in China

National Supercomputer center

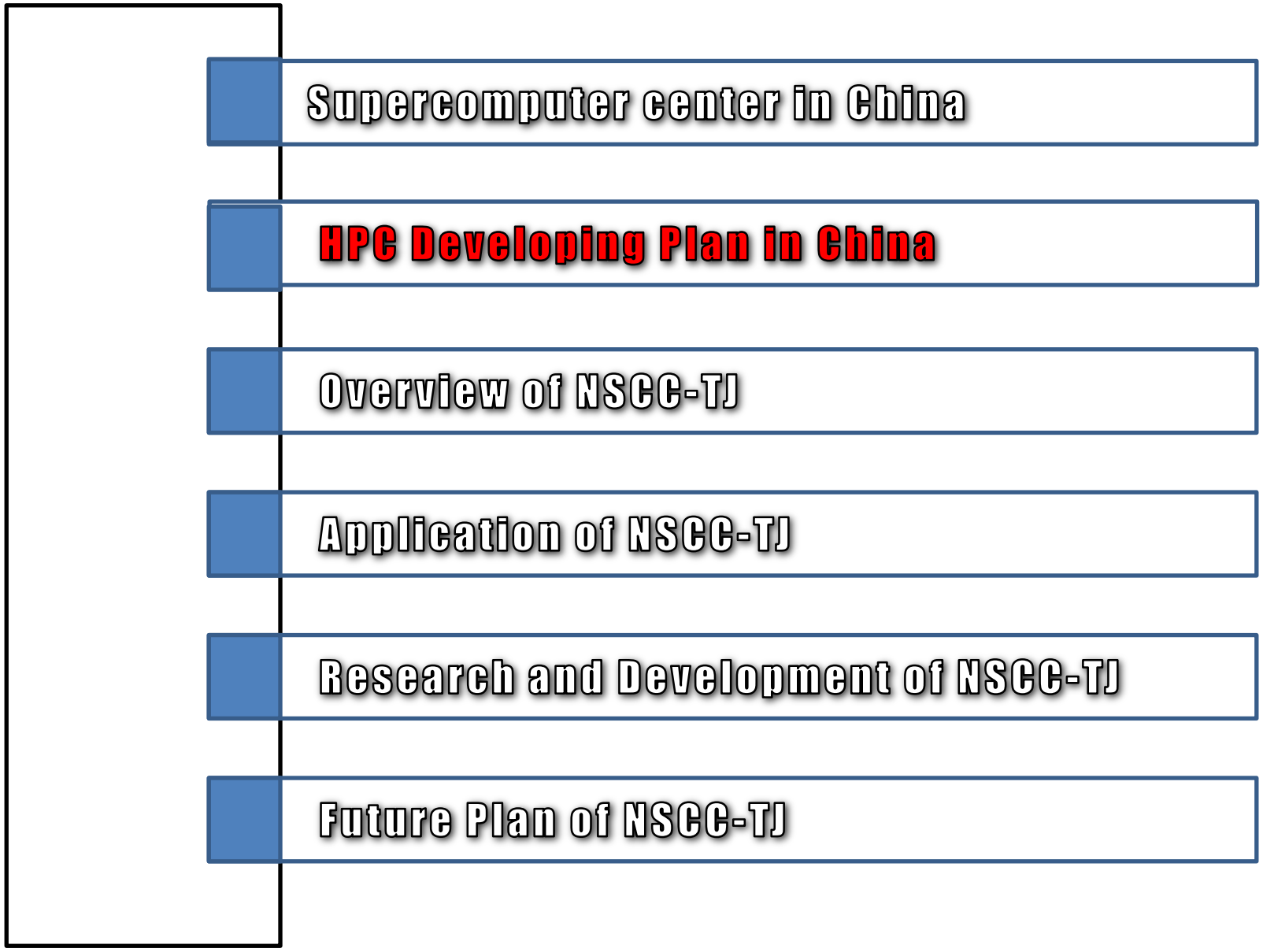
- **NSCC-TJ, NSCC-SH, NSCC-SD, NSCC-CS, …**

Local Supercomputer center

- **SSC, …**

Domain computer center

- **CAS, CMA(China Metrological Administration), …**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HPC Developing Plan in China

NSFC

- Basic algorithms and computable modeling for high performance scientific computing
- Network based research environment
- Many-core parallel programming

863 Program(High Science and Tech.)

- High productivity computer and Grid service environment, HPC Software R&D
- Multi-core/many-core programming support

973 Program(Basic Research and Application)

- Parallel algorithms for large scale scientific computing
- Virtual computing environment

NSCC

HPC Developing Plan in China

863 key projects on HPC and Grid: 2002-2010

Phase I

Phase I: "HPC computer & core software"

- 4-year project, May 2002 to Dec. 2005
- 100 million Yuan funding from the MOST
- More than 2X associated funding from local government, application organizations, and industry

Major outcomes: China National Grid (CNGrid)

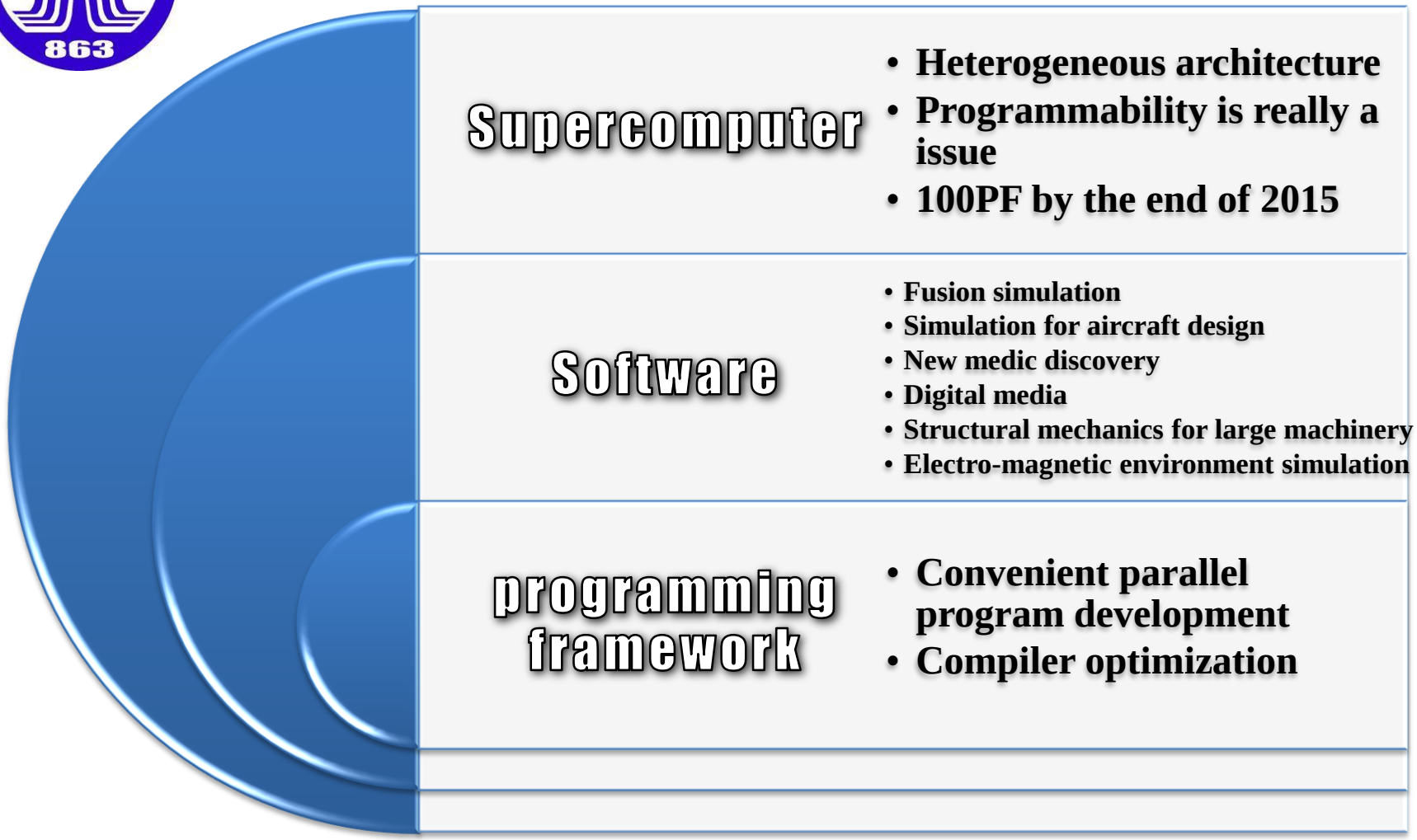
Phase II

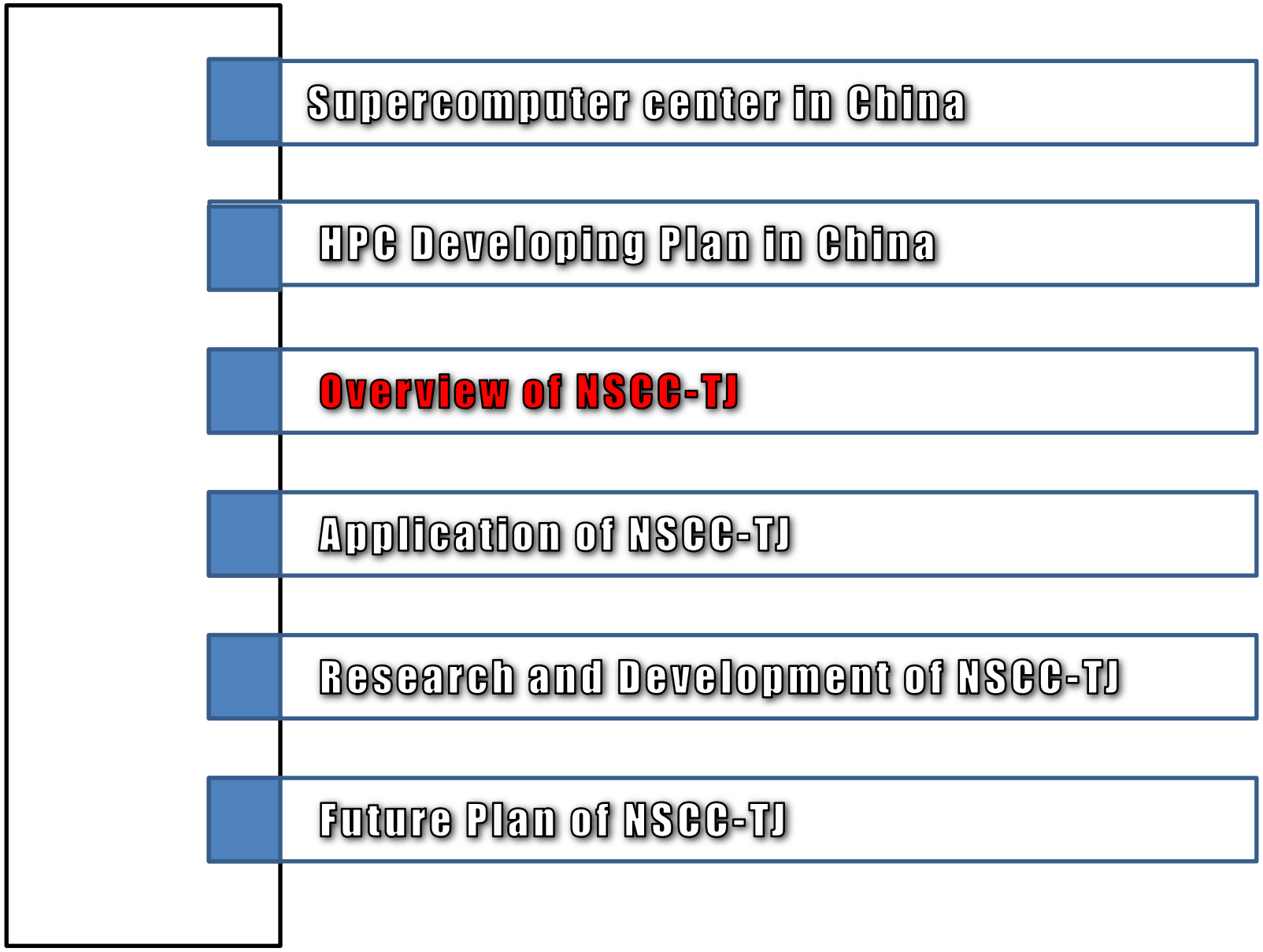
Phase II: "High productivity Computer and Grid Service Environment"

- Period: 2006-2010 (extended to 2012), TH-1A …
- 940 million Yuan from the MOST and more than 1B Yuan matching money from other sources

HPC Developing Plan in China

863 key projects on HPC: 2011-2015

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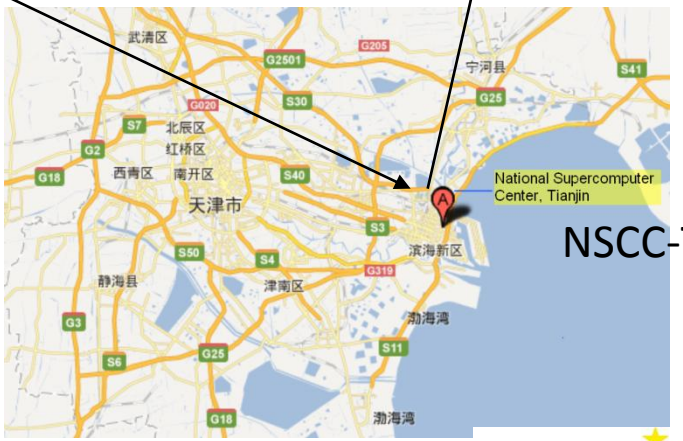
Overview of NSCC-TJ



NSCC-TJ

Overview of NSCC-TJ

Sponsored by

- Chinese government: MOST, MOF…….
- Local government: Tianjin Binhai New Area

Public information infrastructure

- To accelerate the economy, science innovation and industry of China
- To provide high performance computing service to whole China and even to all over the world

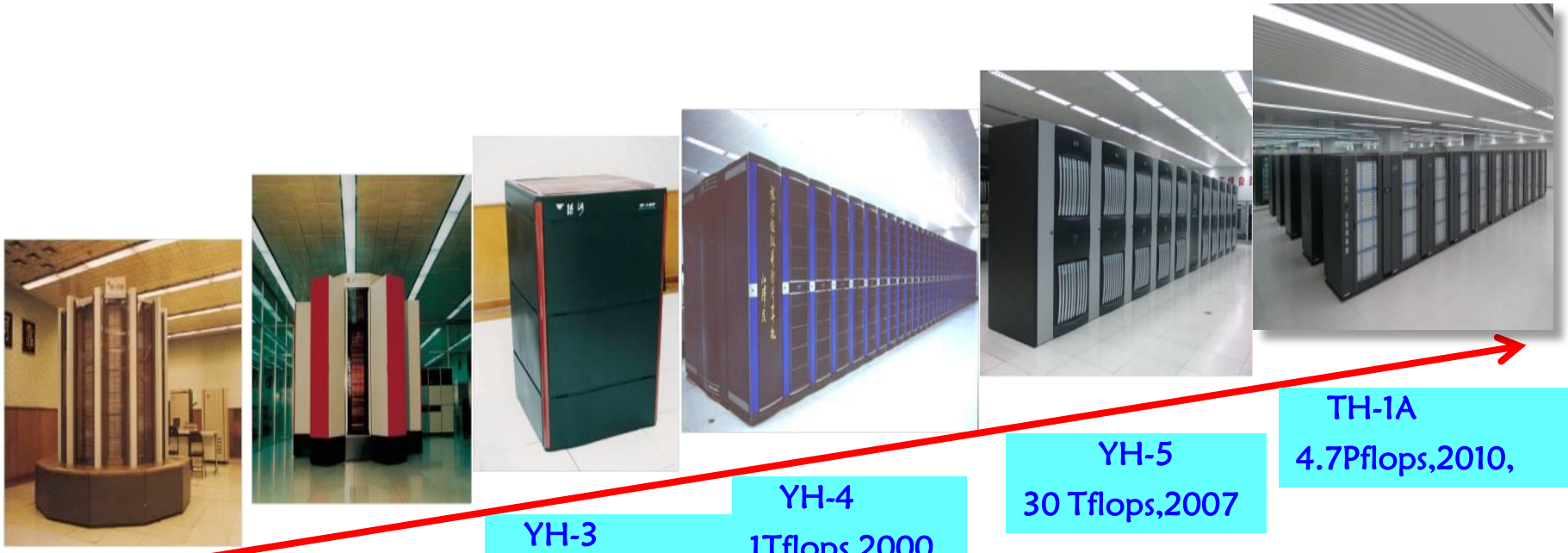
Open platform for science research and education

TH-1A system Configuration

Items	Configuration
Processors	14336 Intel CPUs + 7168 nVIDIA GPUs + 2048FT CPUs
Memory	262 TB
Interconnect	Proprietary high-speed interconnecting network
Storage	4PB (Lustre File System)
Cabinets	120 Compute / service Cabinets
	14 Storage Cabinets
	6 Communication Cabinets

Overview of NSCC-TJ

Roadmap of Supercomputer in China



HPC TOP500 排名	501	20	40	1
年份	1997	2000	2007	2010

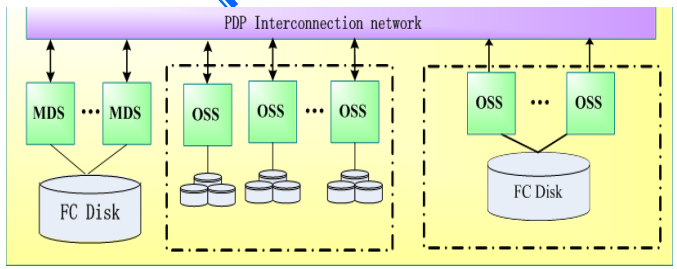
Overview of NSCC-TJ

TH-1A System

Cabinet
(4 x rack)

TH-Net

rack
(16 x cn)

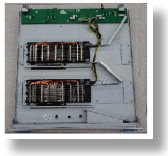


On-line storage

Compute node

(4CPU+2GPU)

Quad cpu blade



Twin GPU blade

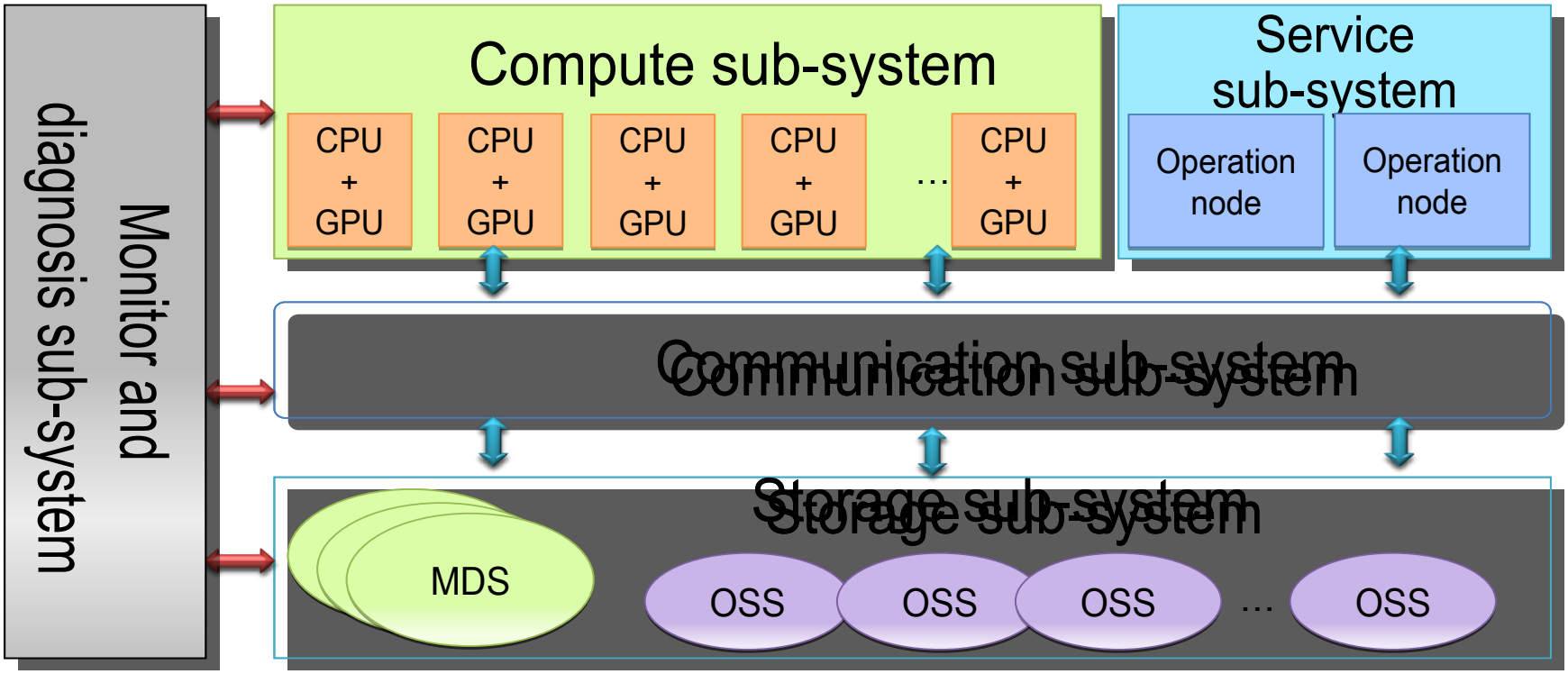
M2050

X5670

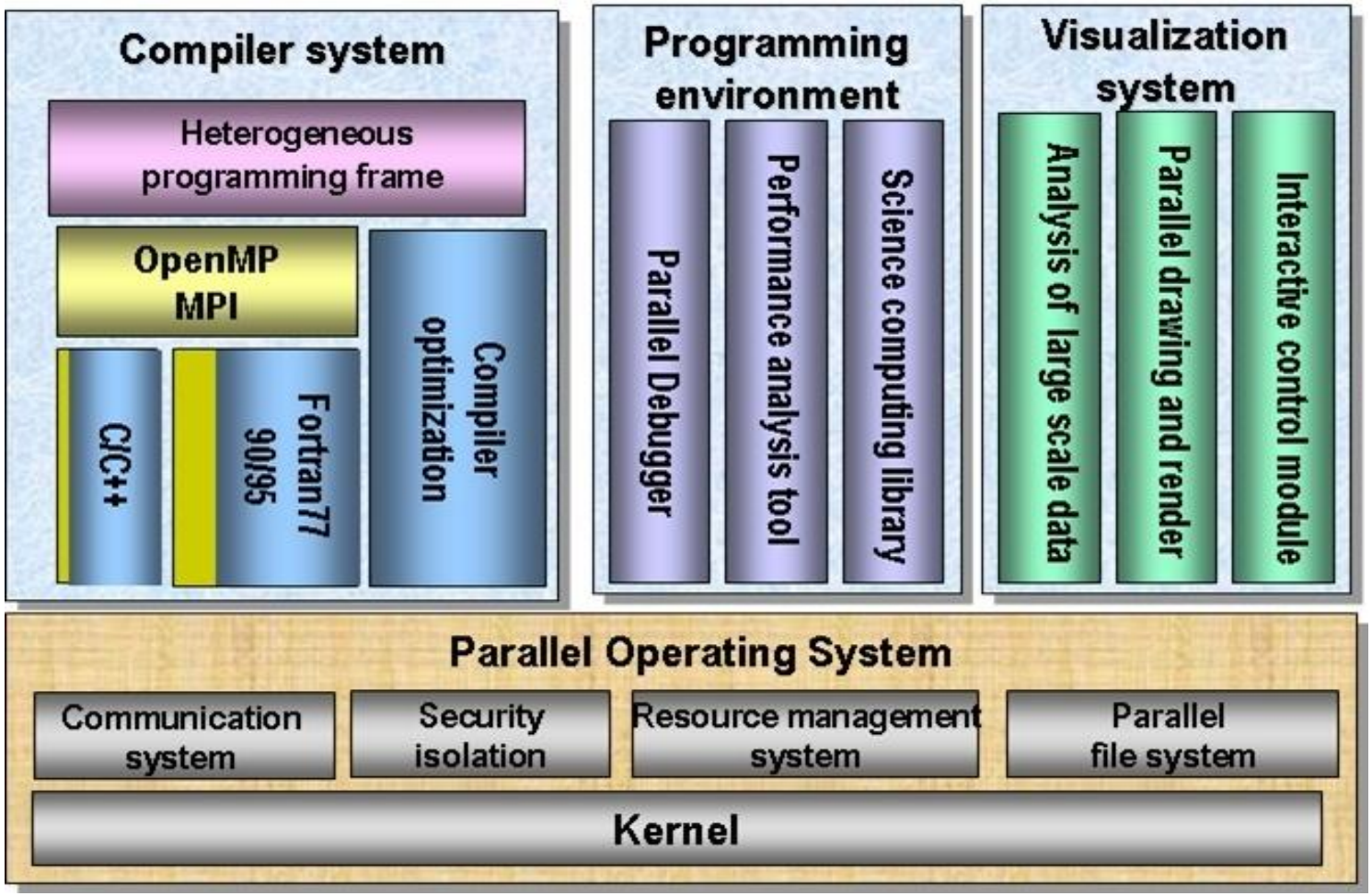
FT-1000

Chips

Overview of NSCC-TJ



Overview of NSCC-TJ



Overview of NSCC-TJ

- **China Supercomputing development Strategy: Cooperating Development and Innovation**

Joint Innovation Center

International Collaboration

Union & Association

Sub-Center

Joint Lab

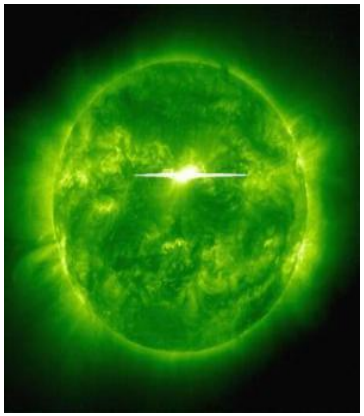
Overview of NSCC-TJ

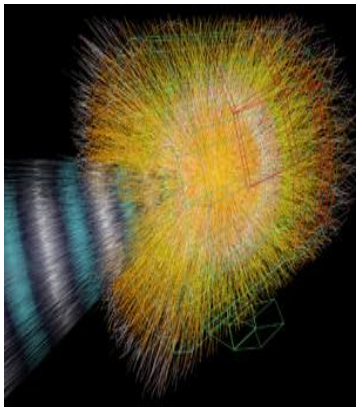
- **Support High Tech. and Industry– Joint Lab, Union, Innovation center**

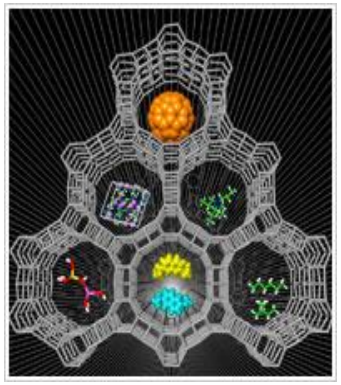
- Joint Lab
  - LASG
  - BGP
  - BGI
  - NVIDIA
  - Communication Univ.
  - NAOC
- Union
  - TH Engineering Design
  - SC Center
- Joint Innovation center
  - HPC Dev. & Appl.
  - Modern Ports Adm.

Overview of NSCC-TJ

Support Basic Science Research– Sub-center at University







Overview of NSCC-TJ

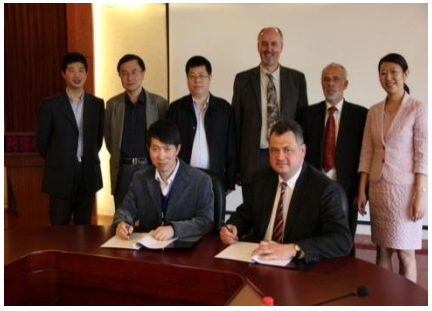
UNIVERSITY OF SURREY

NCSA
NATIONAL CENTRE FOR SUPERCOMPUTING APPLICATIONS

BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

JÜLICH
FORSCHUNGSZENTRUM

bifi Instituto Universitario de Investigación Biocomputación y Física de Sistemas Complejos Universidad Zaragoza



BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

University of Stavanger

NVIDIA

Fraunhofer SCAI

OAK RIDGE NATIONAL LABORATORY
Managed by UT-Battelle for the Department of Energy

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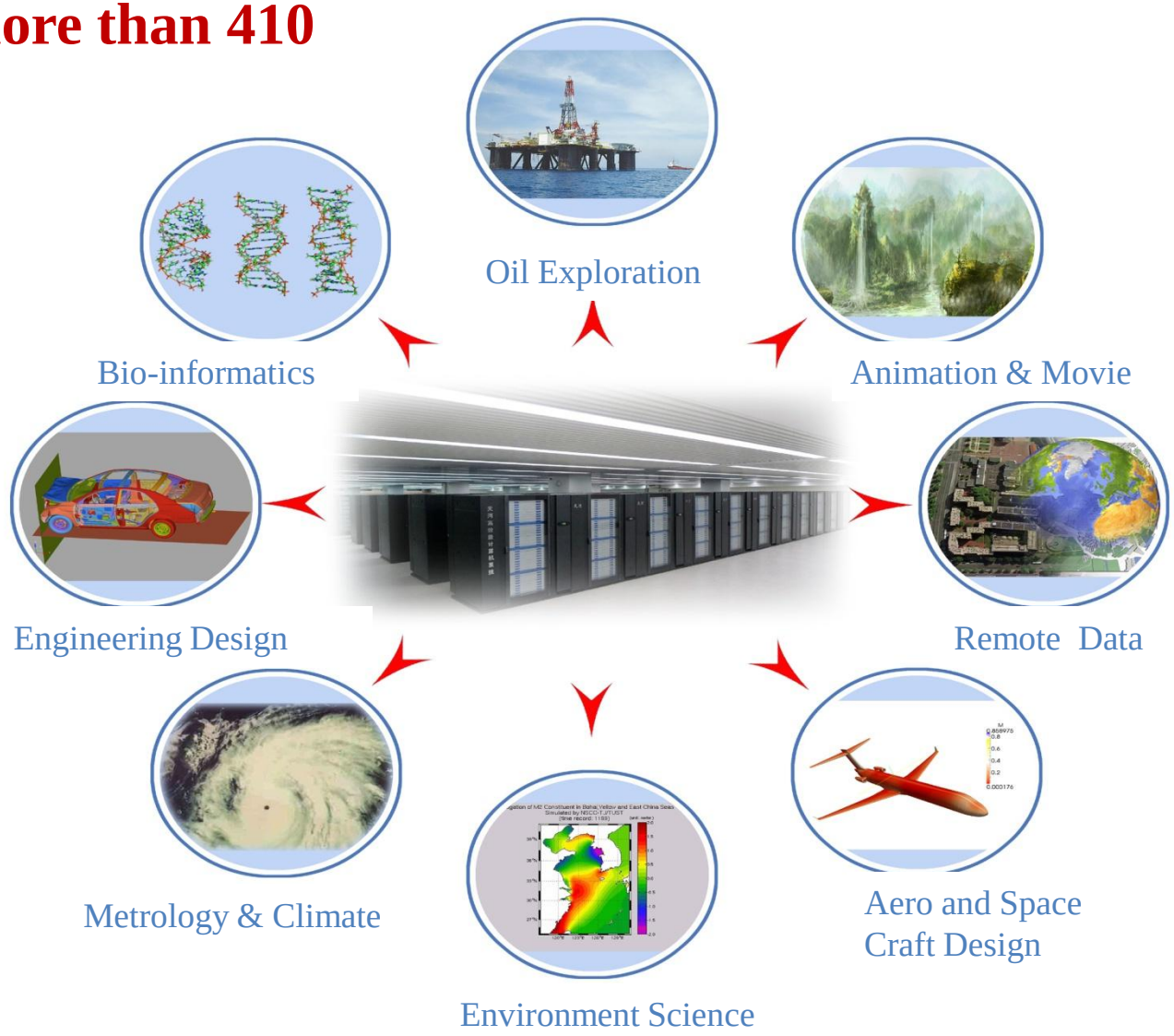
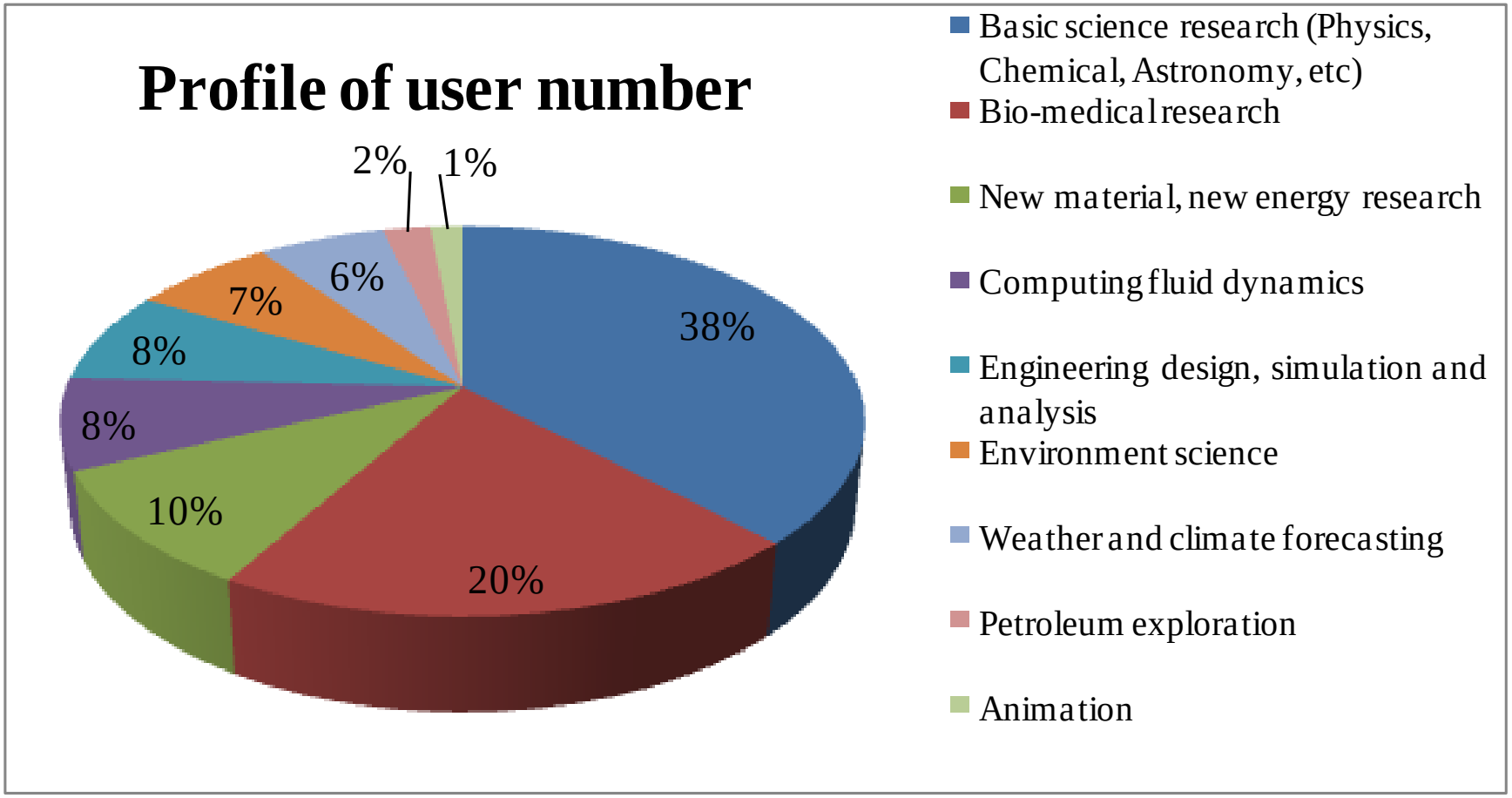
Application of NSCC-TJ

User Number of Research Group and Company more than 410



Application of NSCC-TJ

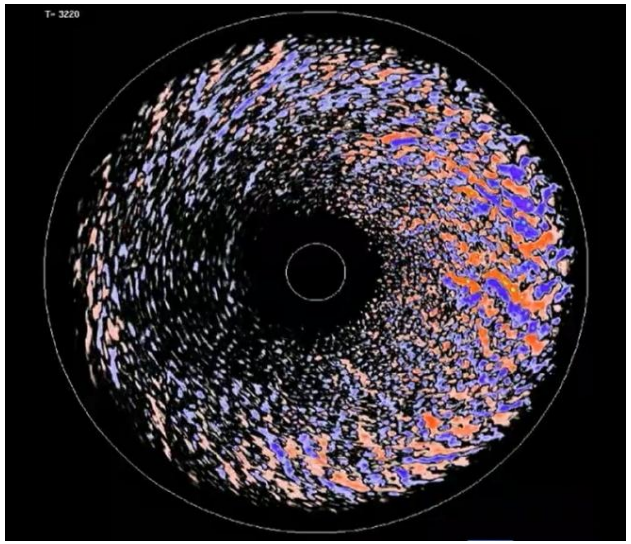
Supported Projects by NSCC-TJ			
NSFC	**863、973 Program**	**Other Key Projects Funded by Central Government**	**International or Local Projects**
>400 item	**>45 item**	**>20 item**	**>10 item**

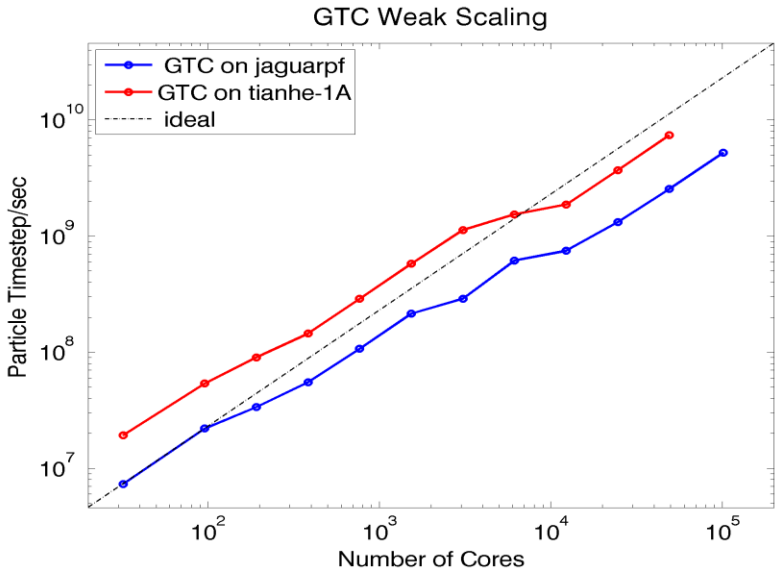


Application of NSCC-TJ

Magnetic confinement fusion research

- International ITER Project: China, EU, USA, Japan, Korea, Russian and India;
- Application Scale: GTC program running on up to 50,000 cores;
- Proprietary Programming (CPU+GPU Version).

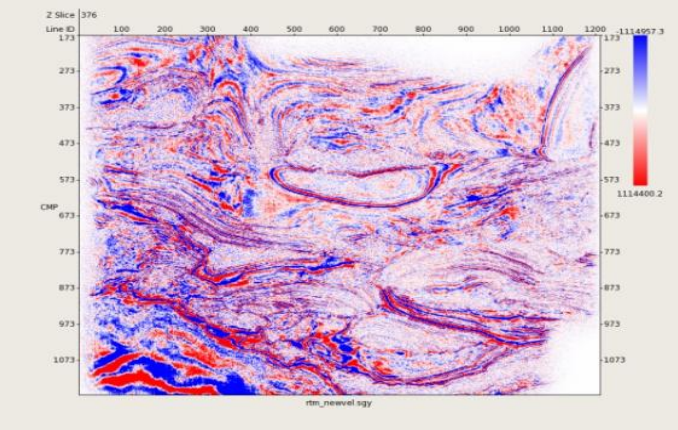


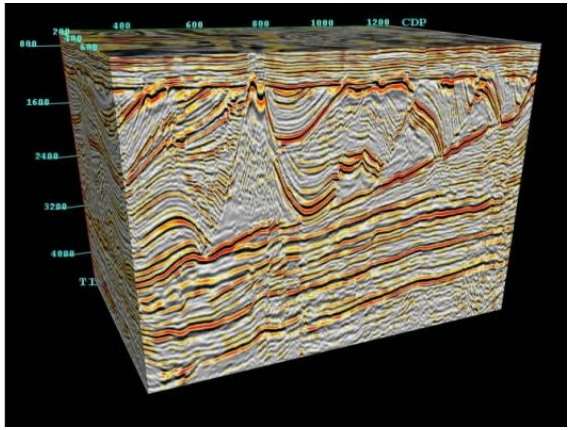


curve

Application of NSCC-TJ

- Petroleum seismic data processing
  - Program: single/double-way wave Prestack depth migration (RTM), proprietary
  - 85860 cores(whole TH-1A)
  - 2600 Km^2 , 2.2TB data; 10000Km^2 , 100TB data
  - New programming : (CPU+GPU) version has good scalability and reaches 4x speedup based-on TH-1A
  - IO based on memory , one IO routine (rearrange data and sum) reaches 3X speedup on TH-1A (reduce form four day to one day on 2000 nodes)





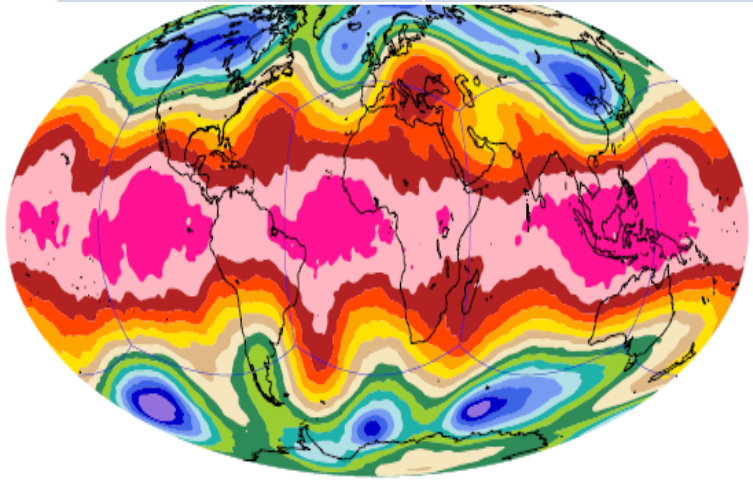
Surface:2600 Km^2 depth:5Km

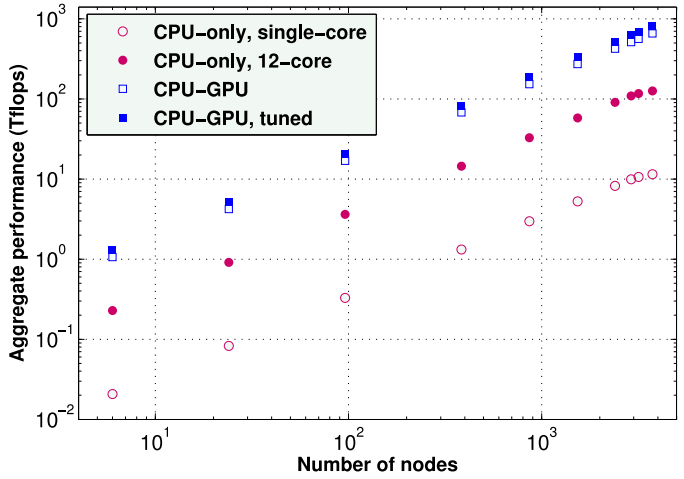
Application of NSCC-TJ

- Large-scale Simulation of the Global SWEs
  - CPU: Using 82,944 cores;Parallel efficiency: 60%
  - CPU+GPU: Towards Peta-scale global SWE simulation, 809TFlops in double precision in 3750 nodes
  - Real topography of the Earth, zonal flow
    - Day 15, 10,240*10,240*6 mesh (1km res)

CPU-only (1-core)	CPU-only (12-core)	CPU-GPU	CPU-GPU tuned
11.5 Tflops	126 Tflops	658 Tflops	809 Tflops

32.8% of peak!

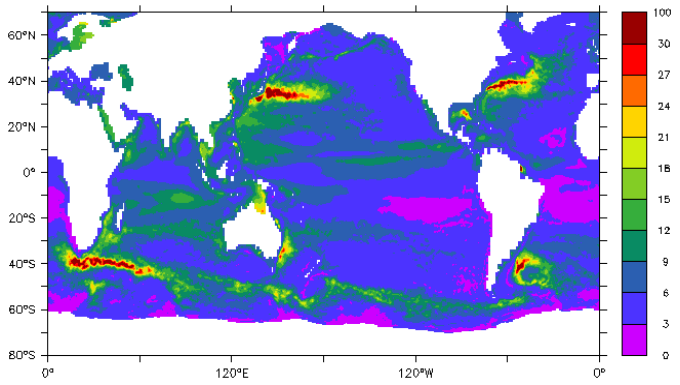




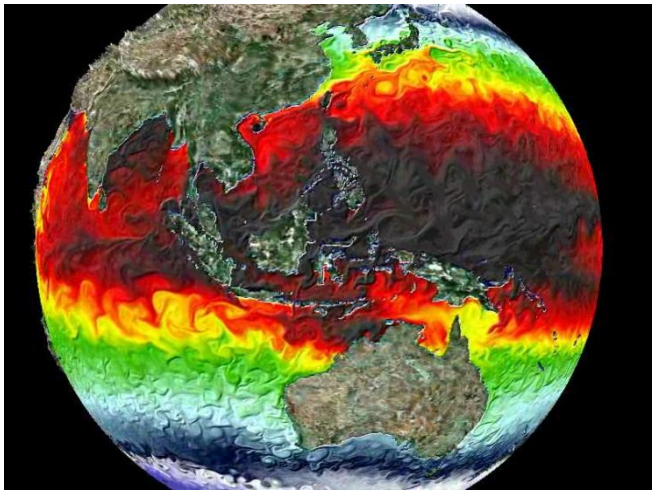
Application of NSCC-TJ

Global Climate Change

- User: Institute of Atmospheric Physics, Chinese Academy of Sciences.
- LICOM pattern: 2D MPI & OpenMP programming.
- Up to 10,000 Cores, complete an numerical simulation based-on 50 years statistics.
- Take 600 hours, 9x speedup performance.
- Capable of completing the high-resolution Ocean Circulation Pattern numerical simulation with massive data.



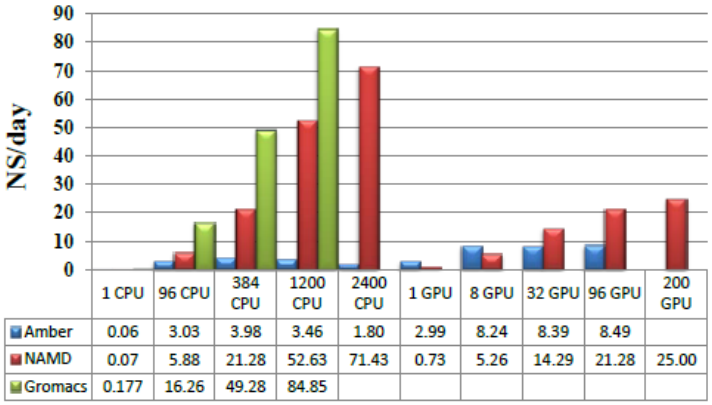
SSHA standard divation: simulation (cm)



Application of NSCC-TJ

Genomics research

- User: BGI (Academe), Etc. Chinese BGI cooperates with Denmark to set up the Academe in Denmark.
- Human Genetics, Animals and Plants, Microorganism
- Cooperation with Bill-Gates Fund : The thousand year plate of UN, human foodstuff and health
- Genic data base : 1PB

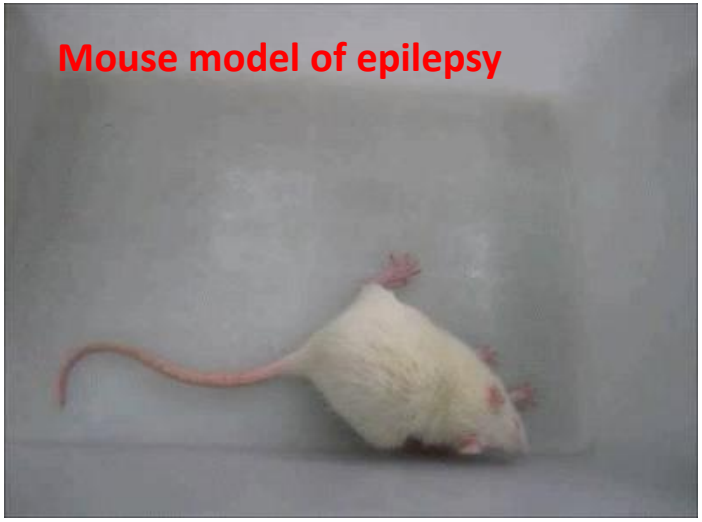


	1 CPU	96 CPU	384 CPU	1200 CPU	2400 CPU	1 GPU	8 GPU	32 GPU	96 GPU	200 GPU
Amber	0.06	3.03	3.98	3.46	1.80	2.99	8.24	8.39	8.49	
NAMD	0.07	5.88	21.28	52.63	71.43	0.73	5.26	14.29	21.28	25.00
Gromacs	0.177	16.26	49.28	84.85						

Application of NSCC-TJ

New medicine design

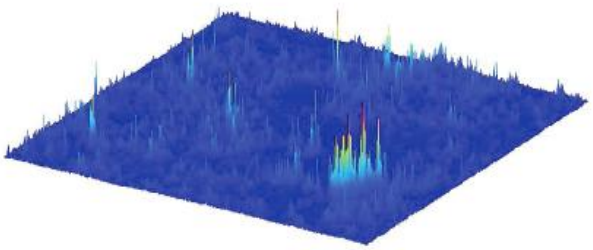
- Institute of Material Medical, Shanghai, China
- Simulation on TH-1A with close coordination of the experiment results
  - Confirmation of a new drug interaction sites;
  - Directly through the drug design， without any chemical modification, obtained lead compounds for drug treatment of epilepsy which has a good activity ability in animal



PKUFFT Application in CFD

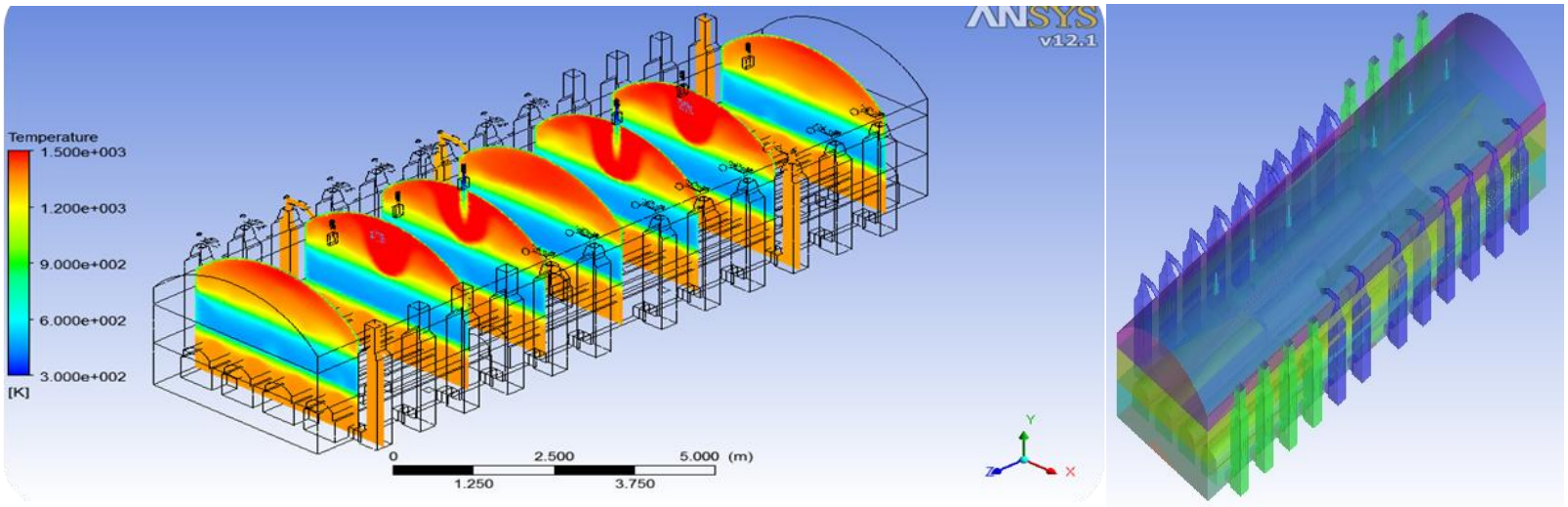
- PKUFFT published at ACM ICS 2010 is the fastest algorithm for GPU clusters
- PARRAY published at ACM PPoPP 2012 is generalized to many application areas as the advanced technology of for GPU cluster
- Resilience Technology has already supported the communication of "TH-1A", including the GPU clusters
- The scale of the Directly Simulating Turbulent Flows, 14333^3 3D, surpassed the 4096^3 3D data, which could lead the research of aerospace, shipbuilding, climate simulation and so on

TH-1A Node	Turbulent Flow	Remarks
2048	4096^3	The largest scale of turbulent flows at that time
4096	8192^3	
7168（including GPU）	14336^3	The largest scale, flow parameter approximately equal the real turbulent flows

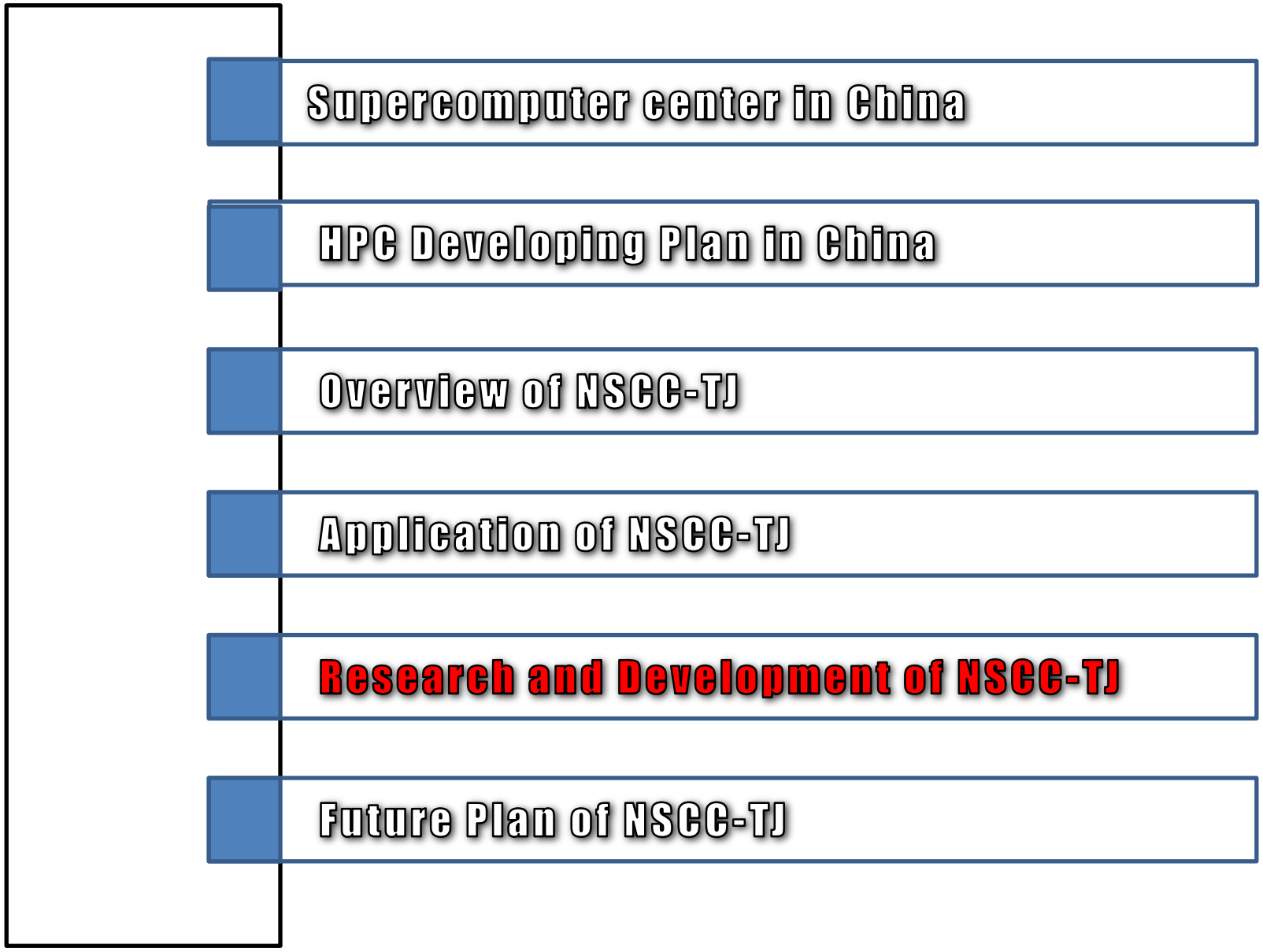


■ Heat recovery coke oven

- chemical engineering institute, Tianjin University
- 3D numerical simulation based-on TH-1A,
- Large-scale, complex procedure of simulation, non-steady state



3D numerical simulation view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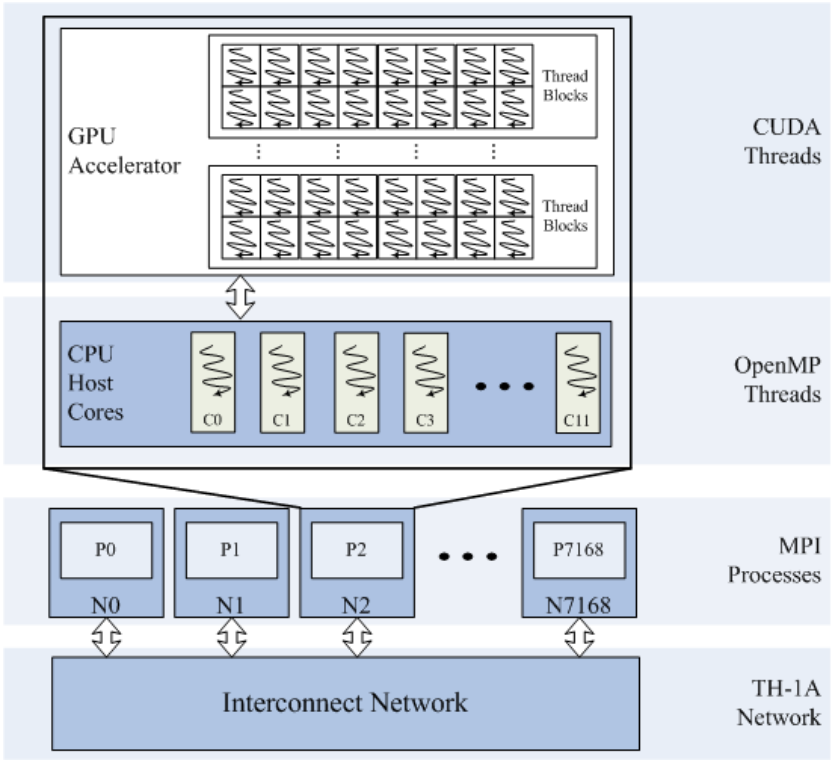
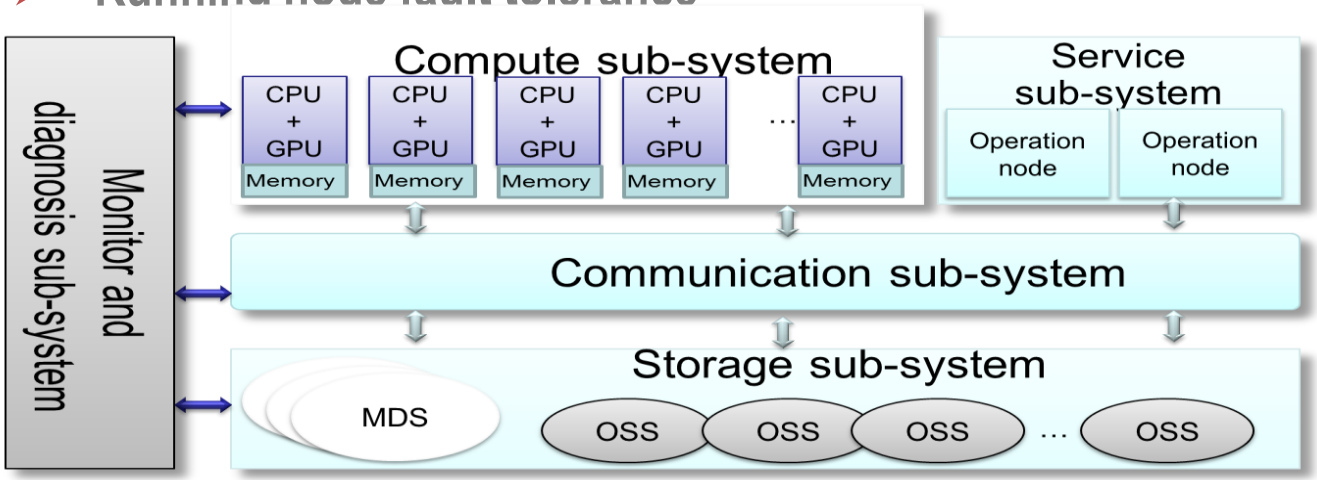
Research and development of NSCC-TJ

- **Multilevel heterogeneous programming model and software**
  - **Hardware structure**
    - Node-node， symmetry form
    - Node inside， hybrid from
  - **Programing model**
    - Node-node, MPI
    - Node inside, share memery
      - Pure CPU-thread
      - CPU-thread(attempering GPU)

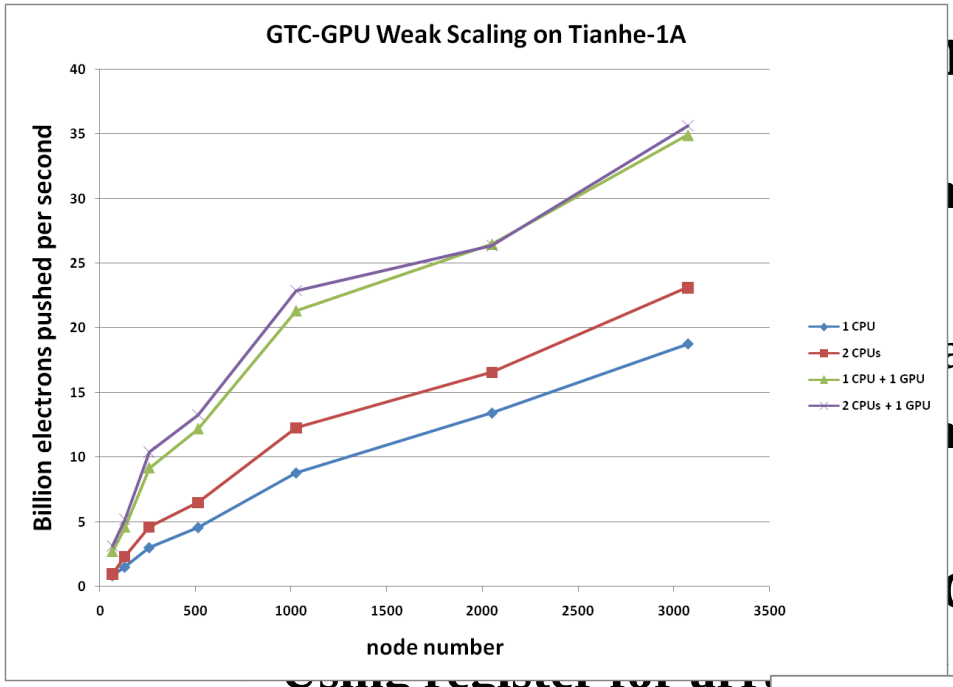


Research and development of NSCC-TJ

- **Hiberarchy Model of Supercomputing Application Environment**
  - **Hiberarchy parallel initialization**
    - Host nodes: arrangement initialization tasks
    - Sub-nodes: finished part of initialization
  - **Hiberarchy parallel computing**
    - Computing resource dynamic allocation
    - Running node fault tolerance
  - **Hiberarchy I/O management**
    - Local memory: temporary I/O
    - Excursion strategy: high-load, no-block



Research and development of NSCC-TJ



n simulation

ning model

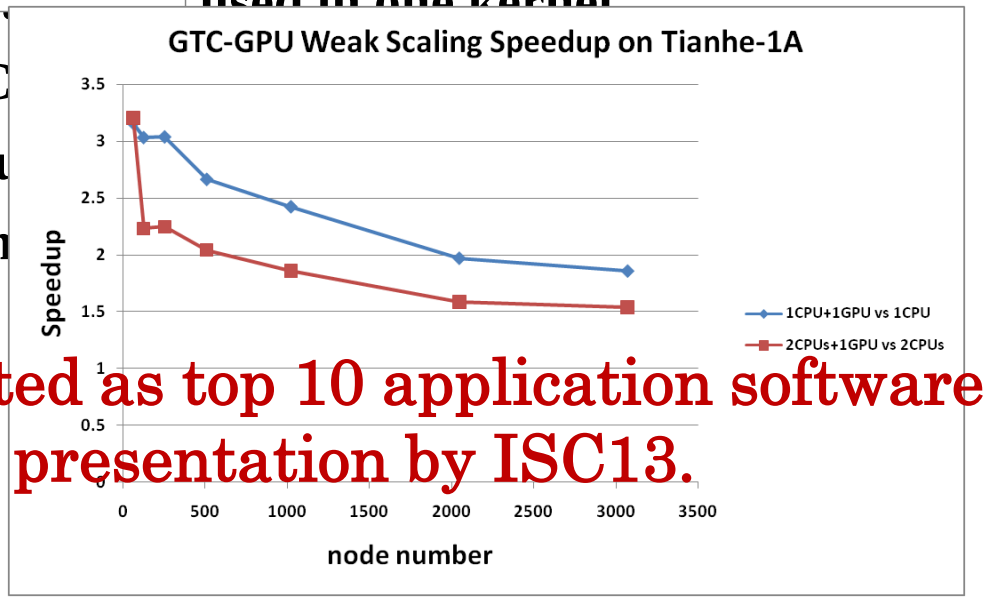
al locality

se texture cache hit

GPU

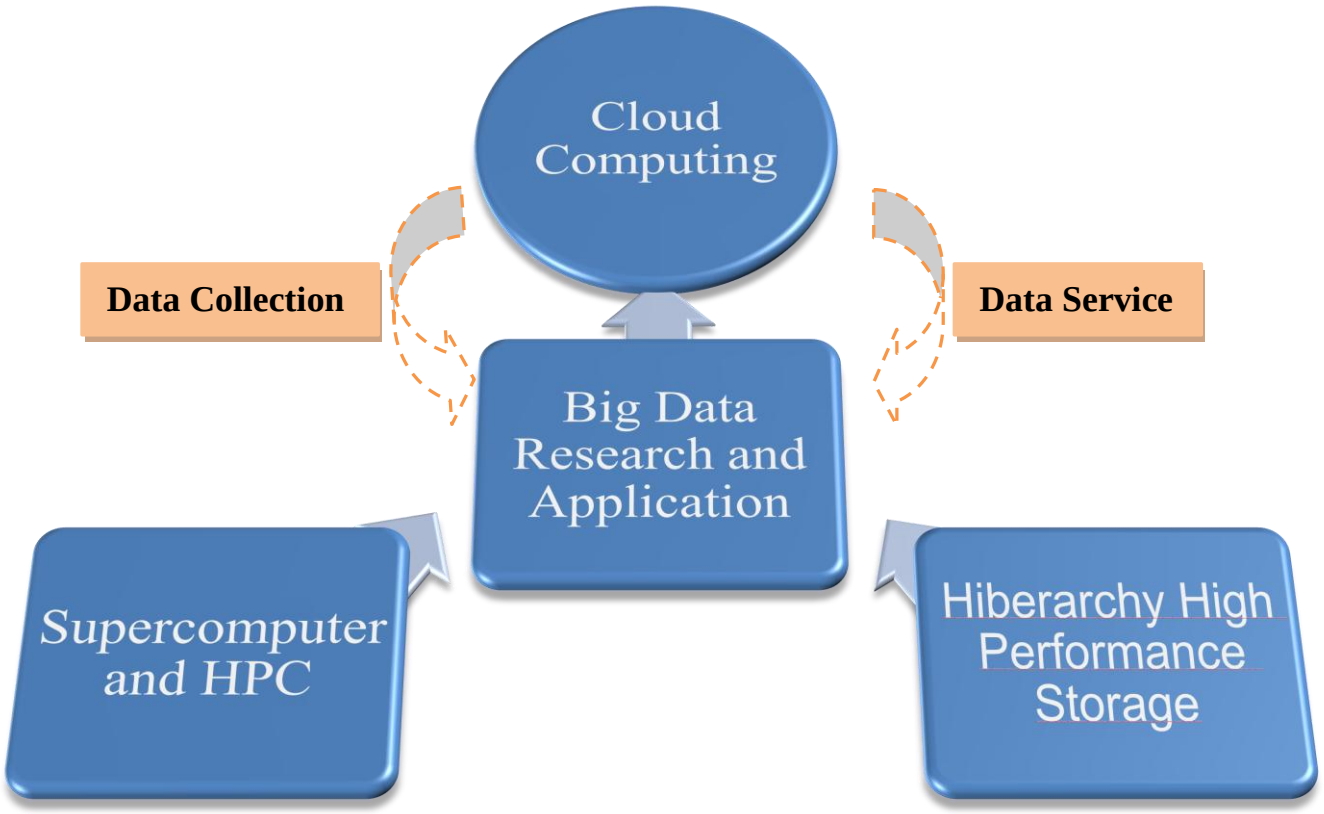
used in one kernel

- **Parallel algorithms for C**
  - ✓ **Hierarchical scan solu**
  - ✓ **Concurrent execution**



This work has been selected as top 10 application software On Titan and accepted to presentation by ISC13.

Fusion Tech. of Big Data and HPC, CC



Research and development of NSCC-TJ

Big-data Technology R&D

- **Collection and service:**

  Model of big data collection and service based on cloud computing;

- **Analysis and process:**

  1), Develop HPC software of big data analysis and process

  2), Model the performance of executing HPC application on cloud platform

  3), Research high cost-performance model of data analysis and process

  4), Research a statistic model that is scalable for distributed big-data set

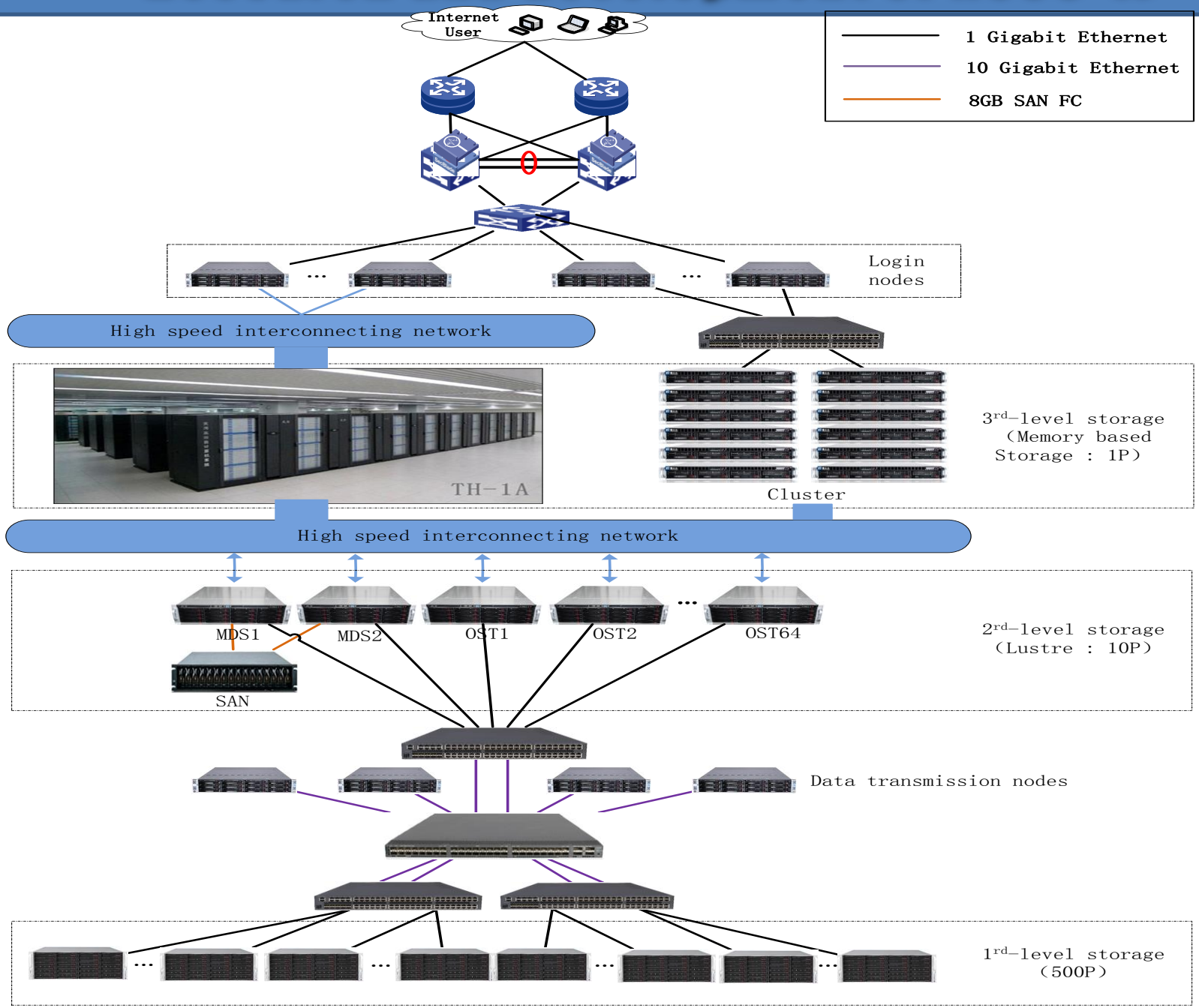
- **Storage:**

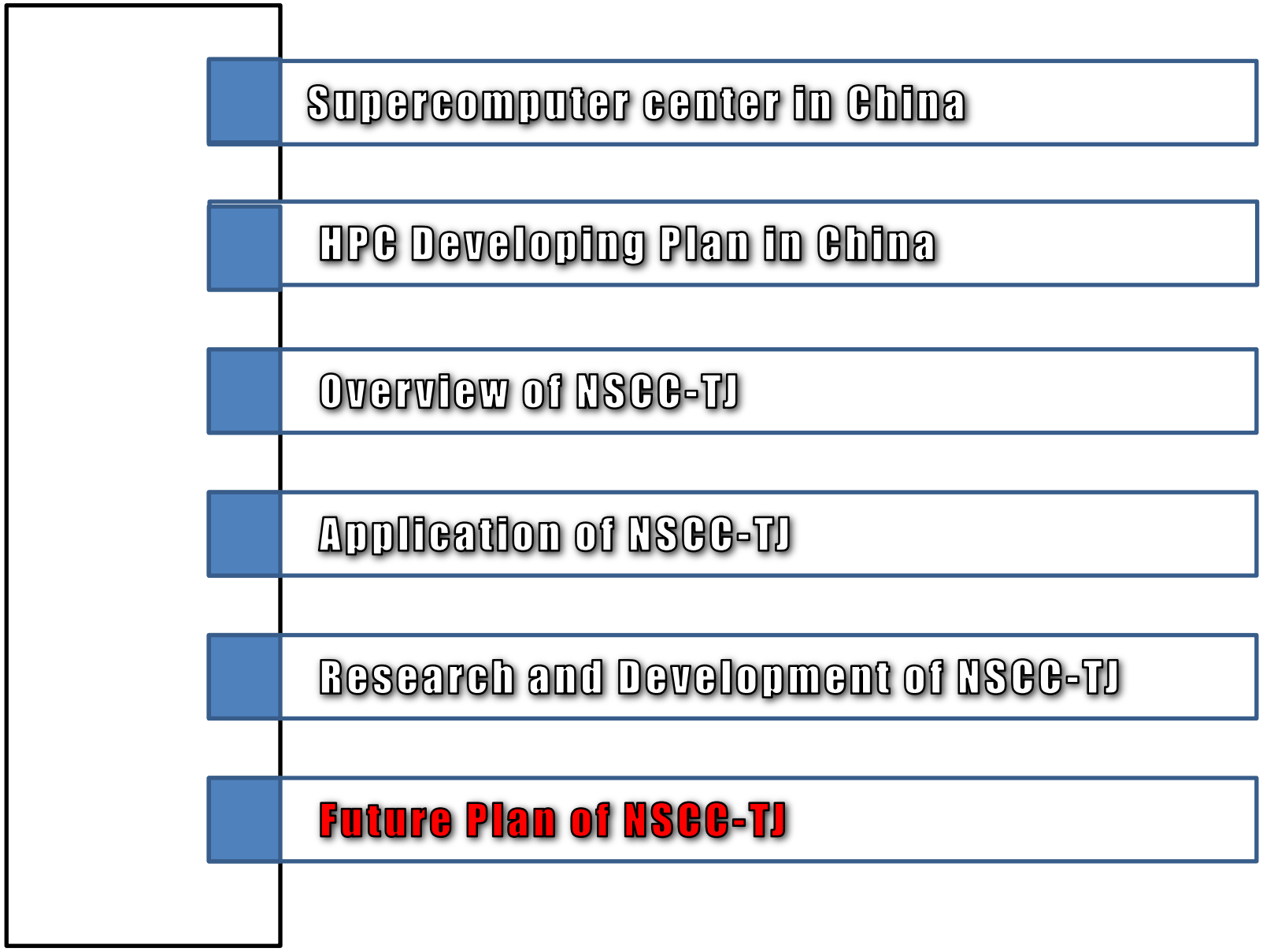
  Building a Scalable Storage based on hardware technology and CC

Big-data Application

- **Genome, geophysics, Climate, Intelligent City, …;**
- **Global systems science**

Research and development of NSCC-TJ

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Future Plan of NSCC-TJ

Strategy to extend High-end Information Tech. Application(HITA) in China and even the world

- **User and Collaborator: University, Academe and Industry**
- **NSCC-TJ : HITA service and technical R&D**

  - Provide HPC, CC, Big-data service for users
  - Research and develop HPC, CC, Big-data technology and construct application platform
  - Training: improve application ability of users and educate more high-end IT talents
  - Collaboration: strengthen international cooperation and lead the HITA development

Area of International Collaboration

- Focus on the important science research area, based on Tianhe-1A and other HPC resource to strength the application cooperation, such as Life science, Energy Development, Climate Change, Physics and so on;
- HPC technology R&D:

  1), Design and optimize programming model for heterogenic supercomputers;

  2), Research the challenges of large-scale scientific computing: I/O wall, Fault-tolerant, Energy efficiency, etc

  3), Model the performance of executing HPC application on cloud platform
- Big data research and application: Fusion technology of Big data and HPC, CC

Thanks

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