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STATE GRID

中国电力科学研究院有限公司
CHINA ELECTRIC POWER RESEARCH INSTITUTE

The Functions and Applications of New Generation UHV AC/DC Power Grid Simulation Platform

Speaker : Yalou Li Date : August 19, 2018



CATALOGUE

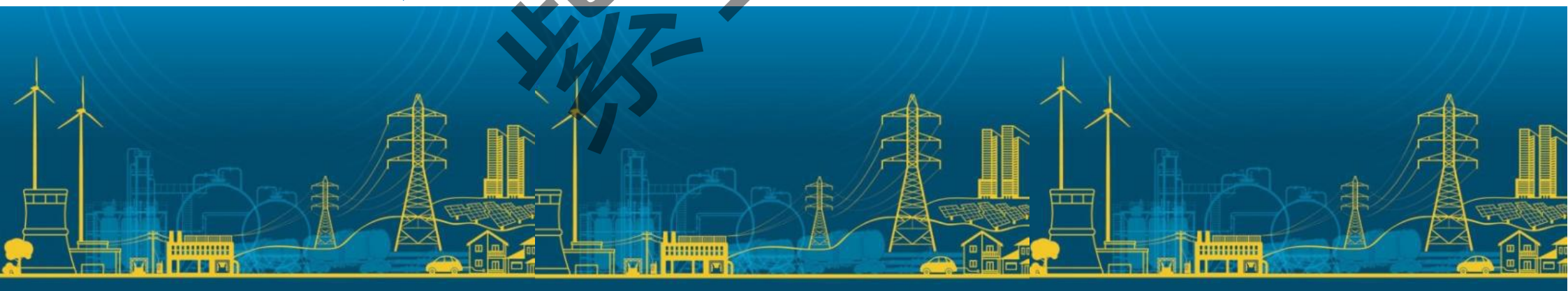


1、 Background

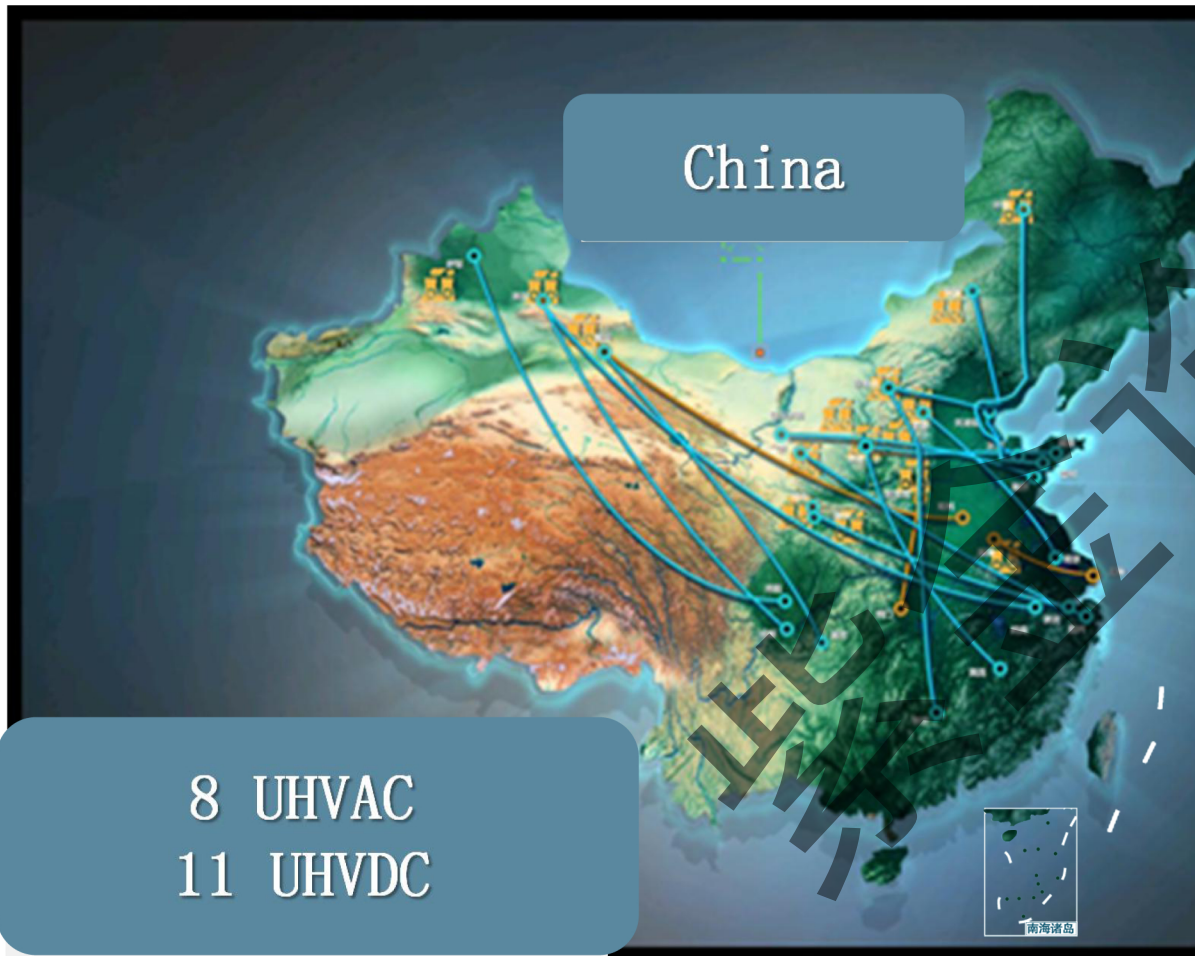
2、 Functions

3、 Innovation and Applications

4、 Conclusions and Forecasts



Background

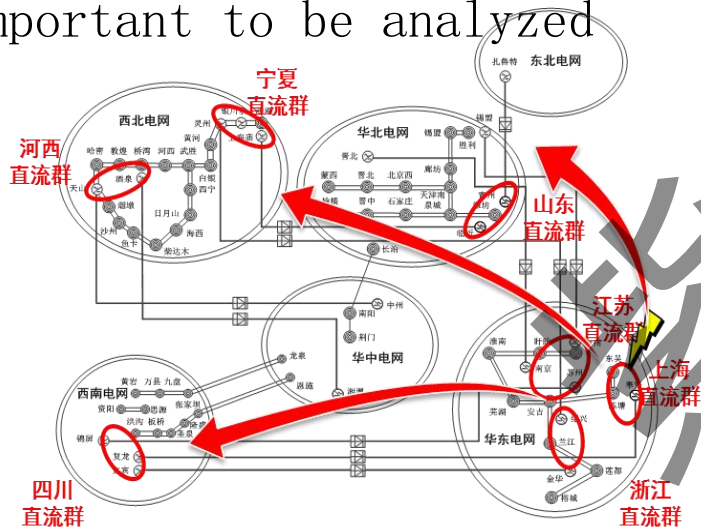


- The reverse distribution characteristics of China's resource and productivity
- The rapid development of renewable energy sources in China
- Forming a large-scale multi-area UHVAC/DC hybrid network in China

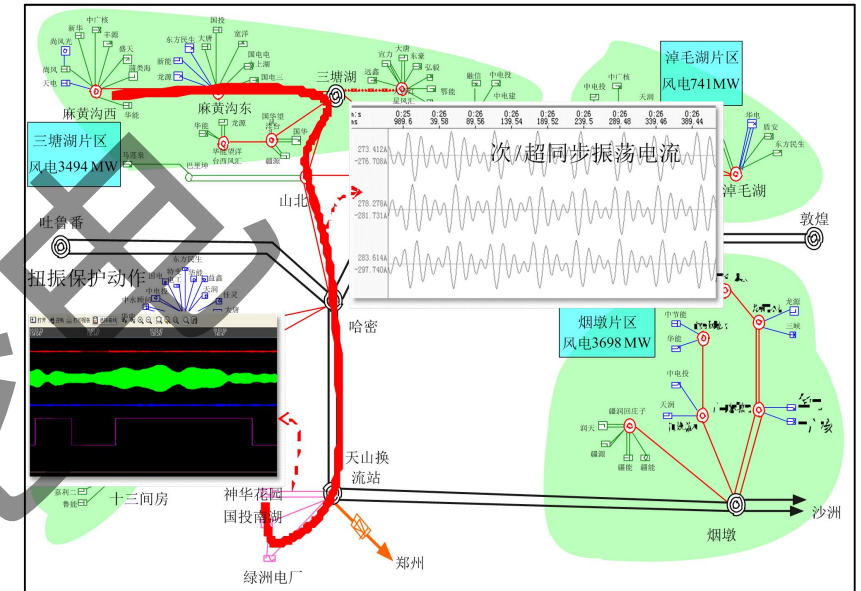
Background

New phenomena of power grid

- The coupling between the receiving and sending system of UHVAC/DC is closer, resulting in the larger fault influence range
- The dynamic interaction characteristics of multi-infeed DC system groups are very important to be analyzed



7 multi-infeed DC system groups in State Grid



Sub-synchronous oscillation phenomenon

- Some oscillation phenomena were also appeared recently

All there new phenomena need simulation tools to recognize and to analyze



Background

New Challenges of simulation

Large-scale electromagnetic transient modeling and simulation

the accurate modeling of complex control systems

the extremely massive calculation

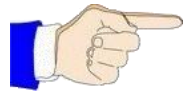
traditional simulation tools cannot satisfy these challenges sufficiently

New Generation UHV AC/DC Power Grid Simulation Platform(NGSP)



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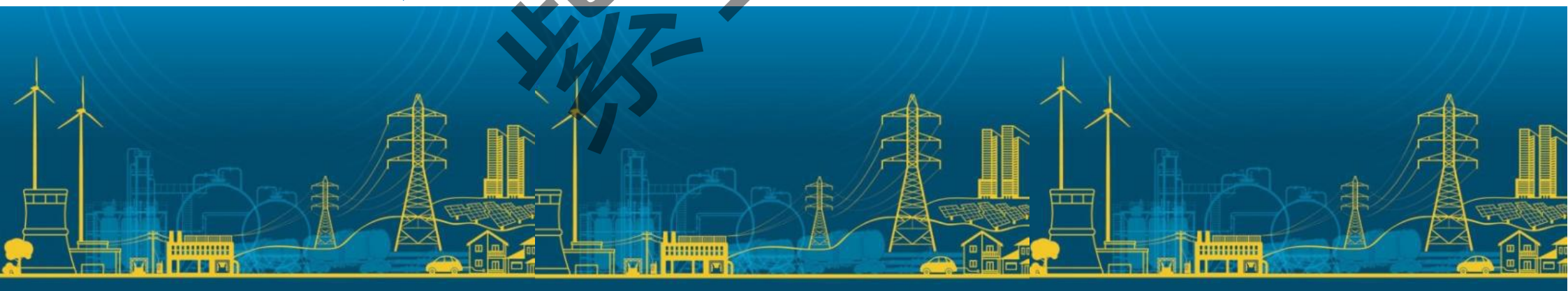
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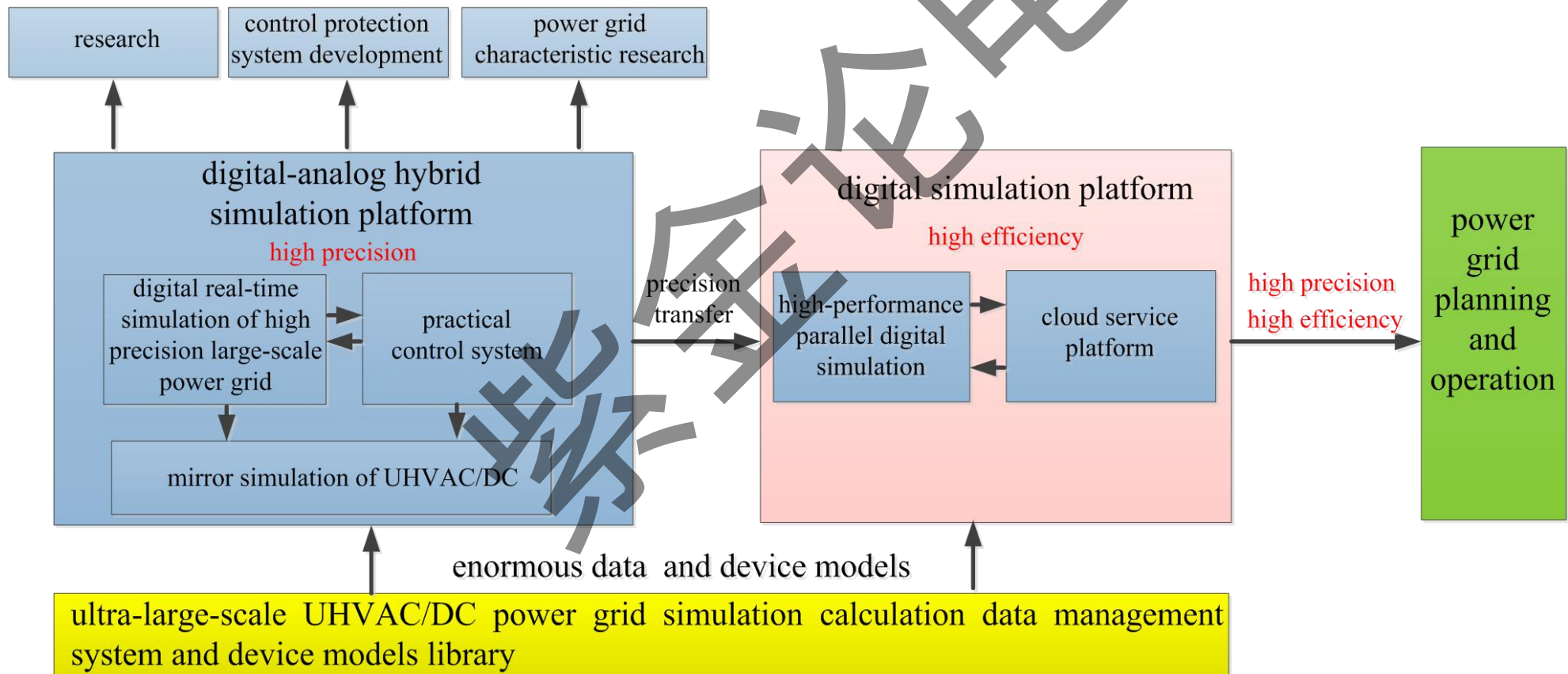
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Platform Architecture

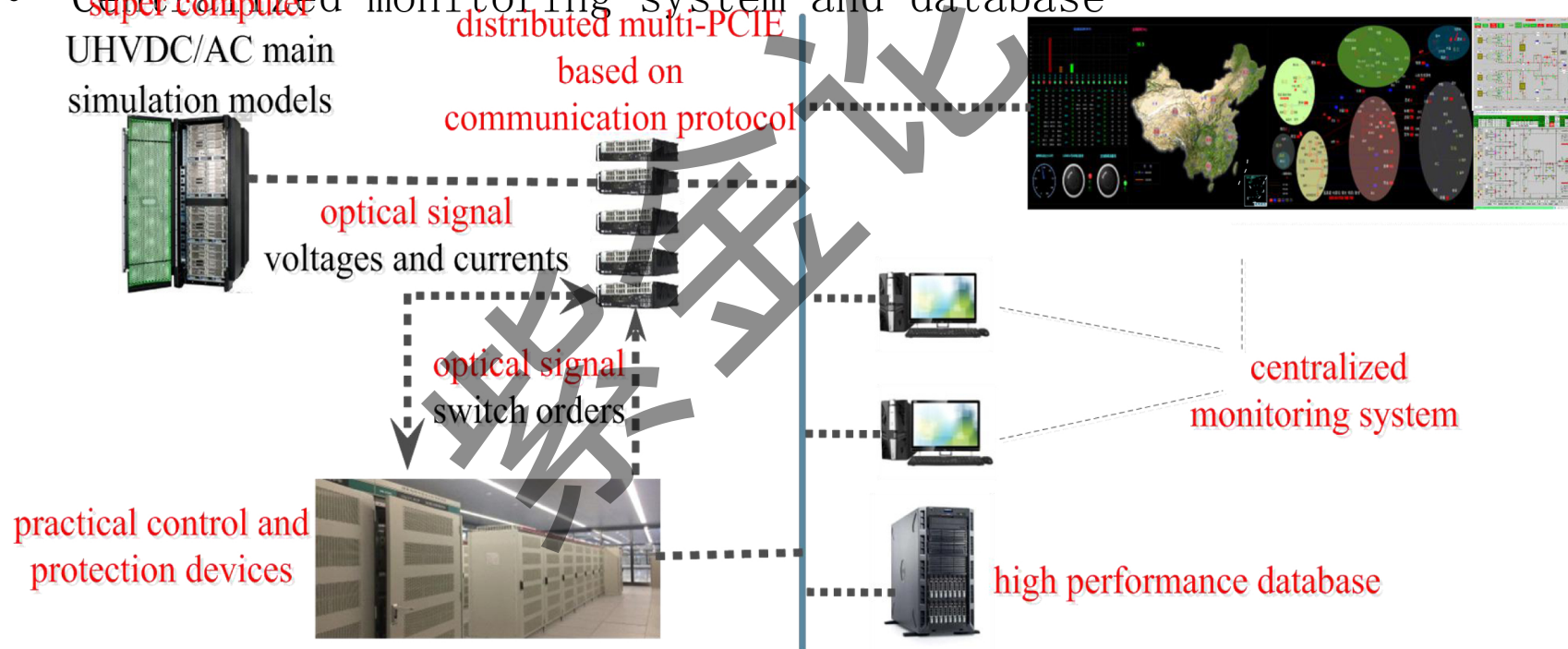
NGSP is constructed by four parts: digital-analog hybrid simulation platform, digital simulation platform, data management system and device models library



Functions

Digital-analog hybrid simulation platform of NGSP:

- Large - scale electromagnetic transient real-time simulation software
- Super computers
- Connecting with the practical control and protection devices
- Centralized monitoring system and database



New generation digital-analog hybrid simulation platform

Functions

Digital-analog hybrid simulation platform of NGSP

6000 nodes

Electromagnetic transient simulation scale

36 UHV DC lines

Interacting with the physical control and protection system

220 kV and more than **220** kV

Achieving electromagnetic transient real-time simulation for any regional grid



6401 three-phase AC nodes

370 generators

159774 MW transmission power

9 physical DC control and protection systems

5109 AC transmission lines

Functions

Digital simulation platform of NGSP:

- supercomputer center
- cloud simulation platform
- monitoring platform

Until to now, owning the highest computing power for power system digital simulation in the world



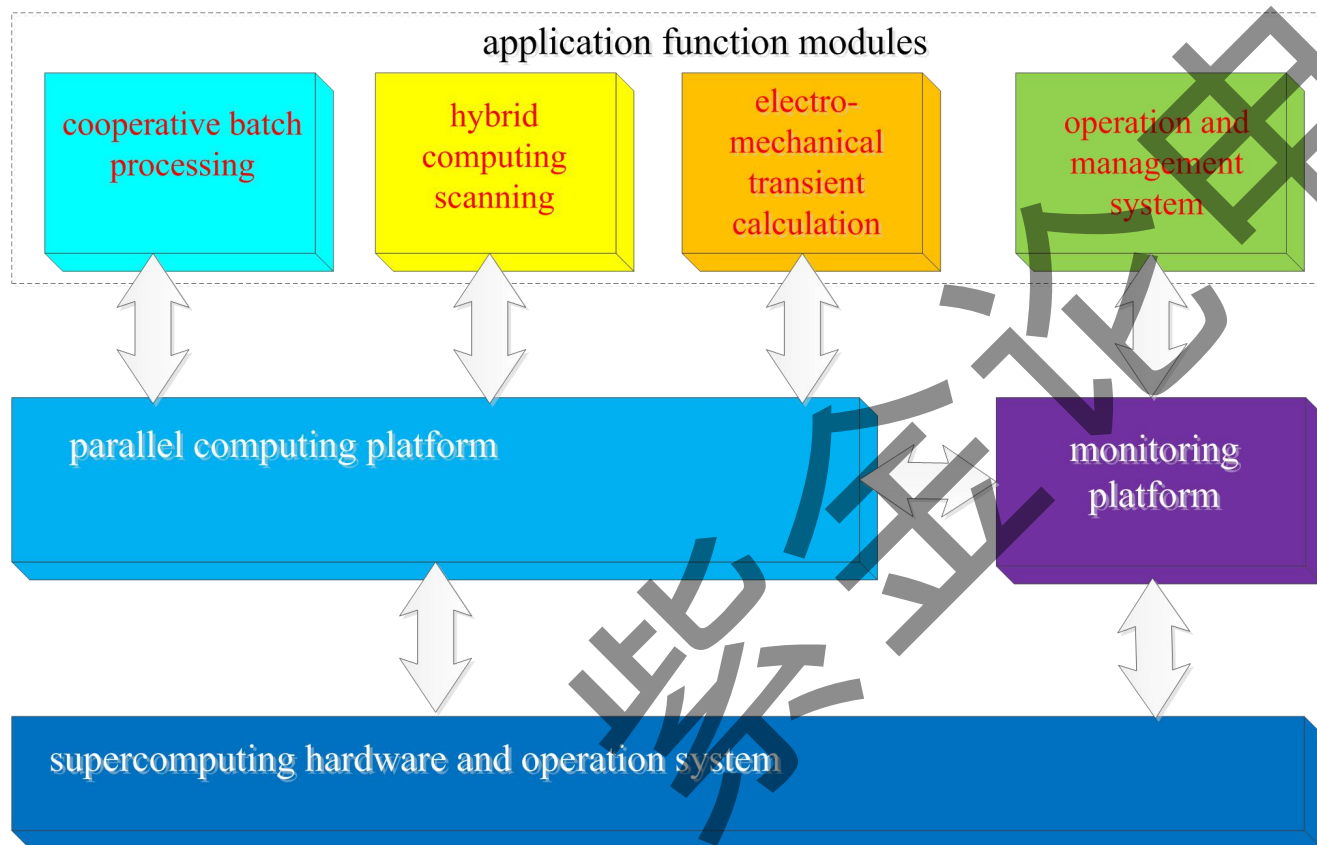
supercomputer
center



monitoring
interface

Functions

Digital simulation platform of NGSP: supercomputer center



- super computing hardware
- parallel computing platform
- application function modules

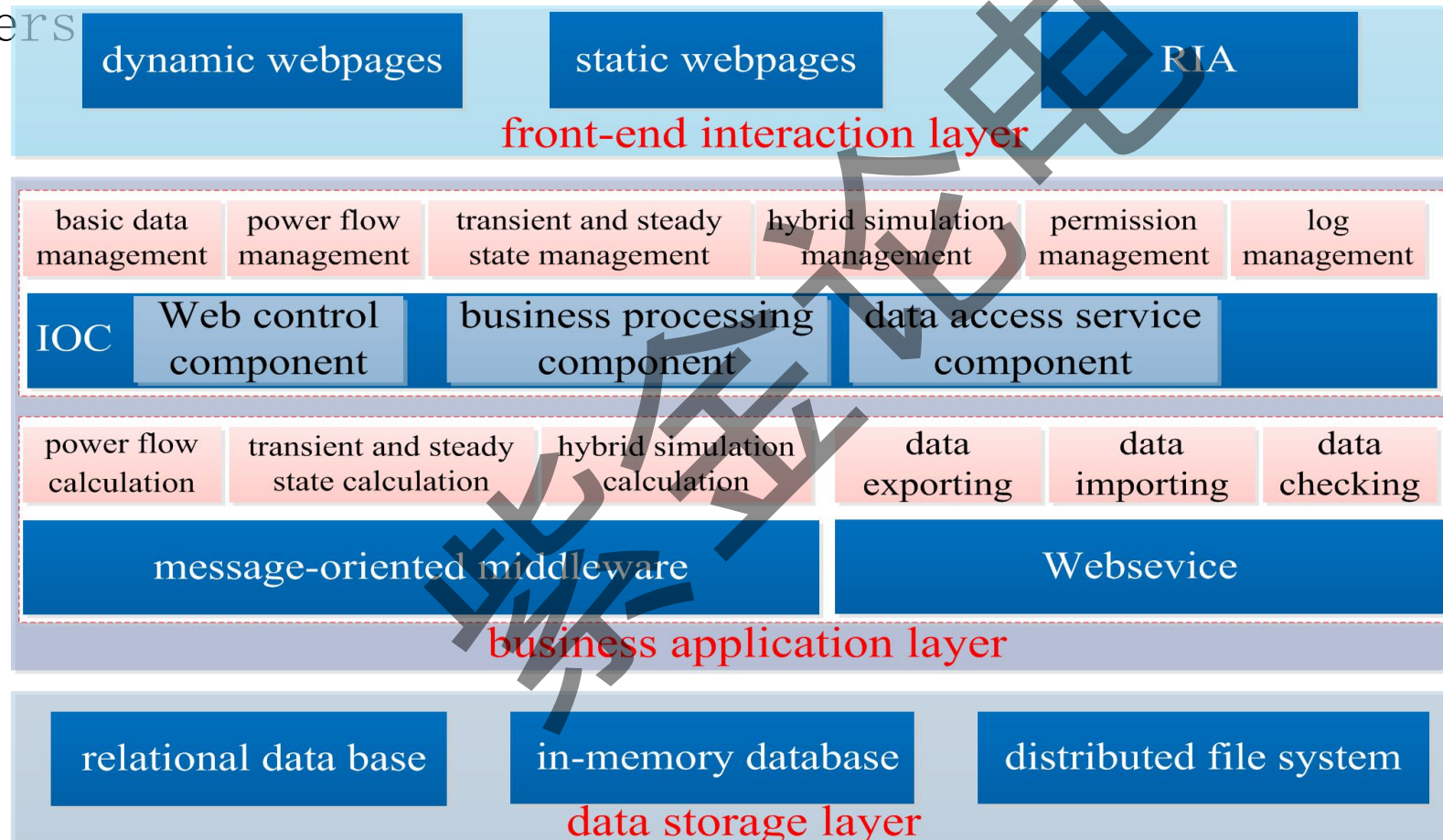
architecture of supercomputer center

Functions

Digital simulation platform of NGSP cloud simulation platform

Hierarchical structure: 3

layers



architecture of cloud simulation platform

Functions

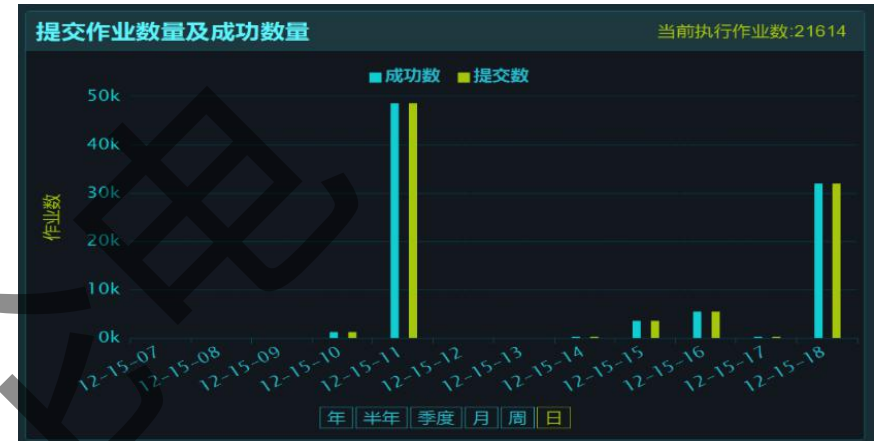
Digital simulation platform of
NGSP

24000 CPU
computing hardware

918.7 Trillion times/s
theoretical peak of computing
power

More than **95**%
real-time utilization of computing
resources

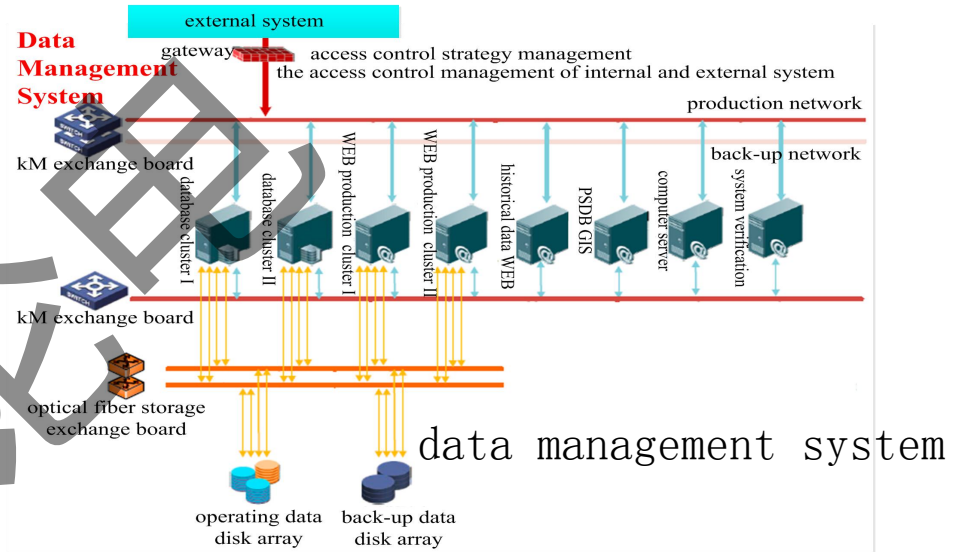
The first power system simulation platform which is based on **supercomputers in the world**: the performance of the parallel simulation algorithm is optimized and could make use of the super-computing resources effectively.



Functions

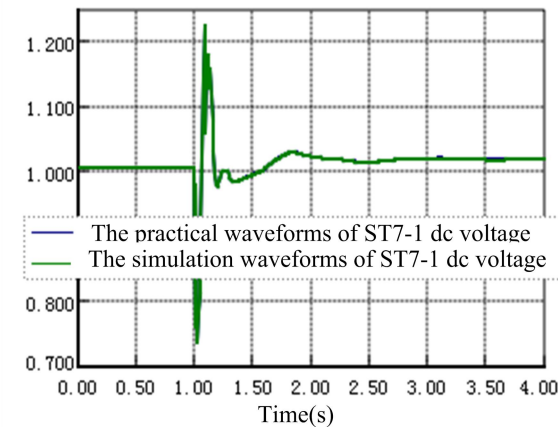
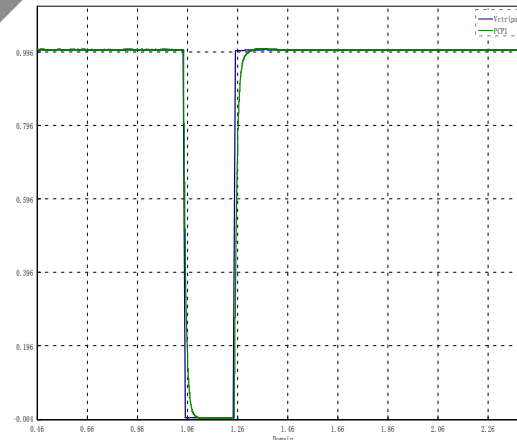
Data management system and new device models library of NGSP:
The simulation data system is established to ensure the security and stable operation of NGSP

- The number of buses >200,000
- The number of AC lines >200,000
- The number of transformers >100,000
- The number of generators >50,000
- The number of loads >100,000
- The number of reactive power compensations >200,000
- The number of DC systems >10,000



The new models library is completed by the modular modeling methods

- ⚙ Yu-e Flexible DC Transmission Project Model
- ⚙ UHV layered DC system model
- ⚙ UPFC model
- ⚙ wind power generation system models
- ⚙ photovoltaic power generation system models
- ⚙ New AC/DC, DC/DC models
- ⚙



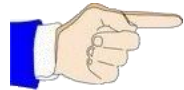
simulation waves of Yu-e Project



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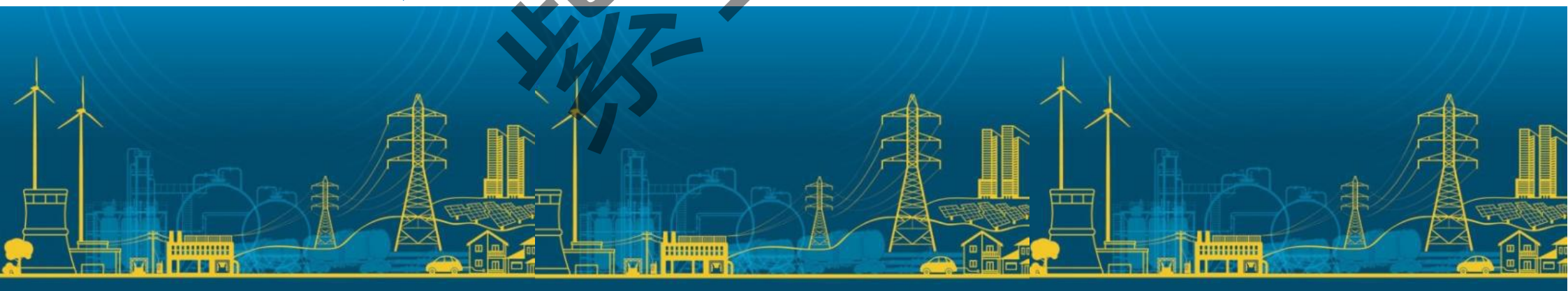
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Innovation and Applications

The innovative technologies of NGSP:



An integrated architecture of new generation UHV AC/DC power grid simulation platform



Large-scale AC and DC power grid electromagnetic transient real-time simulation technology



Large-scale Analog-digital simulation interface technology



High-performance power system cloud computing architecture



Power system parallel simulation technology based on super computers



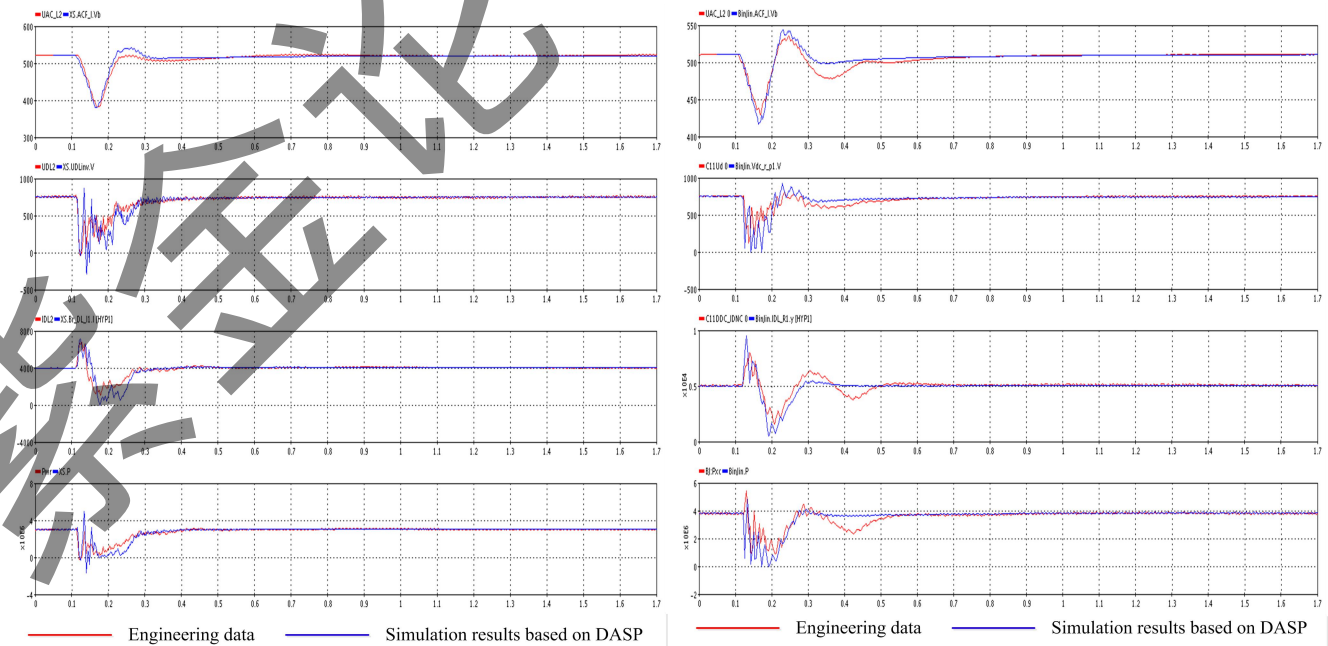
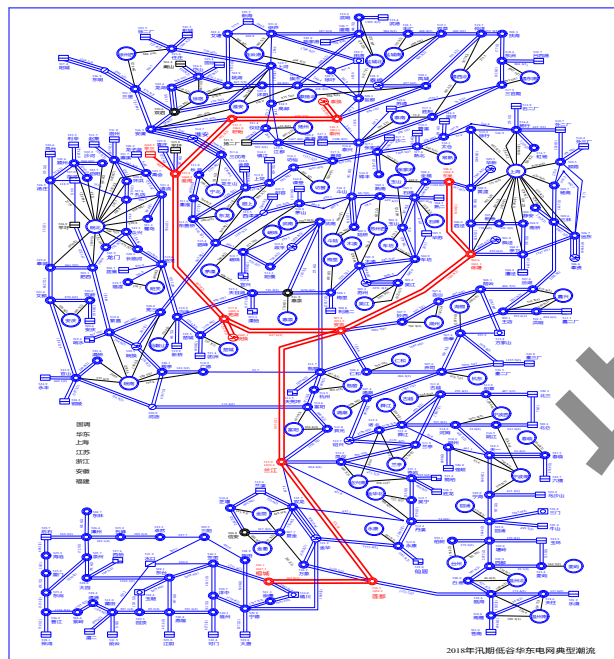
Electromagnetic transient automatic modeling and quick starting method

Innovation and Applications

The Applications of NGSP:

At present, NGSP has been applied to the security and stability analysis of State Grid, and plays an important role in supporting the safe operation of the power network.

- Case study of East China Power Grid



main circuit of East China Power Grid

comparative curves of simulation and actual data of Fu-Feng Project

Innovation and Applications

The Applications of NGSP:

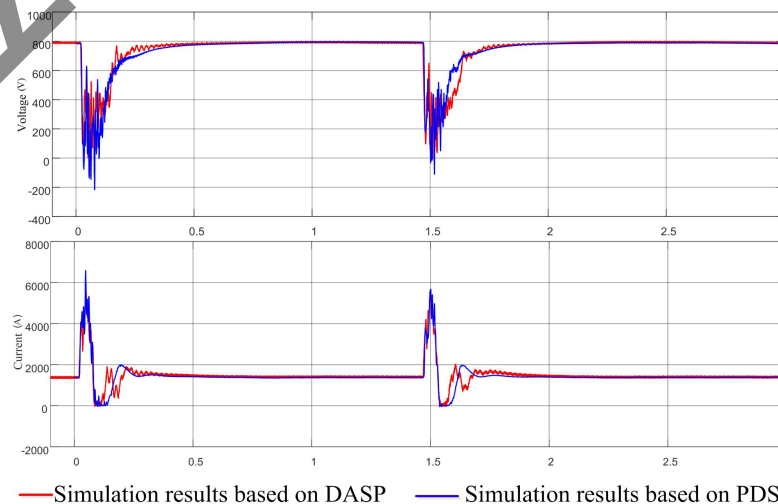
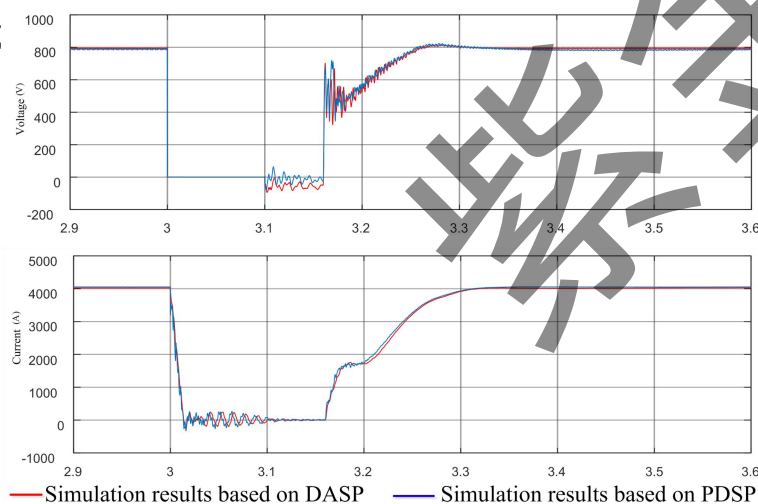
- Case study of Tian-Zhong DC transmission project

In order to increase the transmission capacity of Tian-Zhong DC transmission, NGSP is employed to analyze the power grid's ability to accept the DC systems, and formulate operational control measures from the analysis results. As a result, the DC transmission capacity of Tian-Zhong DC transmission project is increased 1.4 million kW approximately.

- Case study of large-scale network calculations

faults process replaying, operation scheduling and control

optimi:



“6. 30” faults process replaying



Innovation and Applications

NGSP solves the problems of traditional tools:

- slow electromechanical-electromagnetic hybrid simulation
- slow parallel processing of massive computing tasks
- no ability to achieve large-scale electromagnetic simulations

simulation type	traditional tools time	NGSP	speed-up ratio
15000 electromechanical transient simulation cases	32,000 minutes	10.83 minutes	2954.7
5000 electromechanical - electromagnetic hybrid simulation cases	111,300 minutes	35 minutes	3180.2

NGSP changes the large-scale power grid electromagnetic simulation from research tools to production tools.



Examination and Evaluation

December 26, 2017

NGSP is examined by a number of academicians and specialists, and got the following evaluation:

- NGSP could solve the worldwide difficulties in ultra-large-scale UHVAC/DC power grid simulation systematically
- NGSP provides an important technical means to improve the cognition and control ability of complex power system comprehensively. And it could be used to complete the analytical calculations and experimental studies on power grid development planning, dispatching operation decisions, and new equipment development.

项目验收专家组名单

姓名	工作单位	专业	职称/职务	签名
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杨奇逊	华北电力大学	继电保护	教授	杨奇逊
韩英铎	清华大学	电力系统	教授	韩英铎
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黄其励	国家电网公司	继电保护	顾问	黄其励
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郭琦	南方电网科学研究院仿真所	电力系统及其自动化		郭琦

- The technical level and simulation capability of NGSP have reached the international leading level.



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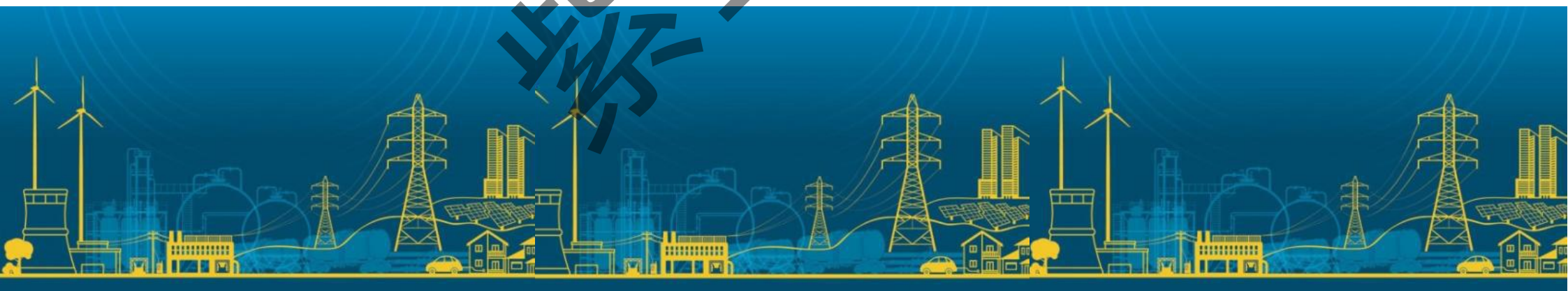
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Conclusions and Forecasts

Until now, the largest electro-magnetic transient real-time simulation systems and digital simulation platform have been built in NGSP. And NGSP could solve the worldwide difficulties of ultra-large-scale UHVAC/DC power grid electromagnetic transient simulation, high precision requirements for control and protection of power electronic equipment simulation, and high efficiency of massive computing tasks.



Conclusions and Forecasts

At present, the energy systems of the world is changing to the clean, low-carbon, safe and efficient systems, resulting in the power grids in China may face some new challenges such as the access of high-energy renewable energy power generation, large-scale application of power electronic equipment, and comprehensive energy system integration, etc. And these challenges will bring new features for power grid simulation and operation. Therefore, several new research directions based on NGSP have been explored to build a new generation power grid security defense system.



- 1 Simulation analysis for power grid which is interconnecting with high proportion of new energy
- 2 Full electromagnetic transient simulation for large power grid
- 3 Power system simulation for integrated power system
- 4 intelligent analysis for power grid simulation



Conclusions and Forecasts

In a word, NGSP could improve the ability of recognizing and controlling complex power grids comprehensively. It will surely play an important role in promoting the electrical technologies of China, and could also be employed to ensure the safe operation of UHV AC/DC hybrid power grids in China.

