



Experiences with Root Cause Analysis Software

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Agenda

Why do we need it?

What have we done?

Did it work?

Where are we going?



Standard Alarm List

NYISO March 29, 2006 Demo

System Overview | Original | GoalArt | Signals

All Events [39] Scroll Lock

Time	Id	Description
10:42:02	FREQUENCY_L	FREQUENCY Low Alarm
10:42:02	GEN_CHAT_HIGH_FALLS_HYD_L	Generator CHAT_HIGH_FALLS_HYD Trip
10:42:02	GEN_HQ_CEDARS_EXT	Generator HQ_CEDARS External Fault
10:42:02	GEN_HQ_CEDARS_L	Generator HQ_CEDARS Trip
10:42:02	GEN_LWR_RAQUITTE_HYD_L	Generator LWR_RAQUITTE_HYD Trip
10:42:02	GEN_NEG_NORTH_FALCN_SE...	Generator NEG_NORTH_FALCN_SEA Trip
10:42:02	GEN_NEG_NORTH_KES_CHAT...	Generator NEG_NORTH_KES_CHATG Trip
10:42:02	GEN_NEG_NORTH_PLATTS_H...	Generator NEG_NORTH_PLATTS_HY Trip
10:42:02	GEN_NIAGARA_216_L	Generator NIAGARA_216 Trip
10:42:02	GEN_NIAGARA_236_L	Generator NIAGARA_236 Trip
10:42:02	GEN_NIAGARA_266_L	Generator NIAGARA_266 Trip
10:42:02	GEN_N_END_FSB_CTL1_L	Generator N_END_FSB_CTL1 Trip
10:42:02	GEN_N_END_FSB_CT2_L	Generator N_END_FSB_CT2 Trip
10:42:02	GEN_SISSONVILLE_EXT	Generator SISSONVILLE External Fault
10:42:02	GEN_SISSONVILLE_L	Generator SISSONVILLE Trip
10:42:02	GEN_ST_LAWRENCE_L	Generator ST_LAWRENCE Trip
10:42:02	GEN_UPPER_RAQUITTE_HYD_L	Generator UPPER_RAQUITTE_HYD Trip
10:42:02	LIN_ALCOA_ALCOA_N_L	Line ALCOA_ALCOA_N Trip
10:42:02	LIN_ALCOA_DENNISON_L	Line ALCOA_DENNISON Trip
10:42:02	LIN_ALCOA_N_MOSES_L	Line ALCOA_N_MOSES Trip
10:42:02	LIN_ASHLEYRD_PLATSBRG_L	Line ASHLEYRD_PLATSBRG Trip
10:42:02	LIN_BRNDSVLE_KENTS_FL_L	Line BRNDSVLE_KENTS_FL Trip
10:42:02	LIN_BRNDSVLE_WILLIS_L	Line BRNDSVLE_WILLIS Trip
10:42:02	LIN_CEDARS_ROSEMNTA_L	Line CEDARS_ROSEMNTA Trip
10:42:02	LIN_COLTON_MCINTYRE_L	Line COLTON_MCINTYRE Trip
10:42:02	LIN_COLTON_SANDSTON_L	Line COLTON_SANDSTON Trip
10:42:02	LIN_DENNISON_ROSEMNTA_L	Line DENNISON_ROSEMNTA Trip
10:42:02	LIN_KENTS_FL_WILLIS_L	Line KENTS_FL_WILLIS Trip
10:42:02	LIN_MCINTYRE_NOGDNRG_L	Line MCINTYRE_NOGDNRG Trip
10:42:02	LIN_NIAGARA_MOSES_L	Line NIAGARA_MOSES Trip
10:42:02	LIN_NOGBNRG_ALCOA_L	Line NOGBNRG_ALCOA Trip
10:42:02	LIN_N_END_ASHLEYRD_L	Line N_END_ASHLEYRD Trip
10:42:02	LIN_N_END_PLATSBRG_L	Line N_END_PLATSBRG Trip
10:42:02	LIN_PLATSBRG_WILLIS_L	Line PLATSBRG_WILLIS Trip
10:42:02	LIN_SANDSTON_DENNISON_L	Line SANDSTON_DENNISON Trip
10:42:02	LIN_STLAWRNC_MOSES_INT	Line STLAWRNC_MOSES Breakers Open
10:42:02	LIN_STLAWRNC_MOSES_L	Line STLAWRNC_MOSES Trip
10:42:02	LIN_WILLIS_MOSES_L	Line WILLIS_MOSES Trip
10:42:02	LOA_COLTON_115KV_GEN_L	Load COLTON_115KV_GEN Trip

Test Case Settings: 1970-01-01 01:00:00
SI Lawrence Incident 54/54

Test Case Speed:
 Speed as defined in the test case
 As fast as possible
 Test case speed with factor:

GoalArt®
Knowledge for Safe Operation

- Too much information
 - Different types of alarms
 - Different importance
 - Several alarms from same place
- Beyond human capabilities to understand this quickly
- Alarm lists become useless during incidents
- Look in other places to really understand what happened...



GoalArt Alarm List

The screenshot displays the 'GoalArt Diagnostic Station - NYISO 2009' interface. It features a top navigation bar with 'Alarms', 'Historical Primary', 'Events', 'Delta', and 'Control Panel'. Below this, there are two main sections: 'Primary Events [2]' and 'Secondary Events [30]'. Both sections contain tables with columns for Time, Station, Object, Description, and Group. The 'Primary Events' table shows two entries for 'ASTORIA4/AST...' with descriptions 'zero flow'. The 'Secondary Events' table shows a larger list of events, including 'HELLGT_W' (zero flow), 'ASTORIA3/AST...' (zero flow), 'E179HST/HELL...' (overload), and 'RAVENSWD' (zero flow). At the bottom, there is a 'Details' section with columns for Time, Station, Description, Condition, Message, Value, Unit, Point, and Sh... The interface also includes a status bar at the bottom with the GoalArt logo, the text 'Knowledge for safe Operation', and two buttons: 'Vista situation' and 'Spare situation'.

Root Causes

Consequences

Plus

- Alarms are grouped per equipment
- Events are moved to another list
- Non-grid alarms are suppressed
- Chattering alarms can be suppressed

This gives large alarm reduction



It is about Situational Awareness

- Too many alarms are detrimental to situational awareness
- Happens exactly when (larger) incidents develop
- Very efficient reduction possible by:
 - Grouping of alarms to "natural" process objects
 - Root cause analysis on the grouped alarms
- Make the root cause stand out among the alarms, and
- Make sure not to lose independent alarms in the clutter of a cascade

It is almost lunchtime, let me show you how this works in practice...



Real Life Alarm Problems

- On September 24th 1998, the recovery boiler of the Vallvik pulp plant blew up
- Hundreds of alarms reported, boiler went into automatic shutdown
- Exactly (almost) the same scenario had happened many times due to “oversensitive” fault detection
- Boiler shutdown is costly, so the operator's practical response was to ignore the alarm shower and attempt manual re-start
- This time, there were extra alarms indicating lost steam pressure
- Water in the smelt => BOOM



Root Cause Analysis

“This system really tells you what happened!
You should call it ‘what happened?’ analysis.”

Richard Candy, ESKOM, South Africa



Root Cause Analysis

“This system really tells you what happens! We should call it ‘what happens?’ analysis.”



What can we do for Power Grids?

- Operates on the entire grid and finds global root causes
- All configuration based on CIM XML --- 100 % automatic
- Handles all grid constructs and all combinations of events
- Has been installed on-line at the Swedish National Grid and at NYISO
- Ongoing delivery project for a European TSO



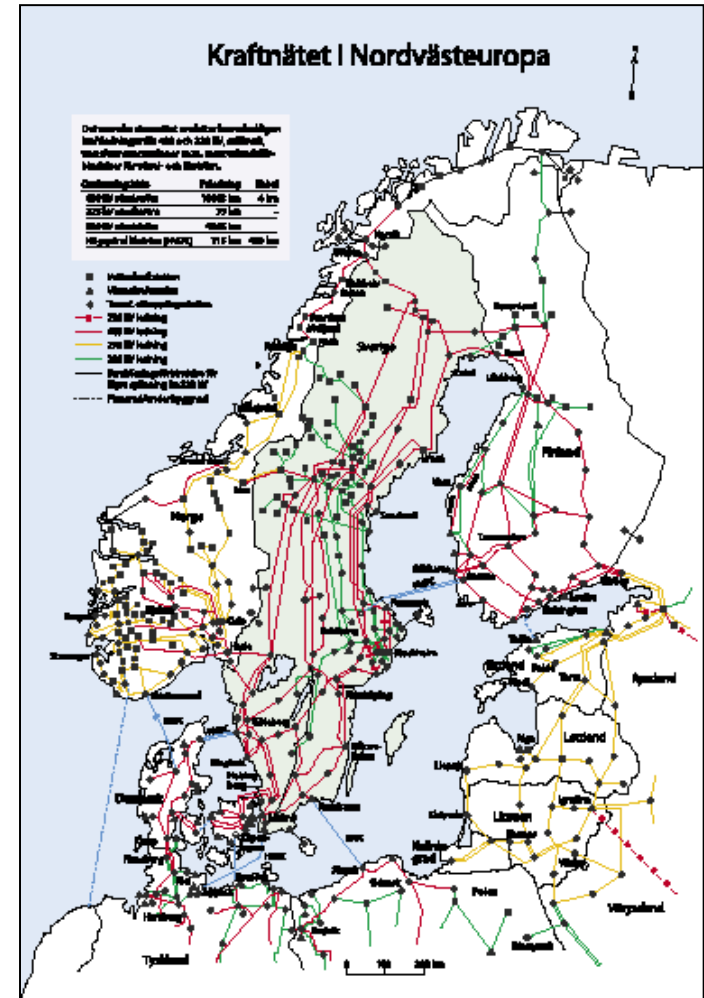
State of Current Power Grid Projects

- Svenska Kraftnät – system running on-line since January 2009
 - Monitors Sweden's power grid on SvK and E.ON / Vattenfall / Fortum levels
 - Located at SvK national control center in Sundbyberg
- NYISO – system running on-line since June 2009
 - Monitors NYISO part of US power grid (1 of 7 monitoring organizations)
 - Located at NYISO control center, Albany, New York



Blackout September 23rd 2003

- Large blackout in Scandinavia
- September 23rd 2003, 12.35 PM
- Root causes
 - 12:30 OKG 3 nuclear reactor trip (east)
 - 12:35 Internal station short-circuit (west)
- Consequences
 - Two lines for all of southern Sweden
 - Southern Sweden collapsed (5-15 min)
 - Eastern Denmark collapsed
 - Lasted 1-5 hours
- Actions
 - Second root cause unknown for 4 hours
 - Helicopters looking for line faults
- Cost
 - Lost ~ 10 000 000 kWh
 - Cost ~ 500 000 000 USD
 - Largest disturbance in 22 years





The Real Root Cause





SvK System

GoalArt larmlista

Primära händelser [2] Visa låg V Visa hög V Visa detaljer Visa dolda larm [0] Lås lista

Tid	Station	Objekt	Beskrivning	Grupp	Dolt
03-09-23 12:35:03	Horred	HORRED 4	skydd utlöst		U
03-09-23 12:36:52	Simpevarp	OVT G3	frånslag / negativt språng		U

Sekundära händelser [47]

Tid	Station	Objekt	Beskrivning	Grupp	Dolt
03-09-23 12:36:52	Glan/Kimstad	CL3 56	frånslag / negativt språng		U
03-09-23 12:36:52	Kimstad/Simpevarp	FL6 51-2	frånslag / negativt språng		U
03-09-23 12:36:52	Glan/Simpevarp	FL1 51-3	frånslag / negativt språng		U
03-09-23 12:36:52	Simpevarp	FT62 T7	frånslag / negativt språng		U
03-09-23 12:37:00	Finnslätten/Hamra	RL6 54	överlast / positivt språng		U
03-09-23 12:37:07	Stadsforsen	STADSFORSE 2	hög spänning		U
03-09-23 12:37:08	Krylbo	KRYLBO 2	hög spänning		U
03-09-23 12:37:09	Tälle	TÄLLE 2	hög spänning		U
03-09-23 12:37:12	Grundfors	GRUNDFORS 4	hög spänning		U
03-09-23 12:37:18	Mollden	MOLIDEN 4	hög spänning		U

Detaljer [0]

Tid	Station	Beskrivning	Tillstånd	Text	Värde	Enhet	Punkt
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- Delivered SvK system contains
 - Auto-generated MFM model from Oracle database
 - SCADA communication protocol based on Web Services (XML)
 - GoalArt custom HMI
- Historical data from Sep 23, 2003
 - Analog and discrete signal data
 - Alarms and events
- Conclusions
 - Correct analysis of fault situations
 - Correct results in historical tests

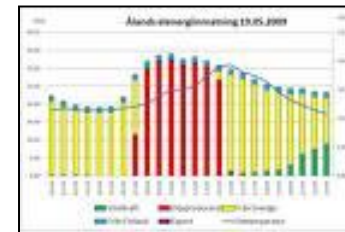


Examples of Alarm Reduction Performance

- Measured December 18th 2009 – January 7th 2010
 - Lowest daily average, December 23rd 2009: **37.6 %**
 - Highest daily average, January 5th 2010: **80.8 %**
 - Total average over the period: **61.1 %**
- East 179th Street Incident, February 7th 2009
 - Directly after incident (7 alarms): **80.0 %**
- Newbridge Incident, June 18th 2009
 - Directly after incident (7 alarms): **82.2 %**
- Astoria West Incident, June 27th 2009
 - Directly after incident (22 alarms): **94.4 %**
- Swedish Blackout, September 23rd 2003
 - Directly after incident (500 alarms): **99.6 %**



Current Grid — Future Grid





Smart Grid

Current grids

Few generators

Few measurement points

Little control, global load balancing

Typically ~ 10 000 signals

Manual fault handling is difficult

Future smart grids

Large number of active generators and loads

Lots of metering and advanced control

Typically 100 000 – 1 000 000 signals

Communication network is critical part of the infrastructure

Manual fault handling will not be efficient



Ongoing Development Project

- Intelligent software support for fault handling is necessary for Smart Grid
- Based on GoalArt alarm processing for current grids
- Develop solution based on same technology for communication networks
- Integrate fault handling for power grid and communication network
- Automated fault handling enables smart grid
- Smart grid enables “green” energy system

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Thank you!

Questions?