



EDISON

A Platform for Simulation based Learning of
Computational Science and Engineering

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National Institute of Supercomputing and Networking, KISTI*

Contents

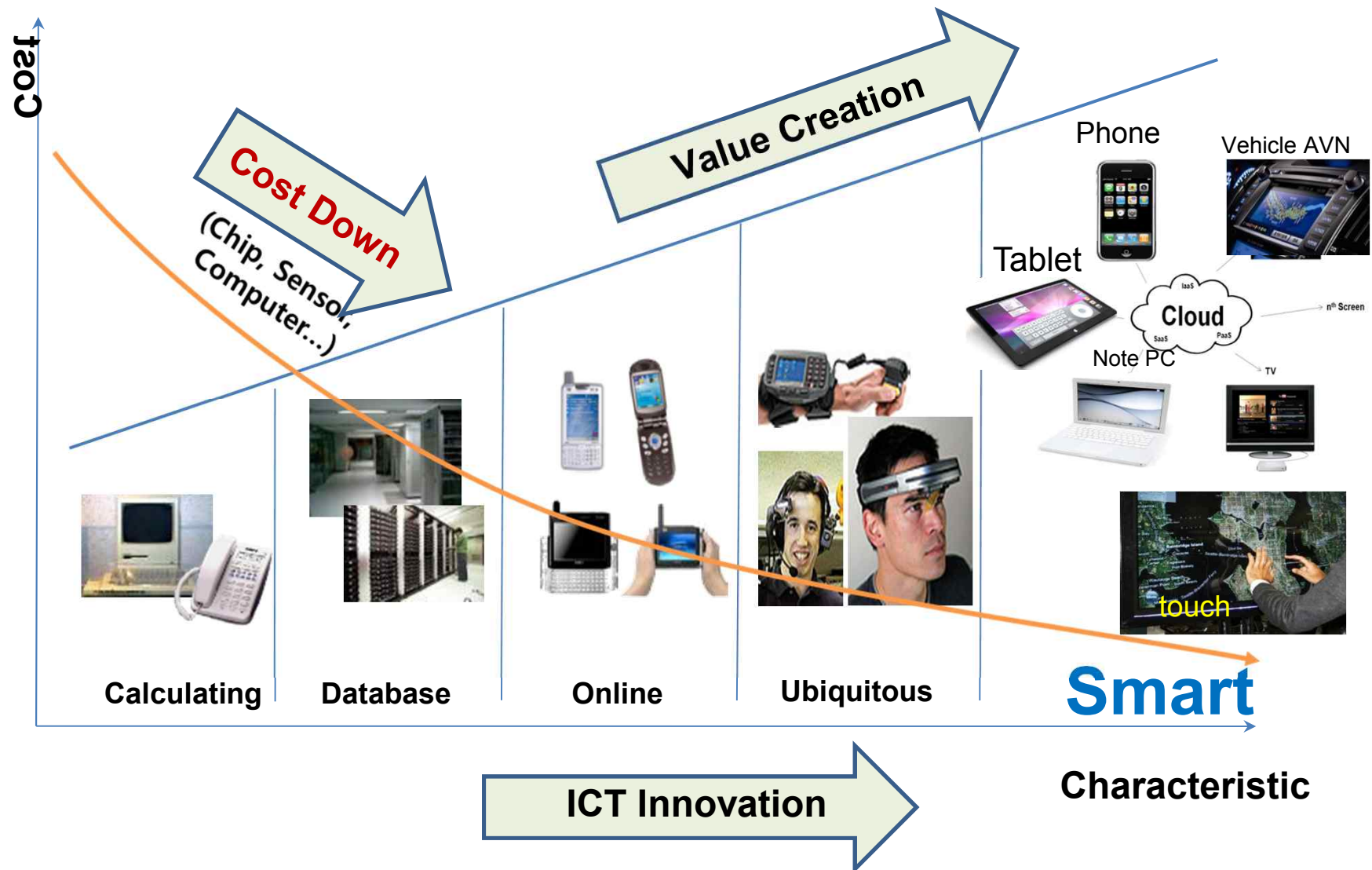
I Introduction on EDISON

1 Status & Necessity of Cyber–Learning System

2 A Cyber–Learning System : EDISON

3 Future Directions of EDISON

1.1 Trend of ICT Innovation & Its Value Creation

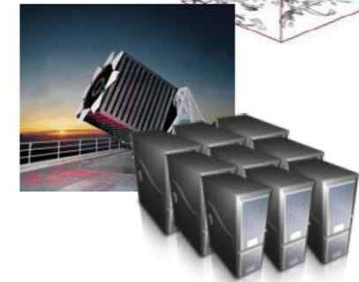
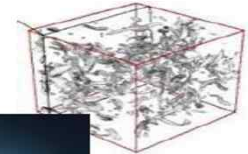


1.2 Changes of a Research Paradigm

1. Thousand years ago – **Experimental Science**
 - Description of natural phenomena
2. Last few hundred years – **Theoretical Science**
 - Newton's Laws, Maxwell's Equations...
3. Last few decades – **Computational Science**
 - Simulation of complex phenomena
4. Last few years – **e-Science or Data-Intensive Science**
 - Scientists overwhelmed with data sets from many different sources
 - ✓ Data captured by instruments
 - ✓ Data generated by simulations & sensor networks
 - e-Science is the set of tools and technologies to support data federation and collaboration
 - ✓ For analysis and data mining
 - ✓ For data visualization and exploration
 - ✓ For scholarly communication and dissemination



$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{4\pi G \rho}{3} - K \frac{c^2}{a^2}$$



Science must move
from *data*
to *information*
to *knowledge*

1.3 Status of Korea's R&D and Education

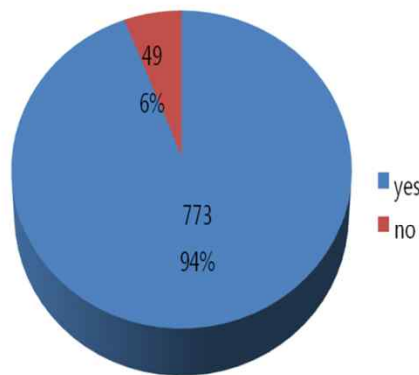
1. As the amount of investment in national R&D projects increases
 - The science competitive power of Korea continues to be enhanced and is in the group of 5 leading countries with the US, Japan and etc
 - In 2010, the Korea's rank of SCI paper was on the 11th place and the rank of international patents was on the 4th place in the world
2. The competitiveness of the national science and technology
 - Korea has been improved and reached to the rank of 5 & 14 in 2010
3. The usefulness and quality of the national science education system
 - The rank of higher education system was the 37th in the world
4. The reeducation cost for the newly graduates is so high
 - The good research results have been hardly applied into the education
 - The higher education of science and engineering in Korea has focused on the theory-based learning rather than experiment-based learning
5. Any solutions? → Cyber-Learning
 - Experiment-based science and engineering education on the cyber infrastructure is one of the possible solutions.

1.4 Necessity of Cyber-Learning System

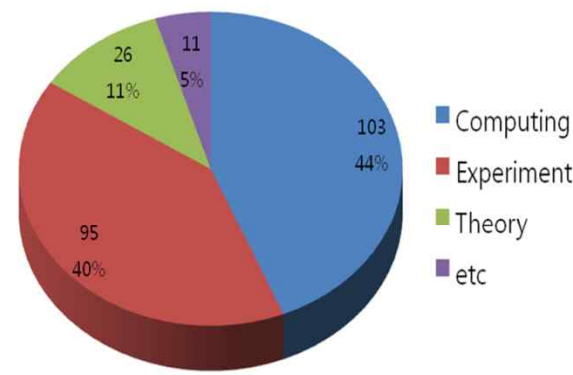
Survey Results (Apr. 2010)

Total Respondents: 822 People

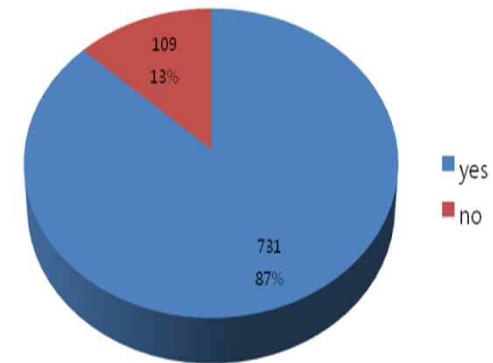
(Professor: 243, Researcher: 279, Student: 190, Industry: 110)



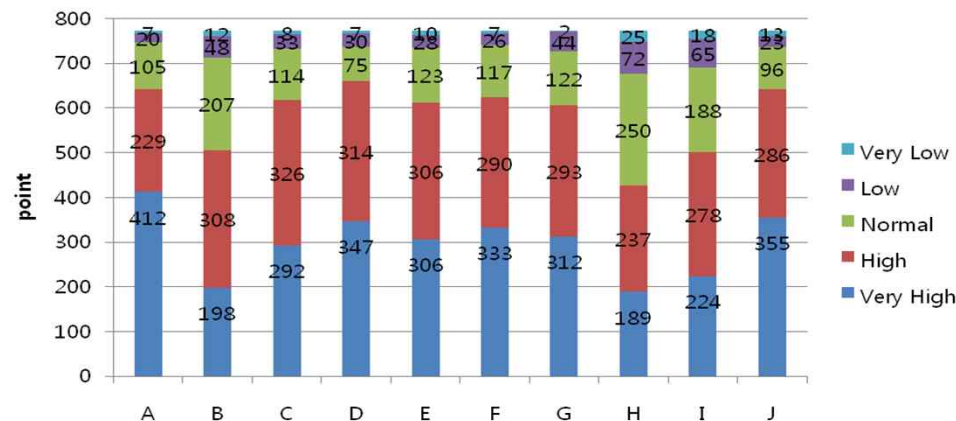
Necessity of improving the higher education environment



Methodologies used for research (Professor group)



Willingness of using a simulation based cyber-learning system



75% agreed to Improve the higher education environment

Contents

I Introduction on EDISON

1 Status & Necessity of Cyber–Learning System

2 A Cyber–Learning System : EDISON

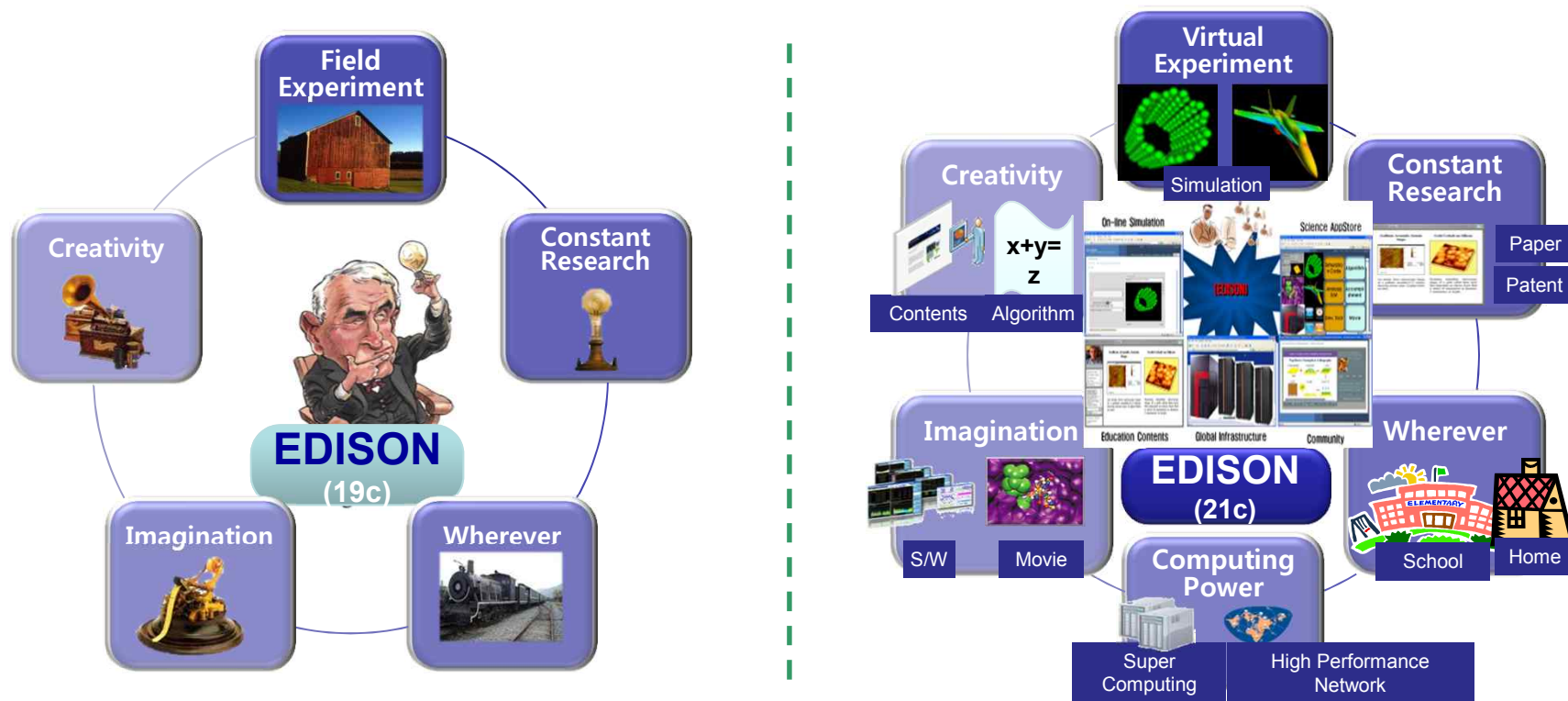
3 Future Directions of EDISON

Background and Overview

2.1 A Cyber-Learning System : Background

EDISON means

EDucation-research Integration through Simulation On the Net

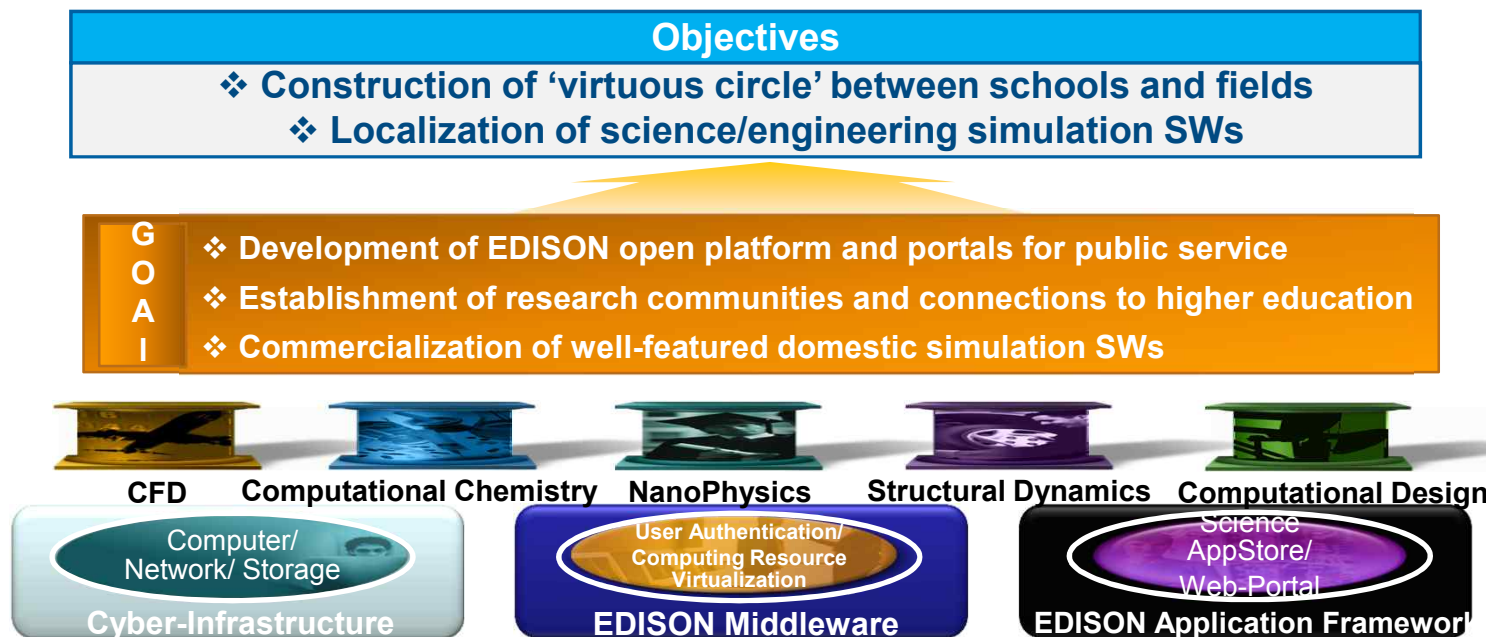


Anyone can learn and understand the theory or system by computer simulation anywhere and can predict operations of the system by easily changing parameters of the simulation model.

2.2 Overview of EDISON (1/3)

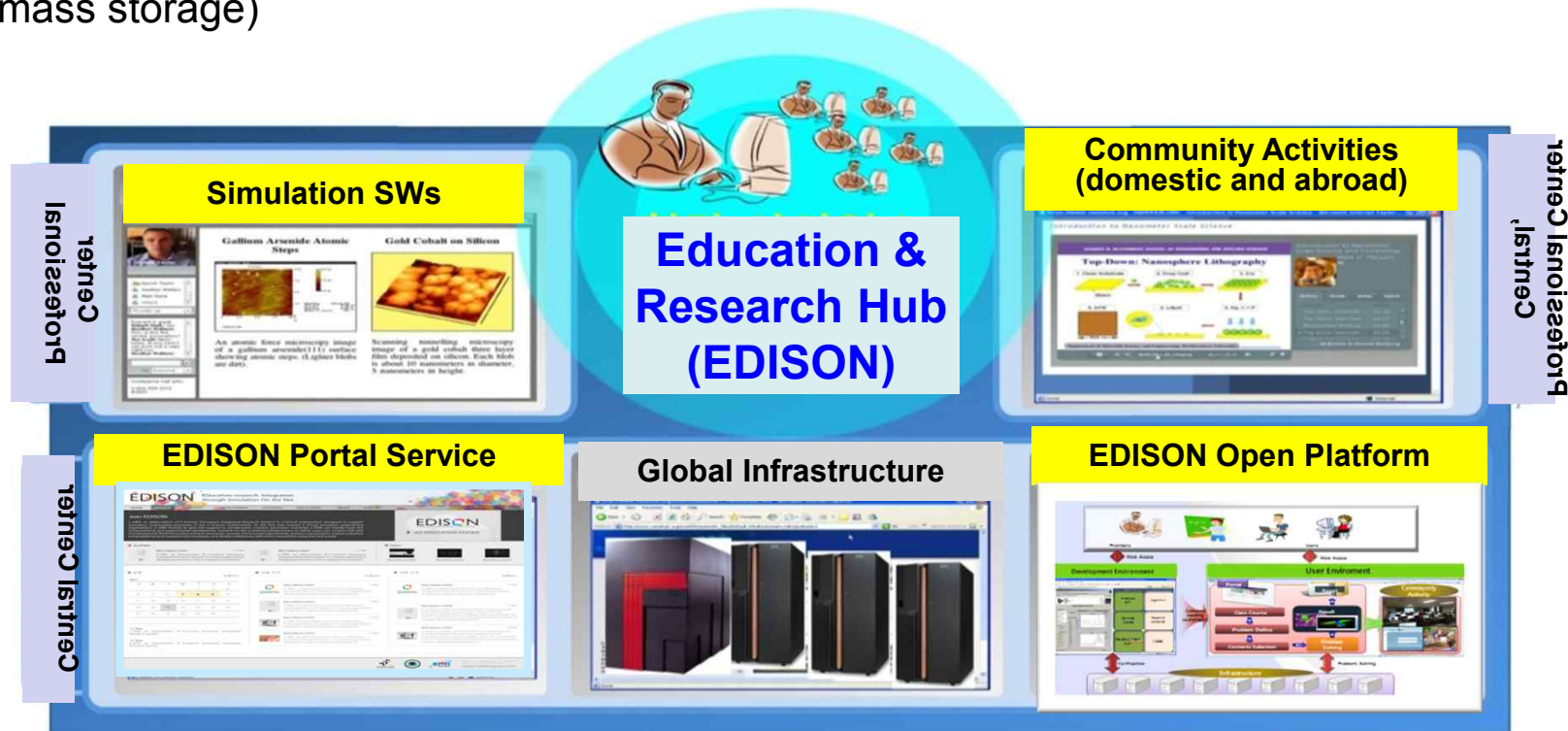
■ Science Gateway for Research & Education of Computational Science

- ❖ To establish a web-based open platform on cyber-infrastructure where people can easily and conveniently access and utilize simulation SWs for the educational and research purpose
- ❖ To help (under)graduate students learn latest technologies and research trends in the engineering/science area, and localize simulation SWs in the various application areas
- ❖ Timeframe: July 2011 ~ Ongoing
- ❖ Budget: U\$3~4M/year funded from Ministry of Science, ICT and Future Planning



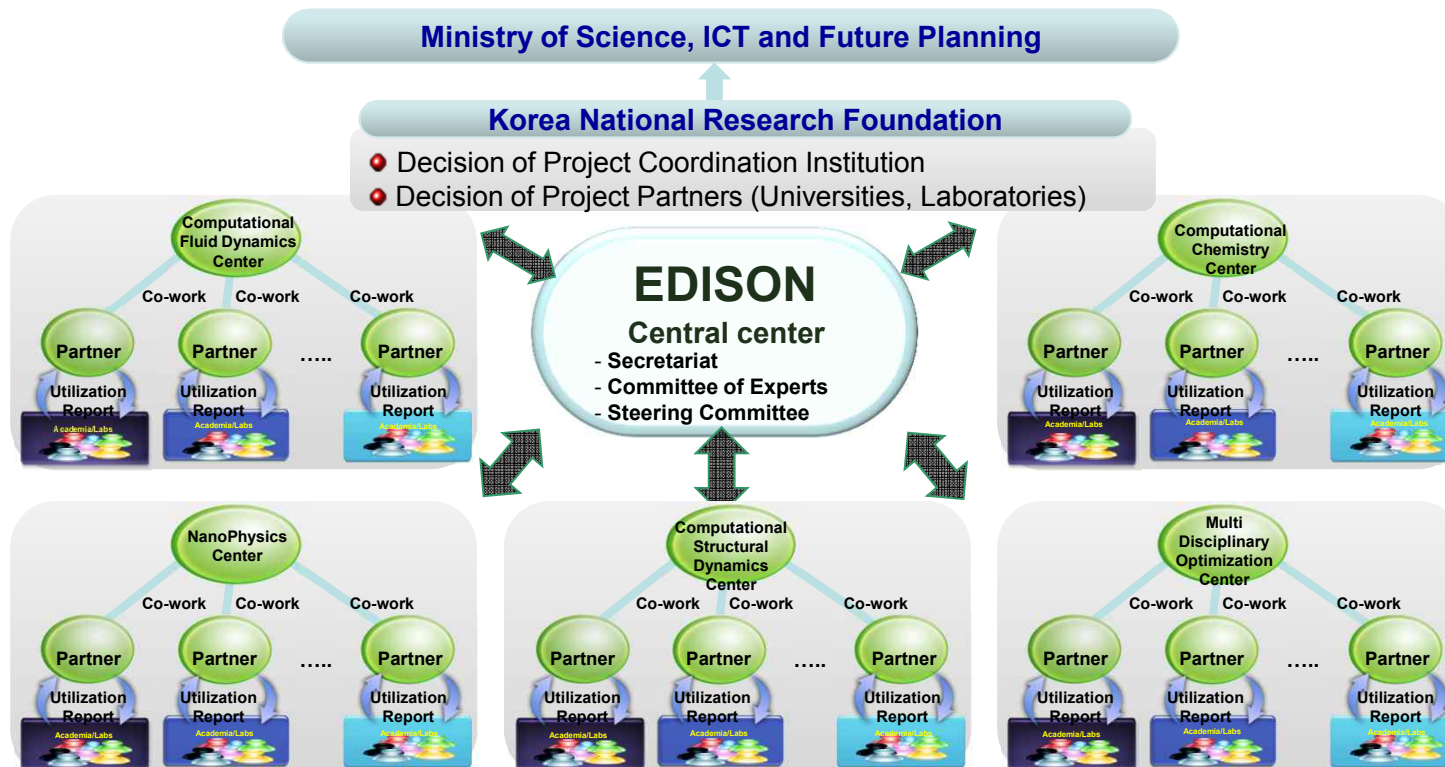
2.2 Overview of EDISON (2/3)

- ❖ Development of web-based EDISON open platform for running simulation, which can be expanded into multiple application domains, and user portal service environment
- ❖ Securement of core technologies through the localization of various computational simulation SWs developed and used for education/research fields
- ❖ Provision of user services for CFD, NanoPhysics, Chemistry and other domains, powered by KISTI cyber-infrastructure (supercomputer, high-speed network, and mass storage)



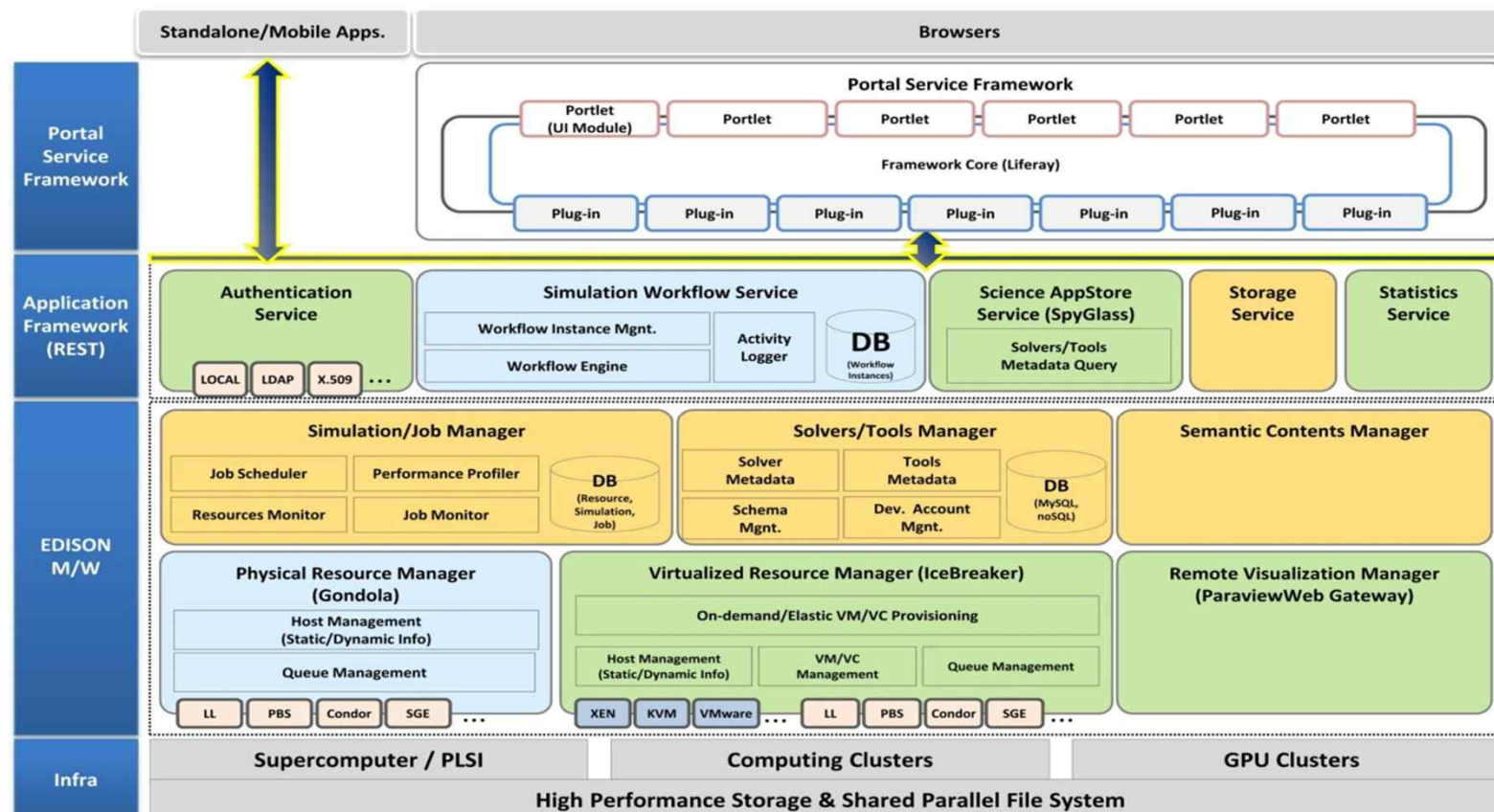
2.2 Overview of EDISON (3/3)

- ❖ EDISON Central Center (KISTI)
 - Development of EDISON open platform and core technologies
 - Provision of computing/network resources for EDISON users
- ❖ EDISON Application specified 5 Area Centers
 - Development of Simulation SWs and contents, and incorporation with lectures



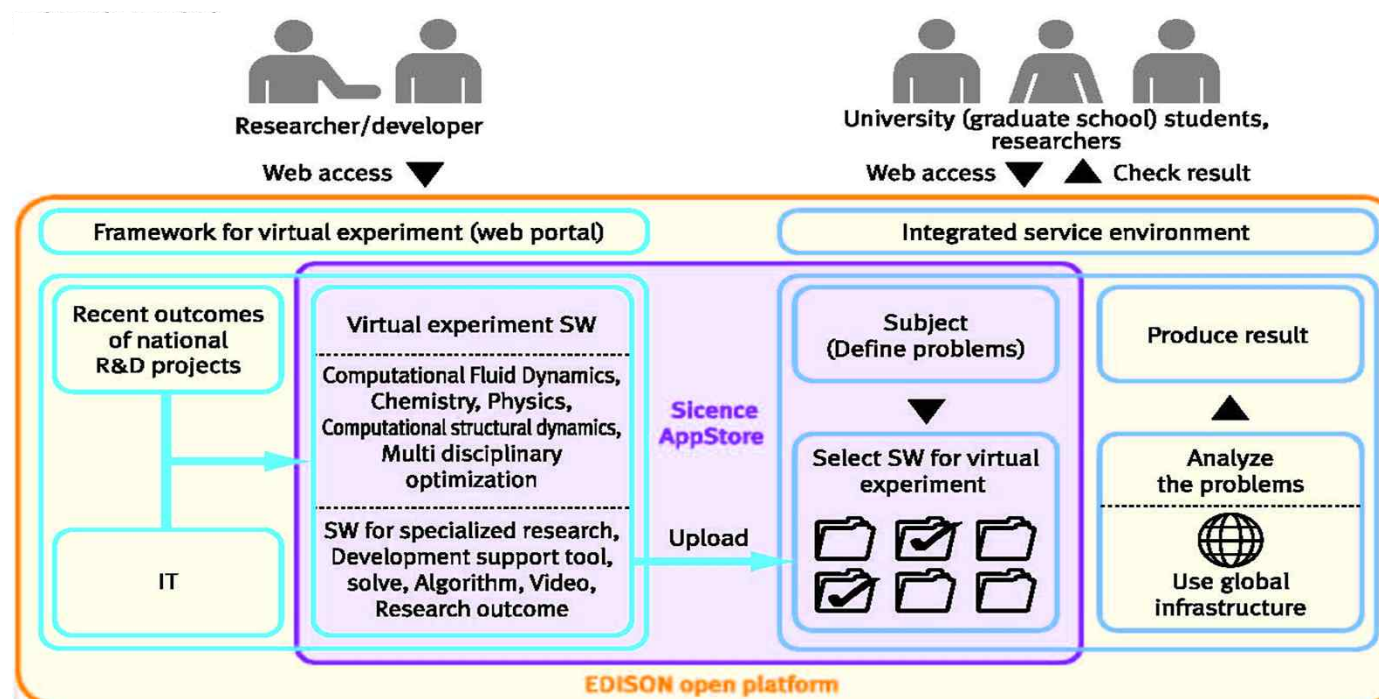
2.3 Overview of EDISON Platform

- ❖ **C**onvenient System → Easy to Develop Simulation SWs
- ❖ **O**pen System → Easy to Expand Various Application Areas
- ❖ **E**ffective System → Stable Web-based Simulation Running System
- ❖ **E**asy System → Easy to Use and Understand Simulation SWs/Contents



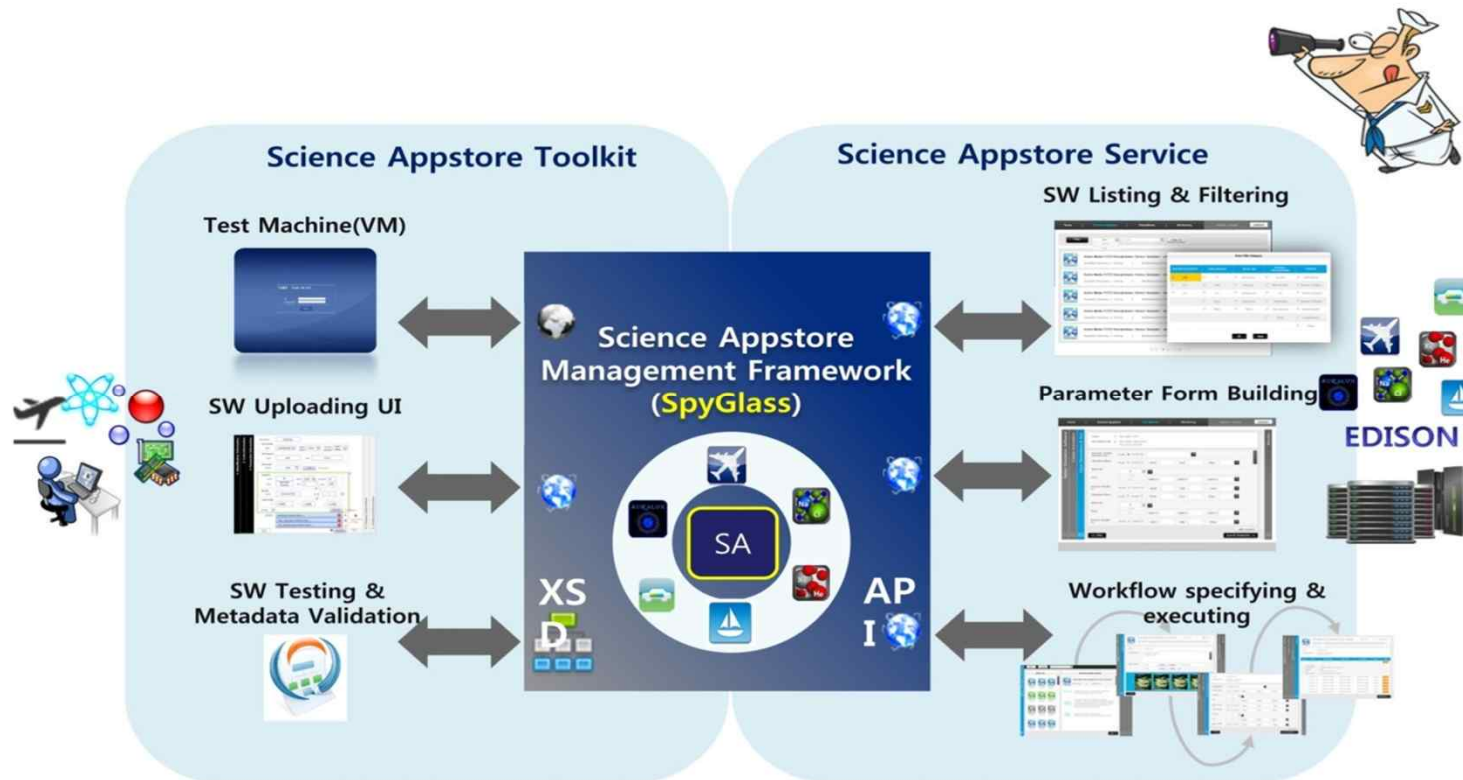
2.4 Simulation Running Scenario on EDISON

- ❖ Researchers/Developers: Developing simulation SWs by combining latest research results with IT through Web environment and register developed SWs to Science AppStore
- ❖ General Users(Students/Researchers): Running their simulation jobs to solve problems by selecting simulation SWs in Science AppStore using the EDISON Infrastructure (Physical/virtual computing resources)



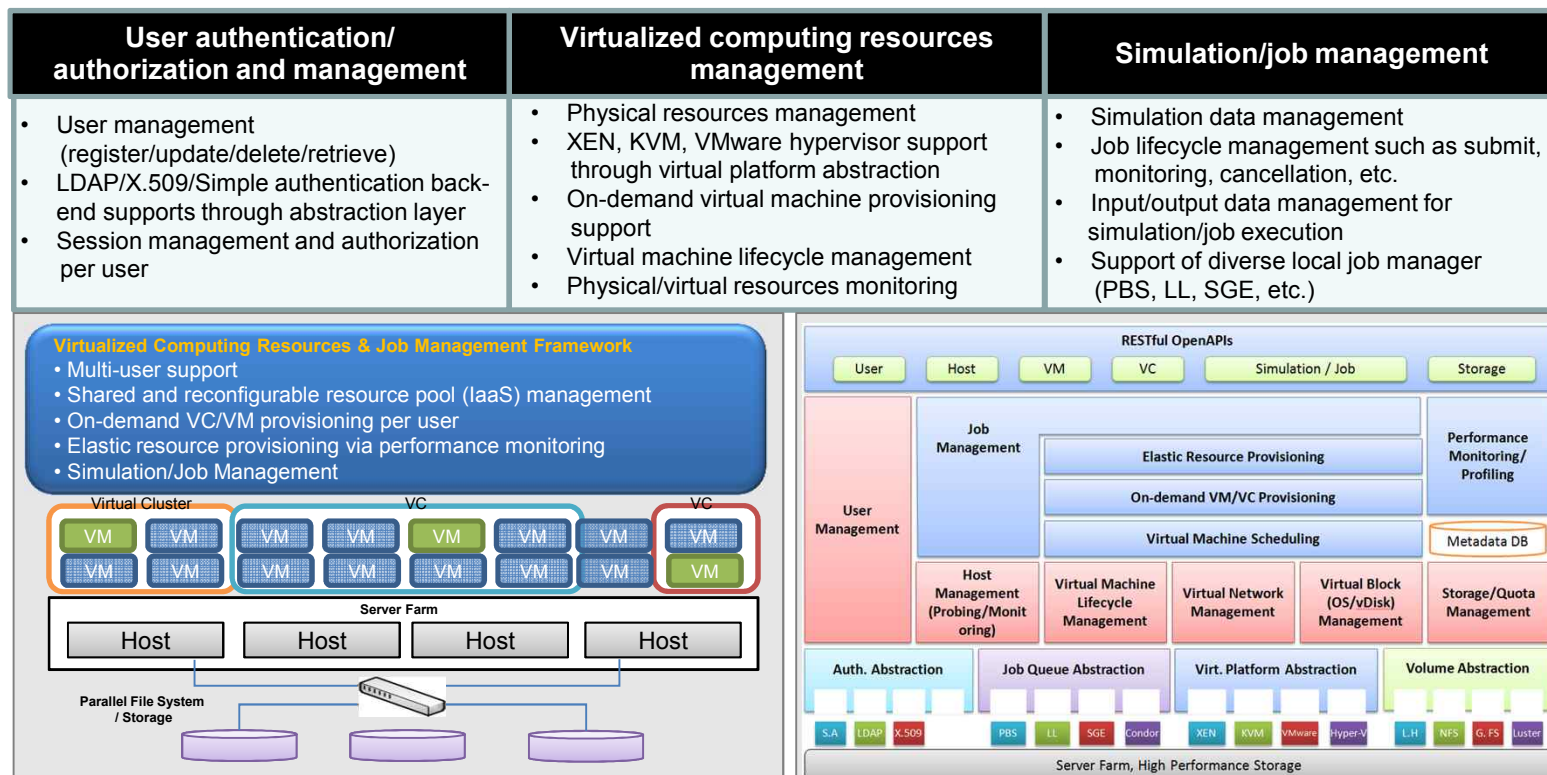
2.5 Core Technology in EDISON Platform (1/2)

- ❖ Science AppStore Management Framework (**SpyGlass**)
 - Repository of simulation SWs and its metadata, which can be executed on the EDISON platform
 - Composed of Science AppStore toolkit (SpyGlass Toolkit) and Science AppStore service (SpyGlass Services)
 - HTTP(S) based RESTful interface provided



2.5 Core Technology in EDISON Platform (2/2)

- ❖ Virtualized Computing Resources/Job Management Framework (**IceBreaker**)
 - User authentication/authorization, virtualized computing resources management and job lifecycle management
 - Virtual cluster and/or VM provisioning via Xen VM monitor (VMM, hypervisor)
 - HTTP(S) based RESTful interface provided



Application Areas

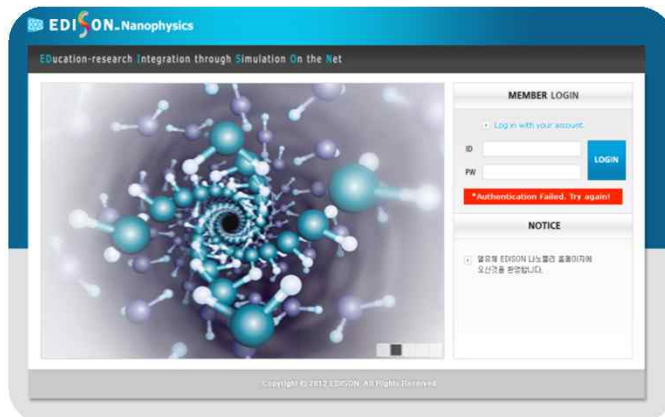
2.6 EDISON Portals : CFD, NanoPhysics & Chem

Computational Chemistry

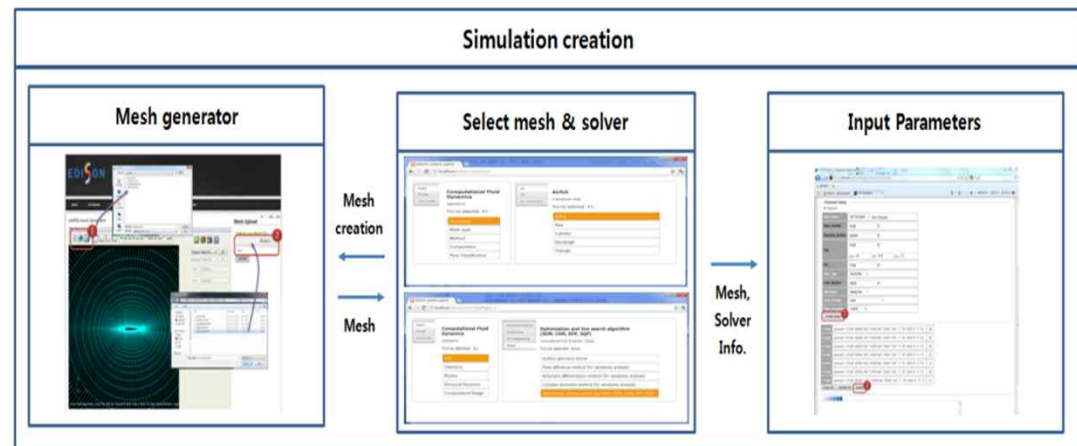


< chem.edison-project.org >

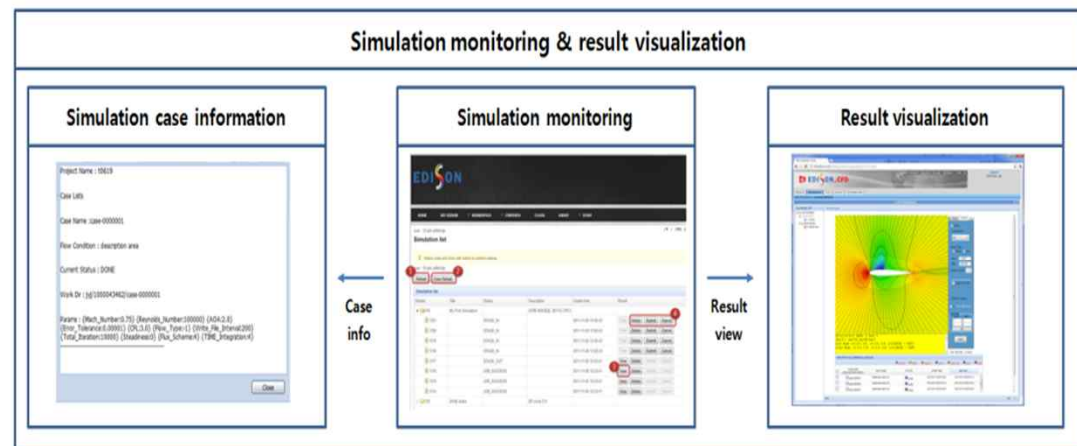
NanoPhysics



< nano.edison-project.org >



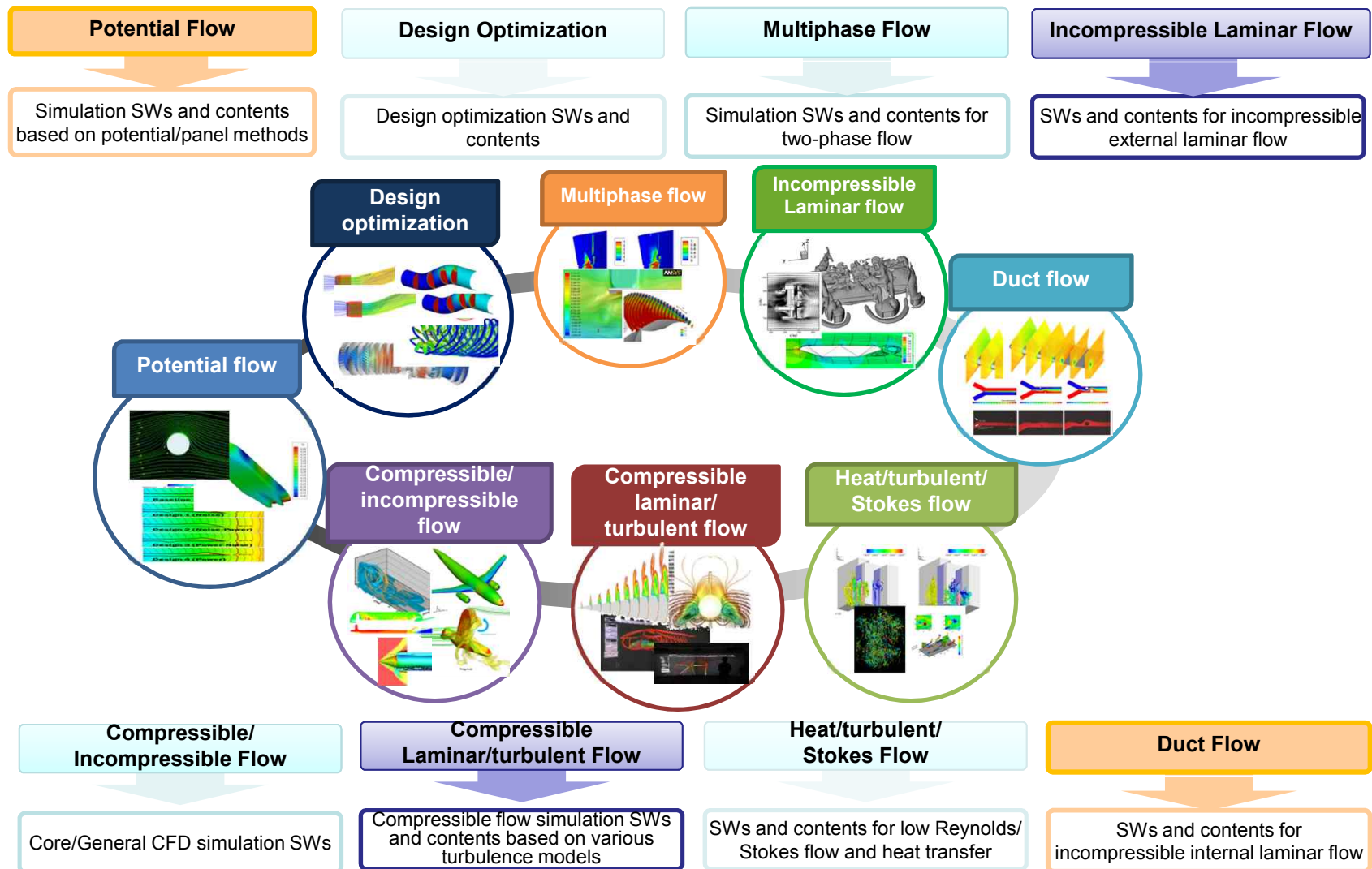
Simulation job submission ↓ Reuse of simulation workflow ↑



< Steps of Running Simulations >

2.6 Application Areas : EDISON_CFD (1/2)

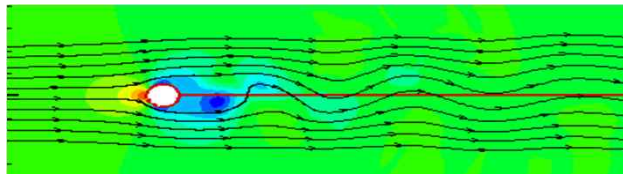
□ Develop & use of basic/applied/advanced simulation SWs and contents



2.6 Application Areas : EDISON_CFD (2/2)

Flow over a Circular Cylinder

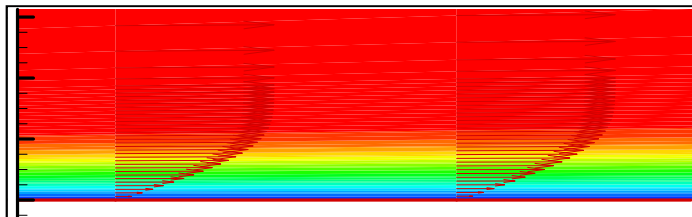
- Karman vortex street
- Reynolds number = 140, AOA = 0.0
- Grid : 101×81 cells



[Vorticity contour and streamline]

Flow over a Flat Plate

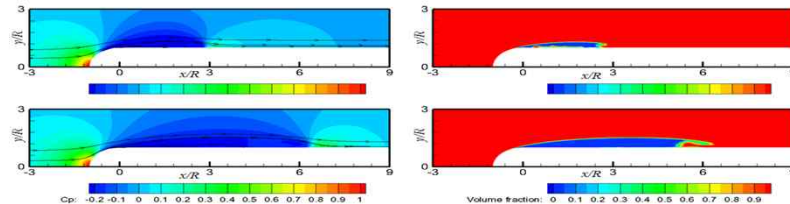
- Reynolds number = 1.08×10^5



[Velocity contour and vector]

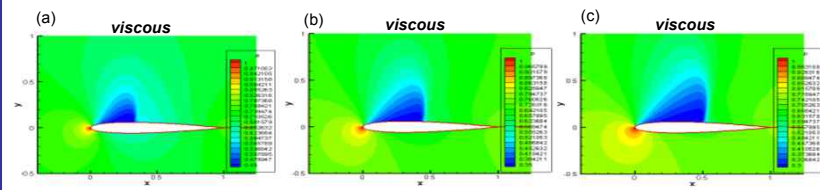
Cavitation Problem

- Reynolds number = 1.36×10^5
- Temperature = 300K
- Grid : 144×80 cells



Flow over a NACA0012 Airfoil

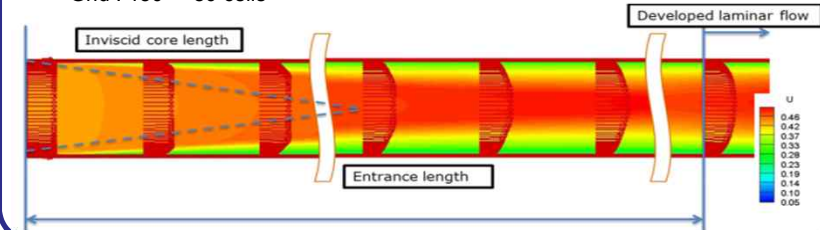
- Case1 : Mach number = 0.73, AOA = 2.0
- Case2 : Mach number = 0.73, AOA = 4.0
- Case3 : Mach number = 0.73, AOA = 6.0



[Pressure contour]

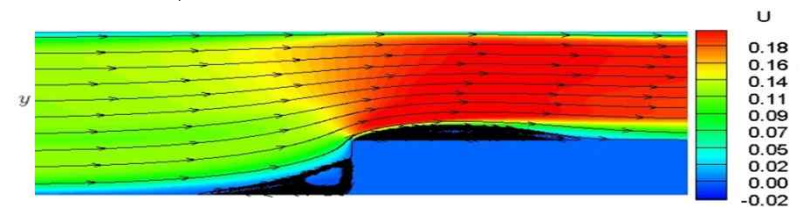
Channel Flow

- Fully developed flow of channel
- Reynolds number = 1×10^3
- Grid : 150×80 cells



Forward Facing Step

- Reynolds number = 4.4×10^3
- Grid : 4,800 cells



[Velocity contour and streamline]

Result Examples from CFD Lectures

2.6 Application Areas : EDISON_NanoPhysics (1/2)

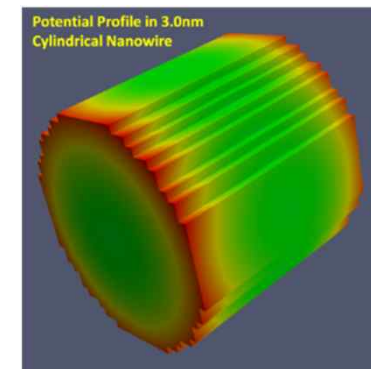
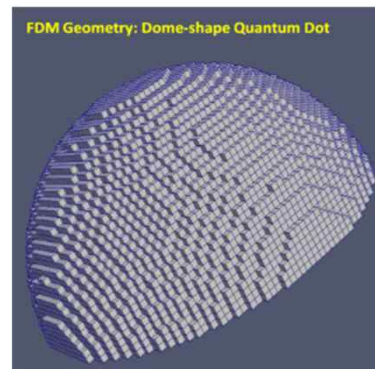
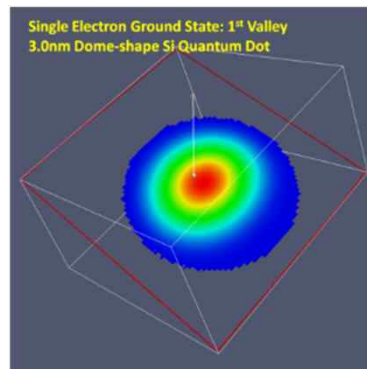
The screenshot displays the EDISON_NanoPhysics web interface. The top navigation bar includes 'ABOUT', 'SIMULATION', and 'VIRTUAL LAB'. The main content area is divided into several sections:

- Appstore:** A sidebar on the left with icons for Appstore, Simulation, and Virtual Lab.
- Simulation:** A central area showing a 3D visualization of a 'Crystalline GaAs bulk' and 'Arsenide' atoms. Below this is a 'Gallium' section with a world map.
- System Resource Statistics:** A table showing cluster usage.
- News and FAQ:** Sections for updates and frequently asked questions.
- Simulation Workflow:** A section on the right titled 'Simulation' with a 'Select Workflow' button and a list of available simulation workflows.

Index	SW name	Version	Affiliation	Name	Date	Manual	Detail View
5	Particle-in-a-Well problem simulation LAB	Ver 1.0	KISTI	Hoon Ryu	2013-08-29	Manual	Detail view
4	P-N Junction diode simulation LAB based on Drift-Diffusion equation	Ver 1.0	KISTI	Hoon Ryu	2013-08-29	Manual	Detail view
3	Nano-MOS device simulation SW	Ver 1.0	KAIST	Ki-Hoon Park	2013-08-29	Manual	Detail view
2	Carbon NanoTube (CNT) FET simulation SW	Ver 1.0	KAIST	Mincheol Shin	2013-08-29	Manual	Detail view
1	Nanowire FET Simulation SW	Ver 1.0	KAIST	Mincheol Shin	2013-08-29	Manual	Detail view

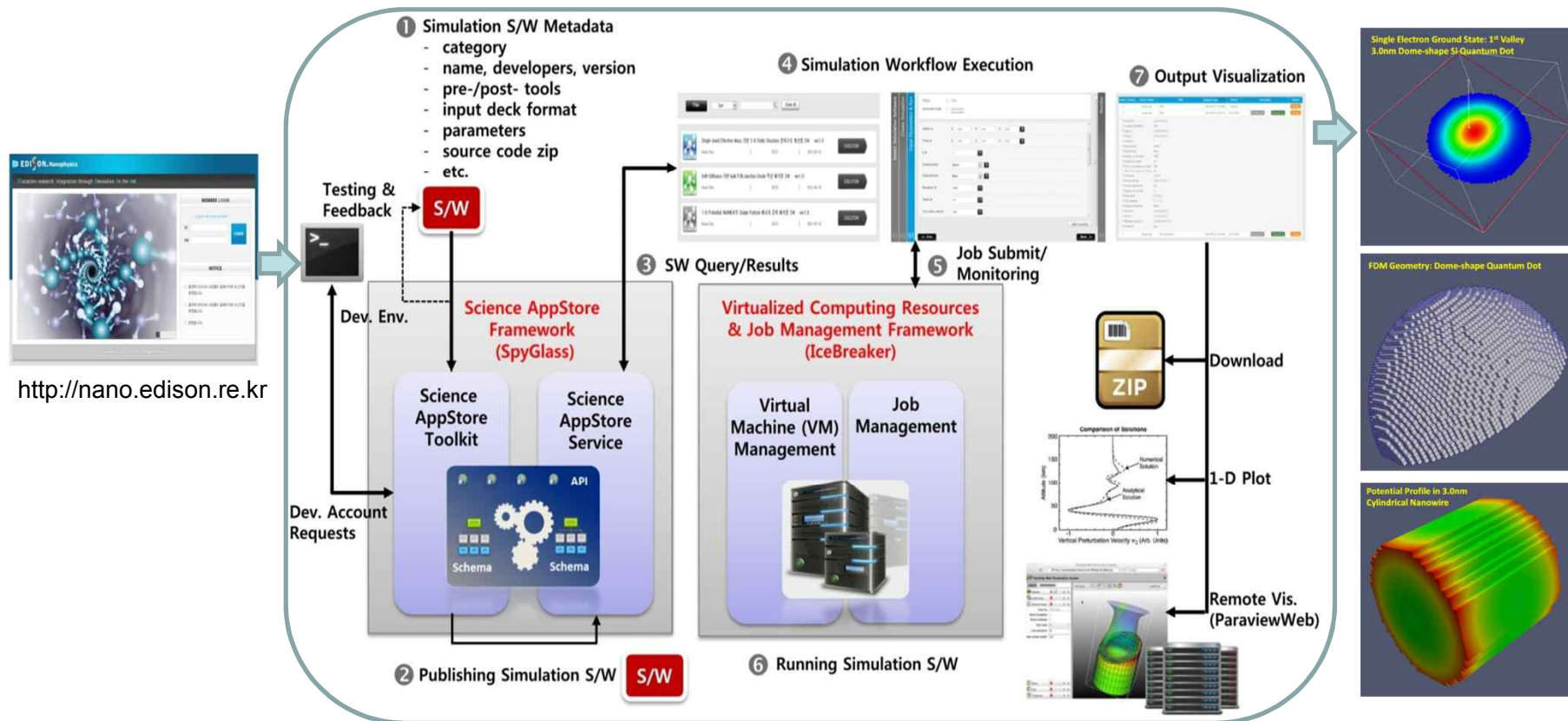
EDISON COPYRIGHT(C) 2011 NATIONAL INSTITUTE OF SUPERCOMPUTING AND NETWORKING. KISTI ALL RIGHTS RESERVED.
Headquarters: 245 Daehak-ro, Yuseong-gu, Daejeon, 305-380, Korea | TEL 042-869-0610 | FAX 042-869-0799 | E-mail elec1020@kisti.re.kr

<http://nano.edison-project.org>



2.6 Application Areas : EDISON_NanoPhysics (2/2)

- Simulation SW metadata management, query, and simulation workflow executions (Science AppStore management framework: SpyGlass)
- Simulation job execution and monitoring (Virtualized computing resources/job management framework: IceBreaker)
- Support of simulation results download, one-D plot, and remote visualization

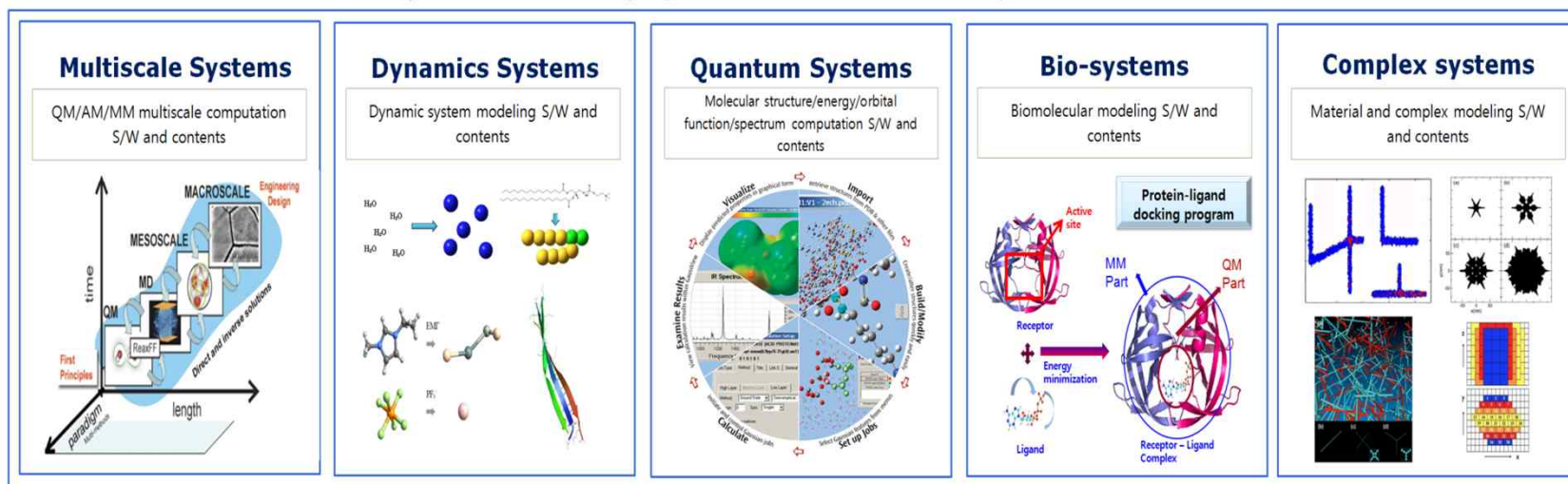


2.6 Application Areas : EDISON_Chem (1/2)

EDISON_Computational Chemistry

Advance on the students' adoptability for the advanced technology by improving education-research level

Development of simulation program and contents for Chemistry education and research



Utilization of the cyberinfrastructure of KISTI for supporting stable computational resource



2.6 Application Areas : EDISON_Chem (2/2)

EDISON_Chem

ABOUT SCIENCE APPSTORE

Computational Chemistry

Length Scales

Time Scales

Molecular Modeling using Multiscale Simulations
Multiscale Systems (MMMS)

Bio & Complex Systems (MMBS & MMCS)
Molecular Modeling for Bio & Complex Systems

Dynamics Systems (MMDS)
Molecular Modeling using Dynamics Simulations

Quantum Systems (MMQS)
Molecular Modeling using Quantum Simulations

System Resource Statistics

Cluster	Total	Used	Avail
vCluster	32	0	32

News

- EDISON 플랫폼 서비스가 2013년 9월 3...
- 광원고개 03
- EDISON 여름학교 강의자료 4 SW 등록에...
- EDISON 여름학교 강의자료 3 입출력자료...
- EDISON 여름학교 강의자료 2 사이버랩

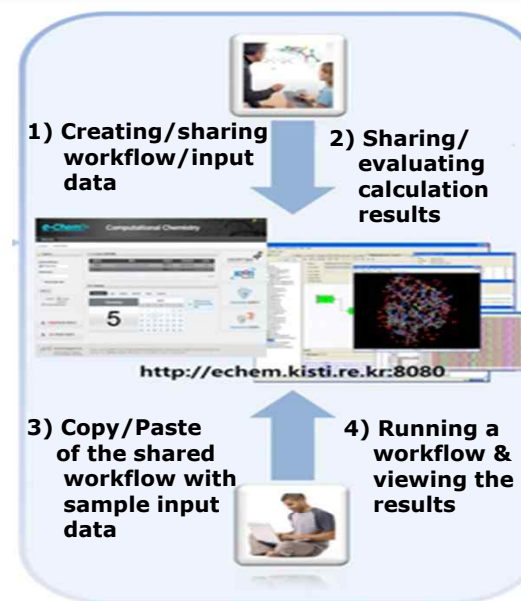
<http://chem.edison-project.org>

Science AppStore

Popular Software

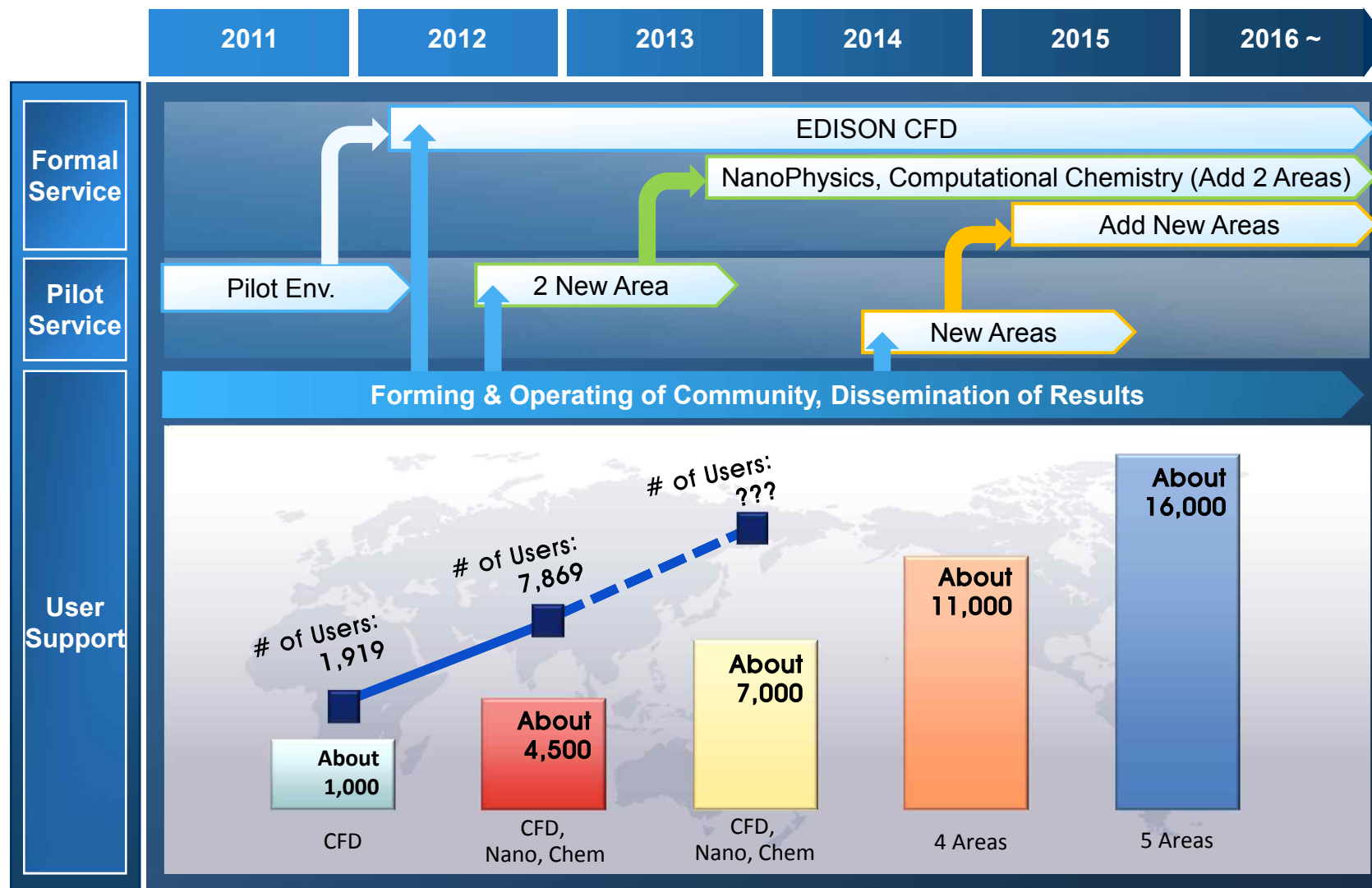
- Wavepacket Dynamics Program Ver1.0 2013-05-29 Seoul National Seokmin Shin
- GalaxyTBM: Template-based protein structure prediction program Ver1.0 2013-09-16 Seoul National Chaek Seok
- GalaxyDock: Protein-ligand docking program Ver1.0 2013-09-16 Seoul National Chaek Seok
- Schrodinger equation solver for 1D model potentials Ver1.0 2013-09-16 KAIST Wooyoung Kim
- Molecular Dynamics simulation program for two different types... Ver1.0 2013-09-16 Sejong University Soonmin Jang

Index	SW name	Version	Affiliation	Name	Date	Manual	Run
5	Schrodinger equation solver for 1D model potentials	Ver 1.0	KAIST	Wooyoung Kim	2013-09-16	Manual	Run
4	GalaxyDock: Protein-ligand docking program	Ver 1.0	Seoul National University	Chaek Seok	2013-09-16	Manual	Run
3	Wavepacket Dynamics Program	Ver 1.0	Seoul National University	Seokmin Shin	2013-05-29	Manual	Run
2	Molecular Dynamics simulation program for two different types of the LJ particle	Ver 1.0	Sejong University	Soonmin Jang	2013-09-16	Manual	Run
1	GalaxyTBM: Template-based protein structure prediction program	Ver 1.0	Seoul National University	Chaek Seok	2013-05-29	Manual	Run



Status of User Services

2.7 Roadmap of User Support (1/2)

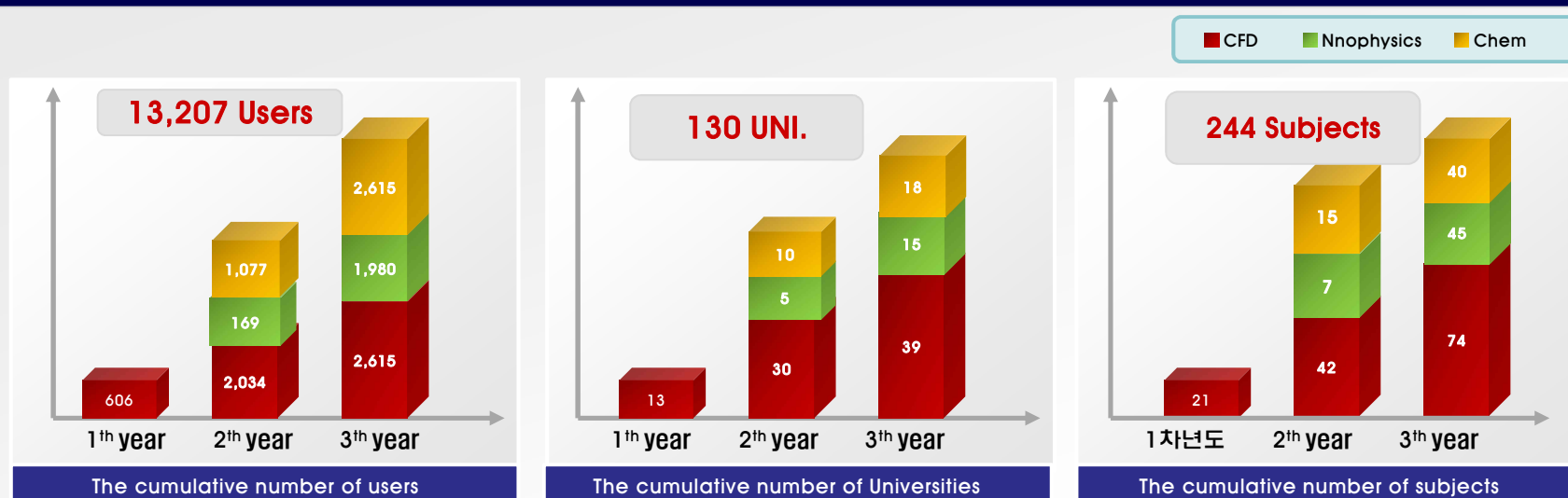


2.7 Roadmap of User Support (2/2)

Status of the EDISON Service (July 2011 ~ Dec 2013)

Area	1 th year			2 th year			3 th year			Total		
	Uni.	Sub.	User	Uni.	Sub.	User	Uni.	Sub.	User	Uni.	Sub.	User
CFD	13	21	606	30	42	2,034	39	74	2,615	82	137	5,255
Nanophysics	–	–	–	5	7	169	15	45	1,980	20	52	2,149
Chem	–	–	–	10	15	1,077	18	40	4,726	28	55	5,803
Total	13	21	606	45	64	3,280	72	159	9,321	130	244	13,207

* the 3rd year: Expected Course Contents



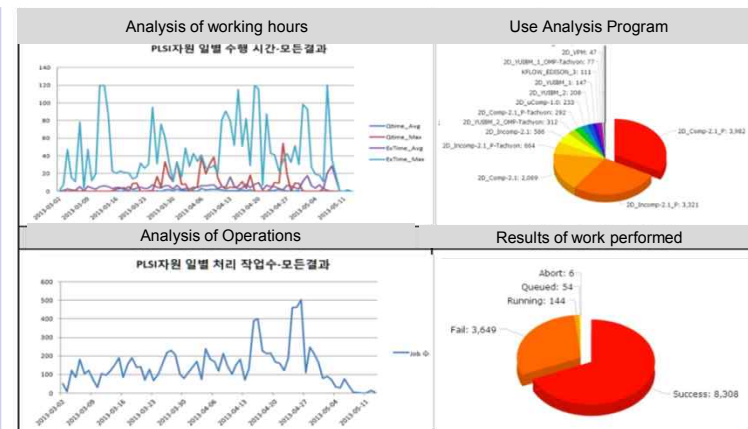
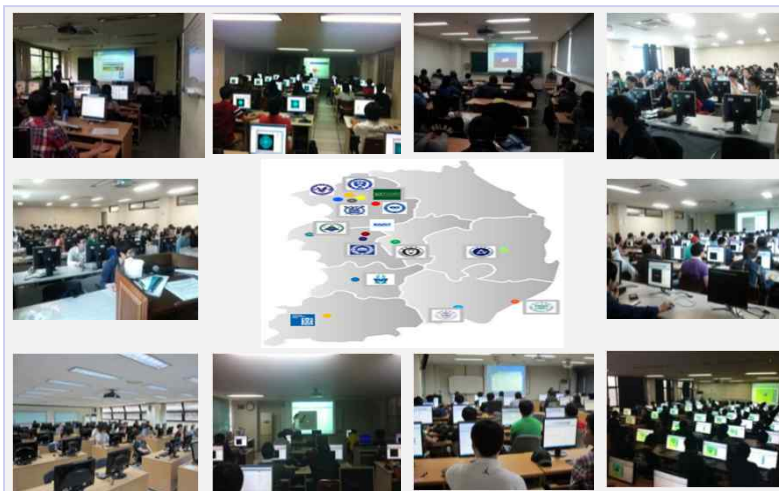
2.7 Status of User Support : CFD

❖ No. of Users: 5,255

- The 1st year in 2011 (2 Semesters)
 - : Total 13 universities, 21 subjects, and 606 students
- The 2nd year in 2012 (2 Semesters)
 - : Total 30 universities, 42 subjects, and 2,034 students
- The 3rd year in 2013 (1 Semester)
 - : Total 39 universities, 74 subjects, and 2,615 students
- The 2nd CFD Competition
 - : Total 48 students in 26 teams from 16 Universities participated (Jeju National University, May 9, 2013)

❖ Statistics of Simulation Execution and Time

- The 2nd CFD Competition
 - Total Execution: 11,646 simulations (Time: 58,854 hours)
- The 1st semester of 2013
 - Total Execution: 29,210 simulations



<The 2nd Competition>

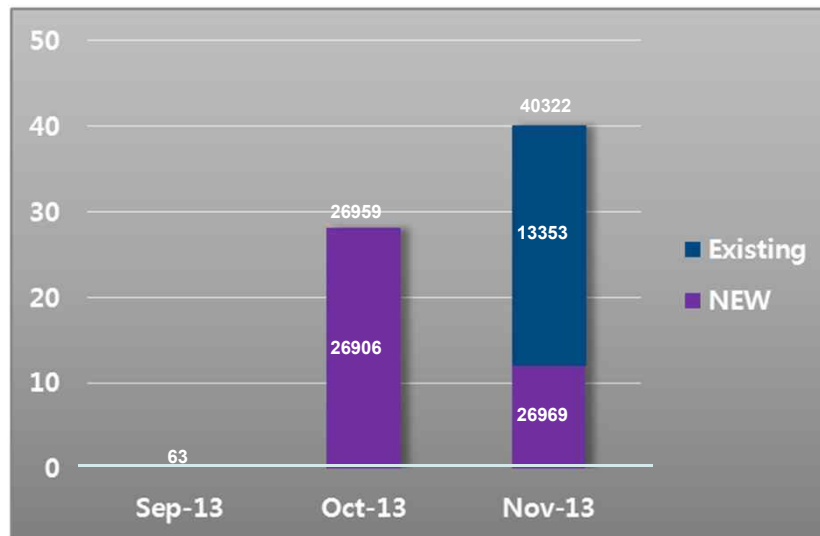
2.7 Status of User Support : NanoPhysics

❖ No. of User: **2,149**

- The 1st year in 2012 (2 Semesters)
: Total 5 universities, 7 subjects, and **169** students
- The 2nd year in 2013 (1 Semester)
: Total 15 universities, 45 subjects, and **1,980** students
- The 1st NanoPhysics Competition
: Total 48 students in 28 teams from 12 Universities participated
(Daejeon DCC, April 25, 2013)

❖ Statistics of Simulation Execution and Time

- The 1st NanoPhysics Competition
- Total Execution: **1,671** simulations(**Total 5,890 seconds**)
- Total Execution: **40,322** simulations after 2nd Semester of 2013



<Performing EDISON_NanoPhysics>



<The EDISON_NanoPhysics class>

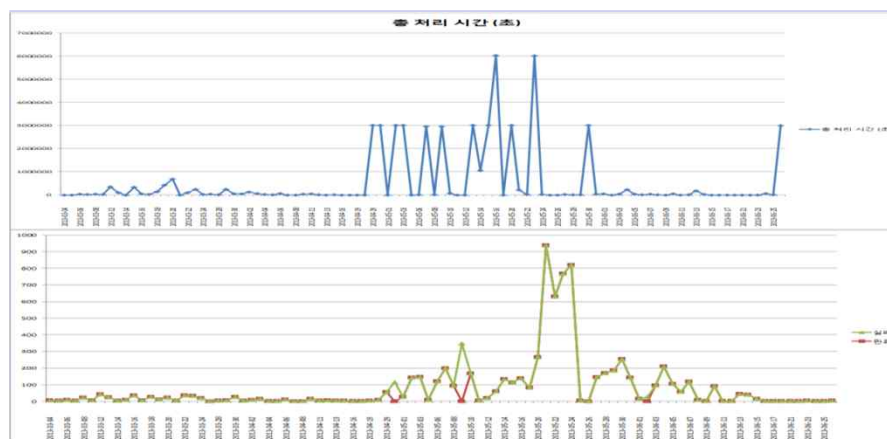
2.7 Status of User Support : Chemistry

❖ No. of User: **5,803**

- The 1st year in 2012 (2 Semesters)
: Total 10 universities, 15 subjects, and **1,077** students
- The 2nd year in 2013 (1 Semester)
: Total 18 universities, 40 subjects, and **4,726** students
- The 1st CFD Competition
: Total 38 students in 17 teams from 10 Universities participated
(Ilsan KINTEX, April 17, 2013)

❖ Statistics of Simulation Execution and Time

- The 1st Computational chemistry Competition
- Total Execution: **495** simulations(**Total 3,317,219 seconds**)
- The 1st semester of 2013
- Total Execution: **7,581** simulations



< the 1st EDISON_Computational chemistry in 2013>



< The 1st Computational chemistry Competition of winners commemorative photograph>

2.7 Activities of Community Building and Support

❖ Holding Competition & Exhibition

- [Computational Chemistry Competition](#) (17 teams participated)
(April 12, 2013, Ilsan KINTEX)
- [NanoPhysics Competition/Exhibition](#) (28 teams participated)
(April 25, 2013, Daejeon DCC)
- [CFD Competition/Exhibition](#) (28 teams participated)
(May 9, 2013, International Exchange Hall of Jeju National University)



❖ Holding Summer/Winter School & Kick-Off Workshop

- [EDISON Winter School & User Workshop](#) (Feb 4~5, 2013, Hoengseong Gangwon)
- [Holding NanoPhysics Summer School](#) (Aug 22, 2013, KSITI)
- [Holding Computational Chemistry Summer School](#) (Aug 19, 2013, KSITI)
- [Holding the 3rd Kick-Off Workshop](#) (Aug 30, 2013, KAIST)

❖ Operating PR Exhibition Booth@ Various Occasions

- Operating PR booth in [2013 Korea R&D EXPO](#)(Nov12~14, 2013, Ilsan KINTEX)



Global Recognition

2.8 IDC Innovation Excellence Award (1/2)

EDISON (EDucation-research Integration through Simulation On the Net)
"HPC Innovation Excellence Award" from IDC, the first time in Korea

❖ Grounds for the Award

- By decreasing dependence on expensive commercial simulation software and providing the free locally developed domain specific simulation software through the development/establishment of EDISON platform & core technologies based on HPC(High Performance Computing), our innovative competence has been recognized.
- Our contribution to the spread of HPC community in the area of computational science engineering through the establishment of close partnership between the central center and domain center has been recognized.

* Central Center: Developing EDISON core technologies and establishing platform for running simulations based on the HPC

** Special Center: Developing simulation SW in the areas of computational science engineering and applying it to education

❖ Awards Ceremony: SC13(November 19, 2013 @Denver, US)

※ Statistics of IDC awards@SC13: Nine from the US, two from UK, one from Germany, one from France, and one from **Korea which is the only award from Asia.**

While Facebook was awarded only in the area of innovation,

EDISON project was recognized in both aspects of innovation and ROI.



Country	No. of Awards	Country	No. of Awards
USA	38	UK	4
China	3	Italy	3
India	2	Sweden	1
Canada			
France			
Germany	1	Korea	1
Spain	1	Total	59

Past award Statistics(11'~13', Total: 6)

2.8 IDC Innovation Excellence Award (2/2)

EDISON (EDucation—research Integration through Simulation On the Net) :
“HPC Innovation Excellence Award” from IDC, the first time in Korea

❖ Background

- Since 2011, IDC has given awards to the world programs/projects showing innovative outcomes and ROI.

❖ Goal

- By selecting and awarding the successful cases in HPC area, it **contributes** to the enhancement of global users', especially **small businesses' understanding of benefits and investment of HPC**.

❖ Award Method

- It is selected and awarded twice a year by International Supercomputing Conference(ISC) held in Europe in every June, and Supercomputing Conference(SC) held in the US in every Nov.
- ※ **As an authoritative award in the supercomputing area**, sponsored by main organizations such as the US Department of Defense and Department of Energy, Intel, Boeing, Hewlett Packard and Microsoft.
IDC "HPC Innovation Excellence Awards" is awarded that was the first time in Korea and the third time in Asia(After China and India).



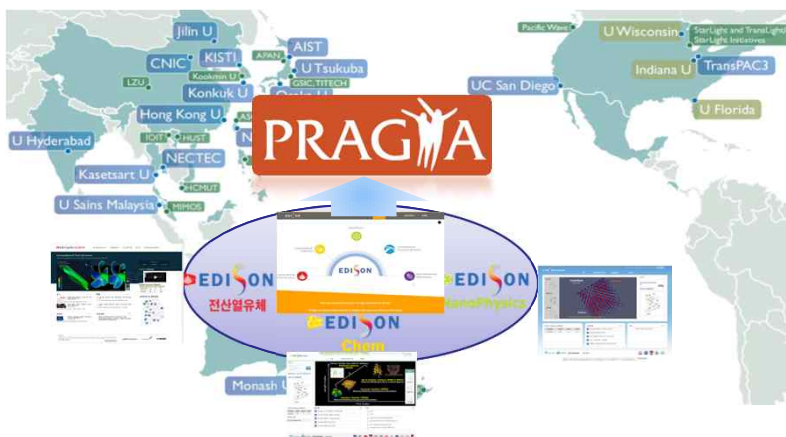
IDC Announces Winners of Sixth HPC Innovation Excellence Awards
National Institute of Supercomputing and Networking, Korea Institute of Science and Technology Information (Korea) The EDISON (EDucation and research Integration through Simulation On the Net) Project, funded by the Ministry of Science, ICT and Future Planning, Korea, established an infrastructure on the Web where users across the country could easily access and utilize various engineering/science simulation tools for educational and research purposes. The EDISON project is accelerating research in five key areas: Computational Fluid Dynamics, Computational Chemistry, Nano Physics, Computational Structural Dynamics, and Multi-disciplinary Optimization. The Project utilizes a novel partnership model between the project and the respective domains to develop area-specific simulation tools that make HPC accessible to domain specialists. **Lead: Kumwon Cho**



2.9 PRAGMA Cyber–Learning WG

Expanding Cyber–Learning Community in PRAGMA(Pacific Rim Applications and Grid Middleware Assembly)

- ❖ **Establishment of PRAGMA Cyber-Learning WG**
 - Proposing Cyber-learning WG at the 24th PRAGMA Workshop (2013.3.20~23, Bangkok, Thailand)
 - Chair(Lee, JongSuk Ruth), and Co-chair(His-Ching Lin, NCHC/Putchong Uthayopas, KU)
- ❖ **Main Results**
 - **Promotion of Cyber-Learning WG & Spreading Cyber-Learning through EDISON to the PRAGMA community** (Taiwan, Thailand and Hong Kong)
 - **Establishment of English EDISON web portal**(CFD, Nanophysics, Computational chemistry) & user service open
 - **Scheduled to hold a tutorial or workshop on Cyber-Learning at PRAGMA 26** (2014.4.9~11, Taiwan)
 - **Kicked-off “Korea-Taiwan International Joint Research Project ”** (13.7.29-15.7.28, 50million Won)



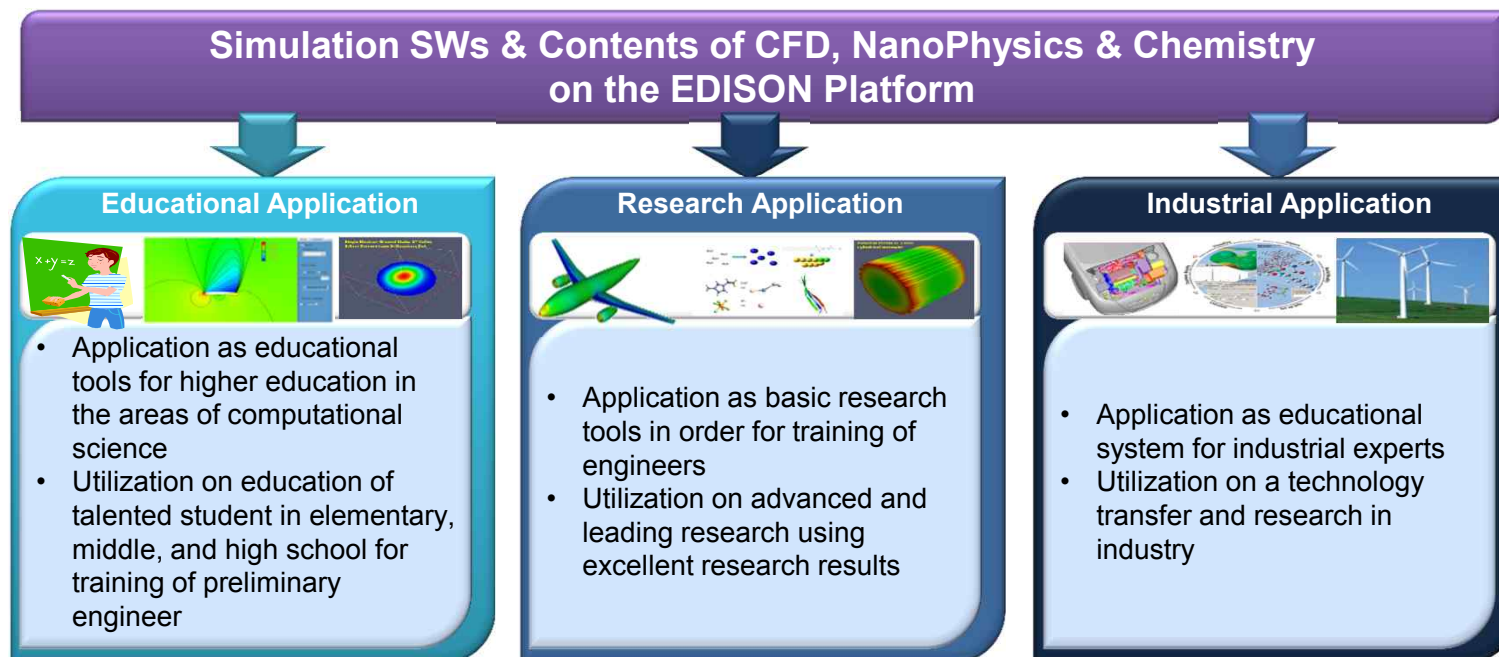
2.10 Expected Contributions

❖ Technical Perspectives

- Offering web-based open platform for education and research in science and engineering can be expected to produce more practical and inventive results
- Providing efficient educational system to student familiar to IT environments

❖ Economical & Industrial Perspectives

- Replacing expensive and imported SWs with domestically developed SWs by domestic researchers, a lot of the national asset can be saved.
- Creating new market for developed system and job market for the experts



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1 Status & Necessity of Cyber–Learning System

2 A Cyber–Learning System : EDISON

3 Future Directions of EDISON

3. Future Directions of EDISON

- ❖ More accomplishments from many R&D projects funded by the Korean government
 - can be used in higher education on science and engineering
 - the effect of using EDISON would be maximized without extra spending to purchase expensive commercial simulation SWs for the educational and research purpose
- ❖ We have learned about
 - building a computer simulation-based cyber-learning environment like EDISON is now inevitable. Everybody likes it and needs it.
- ❖ Develop Mobile Environment & Add New Areas
 - expand EDISON into mobile environment accommodating such as smart devices and support users from other new areas
- ❖ Finding Global Partners and Users
 - collaborating to expand cyber-learning Community
 - changing the education paradigm in computational sciences



Thank You!

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