New Generation of EMS with 3-Dimensional coordination
(topic #3)

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1. EMS History

• **Before 1970**: 1st Generation, SCADA, measurement and control; EXPERIENCE type;

• **1970 to ~2003**: Traditional EMS, Real-Time Network Analysis, some brain, a tool for dispatcher; ANALYSIS type, but Man-driven;
Problems in Traditional EMS

• **Design:**
  – based on static snap shot of a load flow;
  – Mouse-driven based Dispatcher Power Flow;
  – Off-line dynamic security analysis;
  – logic based Alarming, no RTNET based early warning;

• **Network modeling**
  – Local network modeling with some off-line external equivalence
• **Analysis and decision making**
  – Mainly based on static state analysis
  – Separate single functions without comprehensive integration
  – Less or even no decision making

• **Control**
  – Mainly based on measurement, feed back control; less real time network analysis included in AGC & AVC
  – Lack of coordination in time dimension
  – OPF less used on-line, not used to AVC closed loop control
• **Platform**
  
  – C/S; main machine/backup configuration;
  – C & C++; Objective Oriented
  – Can’t satisfy for vast computation for DAE(Differential-Algebraic Equation)
2. What is N-EMS

- **~2003 to the future**: N-EMS, Automatic EARLY WARNING type;
  - Computer initiative, Automatically & continually running;
  - Designed based on 3-dimensional coordination: Space, Time, Objective
  - Closed loop control with global optimization, network constraint considered
Differences between N-EMS & Conventional EMS

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<thead>
<tr>
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<th>Conv. EMS</th>
<th>N-EMS</th>
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<tbody>
<tr>
<td>Type</td>
<td>Man driven Analysis (by mouse)</td>
<td>Automatic Early Warning</td>
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<tr>
<td>design</td>
<td>Snap shot of load flow</td>
<td>evolution process of Load flow</td>
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<td>Dispatcher active, DPF is run only triggered by man</td>
<td>Computer active, PF is run continually &amp; automatically</td>
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<td>Alarming, based on logic</td>
<td>Early warning, based on RT network analysis</td>
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<td>post contingency analysis for summing up experience</td>
<td>pre-contingency analysis for preventive control</td>
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<tr>
<td>Network Modeling</td>
<td>Conv. EMS</td>
<td>N-EMS</td>
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<tr>
<td></td>
<td>Local network model</td>
<td>Global network model</td>
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<td></td>
<td>Off-line external equiv.</td>
<td>Auto, On-line external equiv., tracing the EX network variation</td>
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<td></td>
<td>SCADA Data is exchanged on-line between CC’s</td>
<td>EMS net model is exchanged on-line between CC’s based on IEC61970 CIM/CIS</td>
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<td>Analysis &amp; decision making</td>
<td>Conv. EMS</td>
<td>N-EMS</td>
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<tr>
<td>Static state</td>
<td>Dynamic state</td>
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<td>Multiple single functions, run one by one</td>
<td>Multi-objectives comprehensively coordinated</td>
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<td>Decision making is mainly done by man</td>
<td>computer aided decision making</td>
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<tr>
<td>Based on determinability model</td>
<td>Based on probability model, operation risk evaluation</td>
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<td>Control</td>
<td>Conv. EMS</td>
<td>N-EMS</td>
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<tr>
<td>Based on SCADA Data, feedback control</td>
<td>Based on RTNET load flow, close loop control</td>
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<td>GEN &amp; NET separately modeled</td>
<td>GEN &amp; NET unifiedly modeled</td>
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<td>OPF is used for off-line analysis</td>
<td>OPF is used for guiding on-line control</td>
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<tr>
<td>Based on current snapshot</td>
<td>Coordinated with diff. time dimensions</td>
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<td>Platform</td>
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<tr>
<td>C/S, Main/Backup</td>
<td>Cluster of μ Computers</td>
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<td>process oriented programming, partially OO</td>
<td>Multi Agent System</td>
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<td>Figure &amp; Table based MMI</td>
<td>3-dimensional visualization MMI</td>
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3. Concept design
3-dimensional coordination

- Objective: economy, security, thermal stability, P-δ stability, voltage stability
- Time: μs, ms, min, hour
- Space: district, provincial, regional, state
- Objective: μs, ms, min, hour
• **Space**
  – Global view on the network
  – Decomposition & coordination

• **Time**
  – Time dimensions: hour, 15min, 5 sec
  – Time process: real time, tracing, recursive, continually N-1, instead of simultaneously N-M

• **Objective**
  – Security, economy, quality
  – Static state, dynamic state, voltage stability, power system & protective relay coordination
4. Platform design

SCADA/EMS

保护工作站

运方工作站

调度工作站

维护工作站

PC Cluster

LAN
MAS based software configuration of N-EMS

Broker Agent #1

Comprehensive Security EW
- modelling
- Adaptive Agent
- Adaptive Agent
- Adaptive Agent
- Adaptive Agent
- Adaptive Agent

MVaR-Volt Control - AVC
- Adaptive Agent
- Adaptive Agent
- Adaptive Agent

Visualization MMI
- 三维可视化
- 动态曲线与仪表显示

MW dispatch & Control
- 有功实时调度
- 阻塞校正控制

Common model data service

Broker Agent #2

Broker Agent #N
5. Function design

SCADA/AGC/EMS

Network Re-Modeling (Decomp & Coord, EX Equiv)

AVC & OPF control

Early Warning & Security Countermeasure

Real time MW control

Power System
6. Reports from Practical Operation – developed by Tsinghua University
PC- Cluster
TTC through Flow Gate

TTC Margin for Flow Gate

Practical MW Flow for Flow Gate

Time

MW flow
Min Singular values (current vs history)

Load demand MW margin to kV Stability Collapse point for diff flow gates
Current MW flow through a flow gate
scheduling One day ahead

Real MW

MW Re-Dispatch manually

MW Dispatch
3-dimensional Visualization
7. Where used
More Than 10 Power Grids above 10,000MW in China

- **Decomposition-Coordination between multi CC**: Guangdong, Jilin;
- **EWSC**: Jiangxi, Henan;
- **AVC**: Jiangsu, North China, Southern China, Hebei, Jiangxi, Shanxi;
- **Coordinated MW Dispatching**: Henan, Sichuan;
- **Distant/united DTS training and anti-accident manoeuvre**: Hebei, Shanxi
7. Conclusions

- N-EMS is an **Automatic Early Warning** type system
  - Computer initiative, automatically run;
  - 3-dimensionally coordinated
  - Close loop control
- N-EMS is constructing a tutelary for power system security in EPCC
Thank You !