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Situational awareness architecture for smart grids developed in accordance with dispatcher's thought process: a review

Key words: Smart grid, Situational awareness, Dispatcher's thought process, Technical architecture

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Motivation

- A number of factors, including renewable penetration, marketization, cyber security, and hazards of nature, bring challenges and even threats to the traditionally defined secure and economic operation of power systems.
- Nearly none of conventional technical platforms in use integrate sufficient functions to enable efficient situational awareness in control centers.

Main idea

1. SA solutions and fundamental techniques

■ General concepts

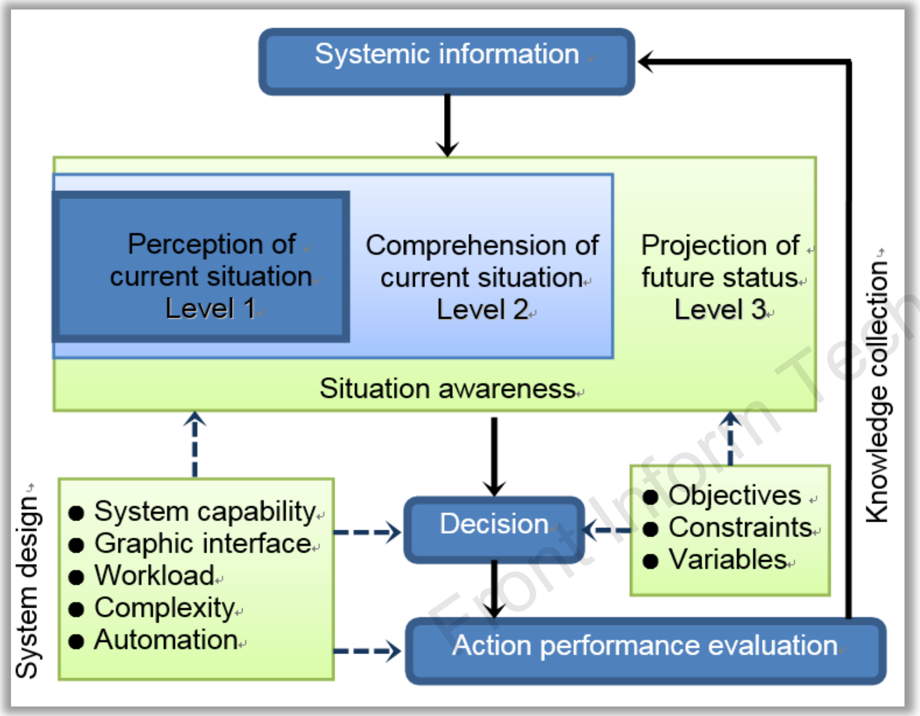
■ Architecture, information and communications technology (ICT), data, modeling, computation, and display

2. State-of-the-art progress of situational awareness

■ Dispatcher thought process oriented situational awareness architecture

■ Tiered technology components

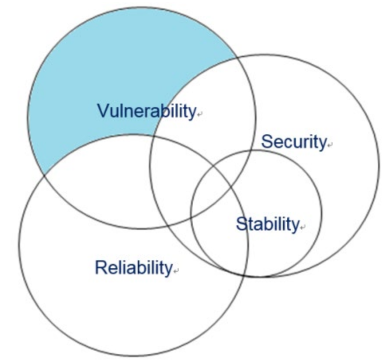
1. Dispatcher thought process oriented situational awareness architecture



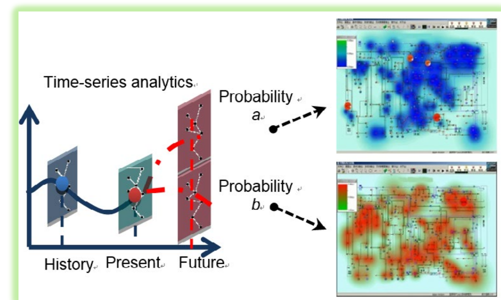
A three-level illustration of situational awareness

Significant concerns of control centers:

1. Multidimensional security awareness



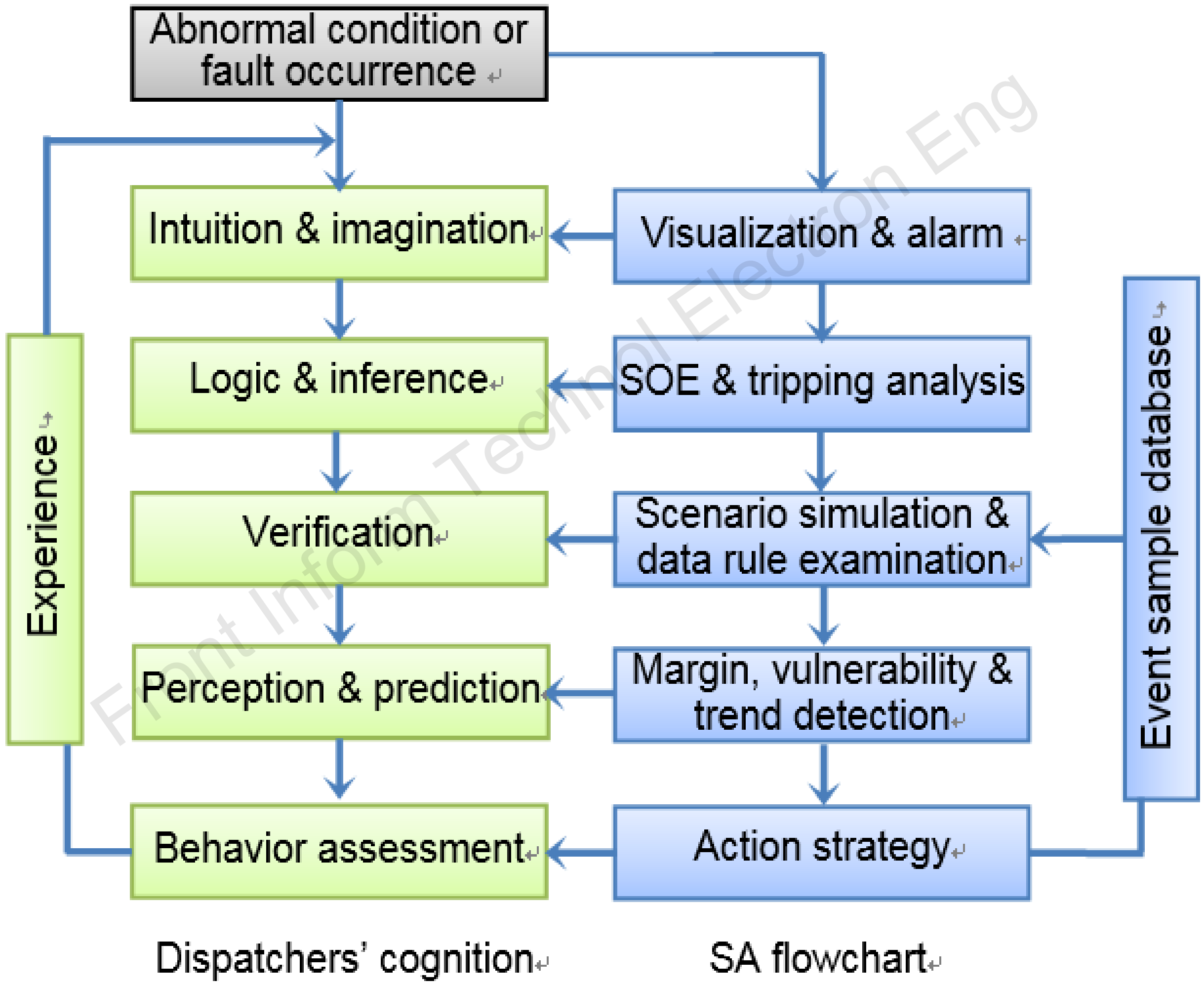
2. Awareness: looking ahead



3. Event-driven strategy assistance

- Load shedding
- Generation re-dispatching
- Substation wire switching

2. Relationship between a dispatcher's thought process and the situational awareness workflow

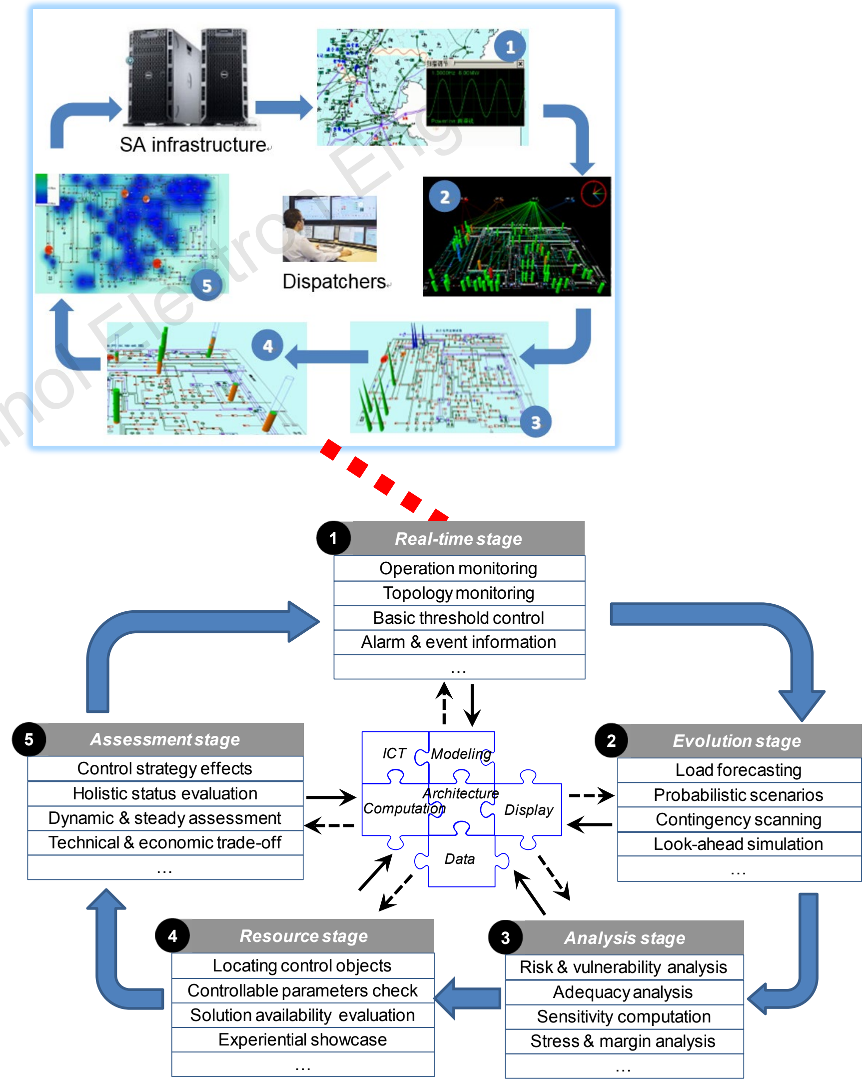


3. Tiered technology components

Table 2 The characteristics of the technical layers involved in the situation awareness framework

Layer	Characteristics & requirements
Architecture	High scalability, flexibility, and compatibility Plugging and playing modularization management Better adaptivity to dispatcher's thought process Restructuring online application routines
ICT	Standardization and scalability management Unified description and protocols Complete convergence for all participating components Enabling high interoperability and testability
Data	Operation & non-operation data acquisition Cross time-scale measureable information fusion Novel database design, such as Hadoop structures External data import and basic analytics
Modeling	Compatibility for data-driven methodologies Wide-area synchronized trajectory implementation Novel simulation mechanisms & algorithms Innovative application and routine development Support for non-operational application modeling
Computation	Enabling cloud computing infrastructure Sufficient computing capability and efficiency Enabling big data analytics Integrating abundant algorithm libraries Supporting user-defined computing workflow
Display	Facilitating intuitive online security perception Highly user-friendly graphical interfaces Compatibility for complicated data environments High flexibility of user-defined visual patterns Guidance roaming for emergency processing

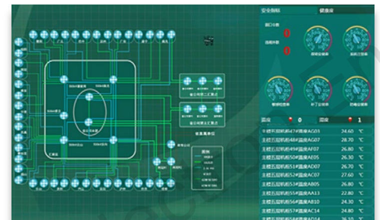
Situation awareness framework



Illustrative demonstration

1. Performance monitoring of cyber systems for one provincial power grid company and its own distribution companies

I. Steady operational situation
II. Capacity real-time monitoring



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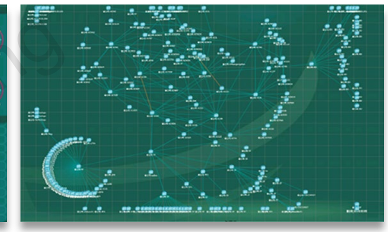
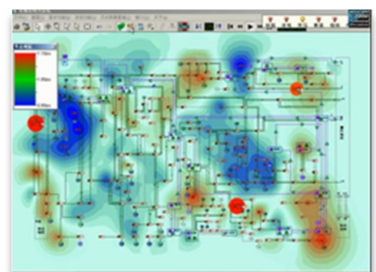


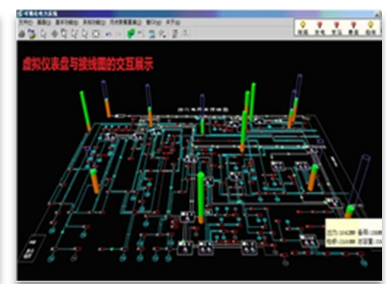
II

2. Visualization perspectives of smart grid operation integrated in an online application suite

a) Steady operational situation
b) Capacity real-time monitoring
c) Substation diagram alarm
d) Critical component monitoring



a



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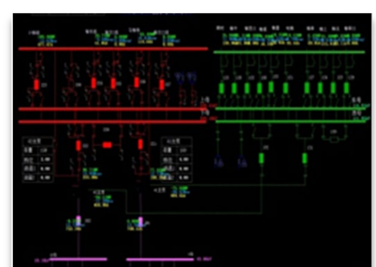

c

d

Illustrative demonstration

1. Coherency monitoring and analysis based on WAMS

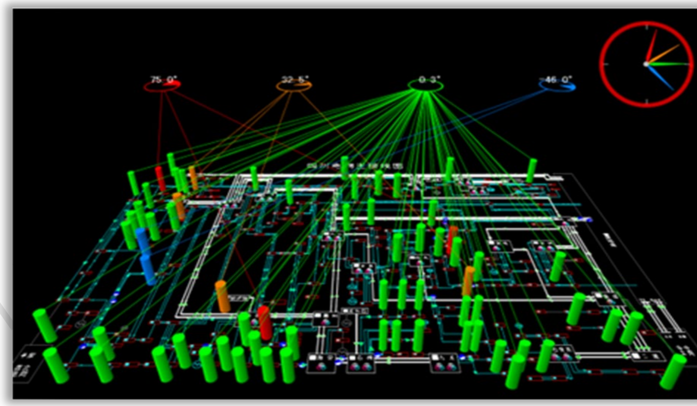

Fig.1

2. An overview of the SA application environment

This platform coordinates the tiered technology components and organizes each function considering the dispatcher's thought process.

Fig.2

Conclusions

- To investigate related SA solutions and fundamental techniques, a variety of technical fields including architecture, ICT, data, modeling, computation, and display were discussed.
- Based on the tiered technical components, a principle for SA designed in accordance with the dispatcher's thought process was proposed.
- A number of demonstrations were illustrated by visualization of situation awareness in realistic power systems.