INTELLIGENT ALARM PROCESS FOR DMS BASED ON "CHRONICLE" CONCEPT

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ABSTRACT

During major disturbance, dispatcher staff in Distribution Management System is overloaded by alarm messages produced when automatic controls operate to clear faults. The paper presents an Intelligent Alarm Processor based on an innovative method which provides a fast and deterministic analysis of events. The principle is based on the "chronicle" formalism.

This method is implemented in the alarm system of AREVA T&D and has been installed on several control centers worldwide. This paper presents the implementation of this application in the framework of the Distribution Control Center of Qatar.

INTRODUCTION

Distribution Management System allows operator to monitor, control, and optimize the performance of the electric distribution network. Alarm handling is a classical issue for any SCADA/DMS system.

Alarm system purpose is to draw operator attention. If the flow of alarms is high and a large number of alarms are just the consequence of a unique cause, then the alarm system becomes helpless for operator. Operator cannot spend time to analyze each alarm, especially in case of emergency which is often the case during alarm avalanche. This issue is particularly important for EMS/DMS control center [1-3].

During major disturbances, dispatchers in Distribution control center are quickly overloaded by the consequential alarm avalanche.

The alarm processing problematic is best demonstrated by an example.

A fault appears on a bus bar X of a primary station. The relay protection system will isolate the faulty bus bar by tripping breakers around the faulty bus bar.

This situation would create a large flow of alarms. There would be alarms indicating that all breakers around the bus bar have tripped. Other alarm signals indicate the protection relay states. Other alarms report the new electrical state in the neighboring of the bus bar e.g. line overload, undervoltage or overvoltage at neighboring busses. While other numerous alarms would come from various devices in the downstream part of the faulty bus, indicating these devices are no more energized.

The dispatcher has to read these alarms, correlate their sequence mentally in order to understand what happened on the network. He or she then has to acknowledge them and take action to restore quickly power to customers. In order to determine a safe and quick strategy to restore the network, dispatcher may have to guess what the power through the tripped feeder breakers was a few seconds before the incident.

If several incidents occurred at the same time due to atmospheric perturbations or sudden load fluctuation, dispatchers are overloaded by a flow of mixed alarms.

The analysis would be much easier if all alarms related to a common root are grouped under a synthetic alarm summarizing the given situation or "chronicle". In the example above, dispatcher would get only one alarm. Its message would be "**Bus bar X has tripped**". The other related alarms would be automatically acknowledged by the alarm system.

By clicking on the synthetic alarm message, operator would read all (acknowledged) alarms/events related to the synthetic alarm. E.g. trip/close messages, protection relay, limit violation, voltage and status change. Dispatchers may also read the SCADA values measured few seconds before the incident e.g. interrupted power values before the tripping.

This method of processing alarms and data has been developed by AREVA T&D and implemented on numerous EMS/DMS worldwide.

This paper presents the IAP application (Intelligent Alarm Processor). IAP is based on an innovative concept of the "chronicle". Diagnosis examples come from the DMS implemented by AREVA T&D for KAHRA MAA in Qatar.

The purpose of IAP is to:

Reduce the number of alarms presented to the dispatcher staff by suppressing nuisance alarms and substituting a set of alarms with a single synthetic alarm.

Diagnose current situations occurring on the power system. The diagnosis conveys a clearer idea of the power system condition causing the alarms.

Aggregate information: group alarms/events sharing the same root, to show SCADA values before the incident.

IAP is an intelligent event processor. It can deal with any event coming through SCADA or any other DMS application.

GENERAL PRINCIPLE

Research status

During the last twenty years, a lot of research has been done to solve this data overloading. Several methods based, either on expert system , neural network, fuzzy logic, genetic algorithm, or decision tree have been proposed and experimented by the research and industrial community.
Unfortunately these methods remain complex regarding the need to configure and to maintain the knowledge base. They may also appear unreliable as they sometimes generate incorrect diagnose and there, it is difficult to understand how the diagnosis was determined. Or they may lack the ability to model universal and complex situations. Also, they may suffer from slow performance in the real time situations found in large networks. These difficulties explained why there was no real productized Intelligent Alarm Processing for DMS/EMS. This situation was mentioned in 2004 by Richard Candy of ESKOM, the South African utility; "In a recent tender evaluation for the delivery of a transmission Energy Management System, none of the largest international EMS vendors included, as part of their standard alarm package, any form of artificial intelligent alarm processing" [4].

Typically, a diagnosis system is a process of symptom pattern recognition.
A symptom pattern is a scenario of events occurring in a specific topologic state in a given time period. The format needed to model a temporal scenario is called a "chronicle". The word "chronicle" used to represent this concept seems to be introduced for the first time in reference [5].

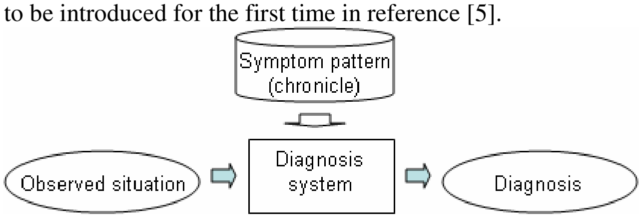

Fig.1. Diagnosis system framework

A chronicle describes a generic scenario of a normal or abnormal change to be monitored. It is represented as a set of events and a set of temporal constraints between these events, associated to diagnosis messages depending on topological constraints.
Reference [6] presents a detailed description of the chronicle concept and syntax implemented in IAP.

Workflow

This section gives an overview of the general architecture; more detail can be access in reference [6].
IAP is divided in two processes:
- IAP online recognizes specific situations modeled by chronicles on fly from alarms received and SCADA values read. When an observed situation matches a chronicle then IAP generates a synthetic diagnosis summarizing the situation. IAP may also remove from the alarm list a group of alarms which are replaced by the single diagnosis.
- IAP offline creates those specific situations (also called chronicles) from the databases modeling the NETWORK and SCADA, and a configuration file called "chronicle template".

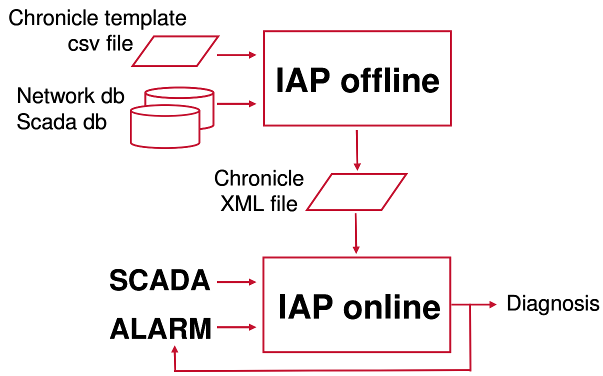

Fig.2. Input and output of the online and offline processes

User Interface

Operator may see diagnosis message from the alarm list or from a display dedicated to IAP. This display lists all diagnosis even diagnosis which were not sent to the alarm list.
Operator may click on a diagnosis message, to see more detail information related to the diagnosis cf. fig 3.

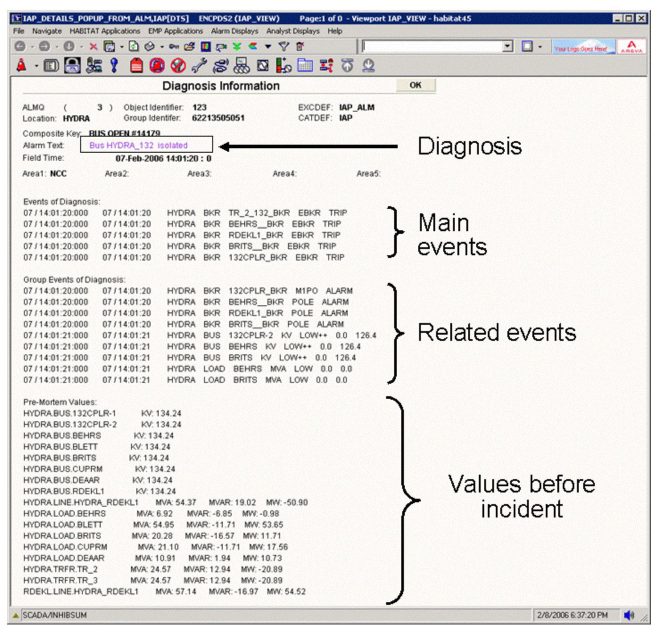

Fig.3. Example of detailed popup.

EXAMPLES OF DIAGNOSIS

IAP is currently installed in the EMS of these companies: ESKOM (South Africa), EPS (Serbia), Dammam (Saudi Arabia), Riyadh (Saudi Arabia).
This section will focus on diagnosis for DMS. The presented diagnosis will come from the DMS of the KAHRA – MAA utility in Qatar. This DMS and its IAP have been in service since November 2006.

Distribution network organisation

Qatar has a modern distribution network. Primary stations are telemetered and controllable from the DMS control center. The distribution network below the primary stations is rarely telemetered by SCADA.

In Qatar, the position status of the breaker upstream the primary transformer is not sent to the SCADA/DMS.

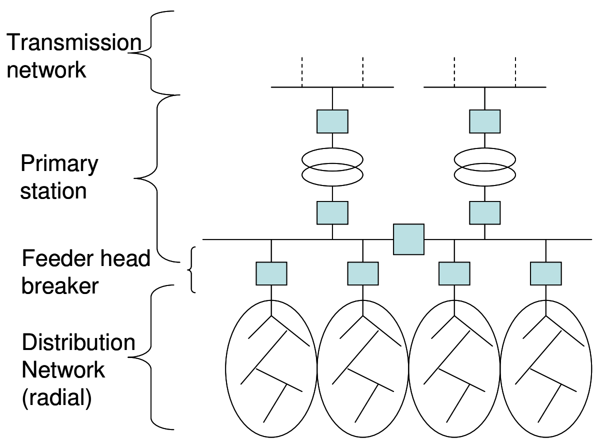

Fig. 4 Classical distribution network organization.

The distribution network is usually radial, i.e. there is no electrical loop.
- Usually, if there is a fault in the distribution network then the protection system would trip the feeder head breaker in order to isolate the faulty device. Depending of the protection system setting, the breaker may be automatically reclosed to test if the fault is still there. The breaker would reopen if the fault is still there. This sequence of auto-reclosure can be repeated three times.
- If there is a fault in the primary station, then the protection system would trip every breaker around the faulty device.

Operator may send remote control actions to open or close breaker inside the primary stations.
Maintenance crew on field may also change the positions of the breakers.

Diagnosis types

From the above description of the distribution network organization, the diagnosis types are straightforward defined.

There is a specific diagnosis when:
- All closed breakers around a bus bar trip.
- A breaker trips.
- A feeder head breaker trip then stays close in an auto-reclosure sequence.
- A feeder head open / close then stays open.
- A feeder head open / close /open then stays close.
- A feeder head open / close / open / close then stays open.

If the change of breaker position was not remote controlled by operator, then these above diagnosis go in the alarm list.

There is also a diagnosis when a
- A bus is reconnected
- A breaker feeder head close

IAP will attach to the diagnosis the alarms/events coming from the switching of position of the breakers.
IAP will also attach all events/alarms appearing on devices located in the primary station or on the downstream part of the tripping feeder head, and if these events/alarms occur few second before or after the initial switching. E.g. limit violation, voltage status, remote control action from operator. The attached alarms will be removed from the alarm list and replaced by the diagnosis

IAP will also store the electrical status in MW, MVAR, KW, Amp of the SCADA measurements connected to the feeder head. These SCADA values will be attached to the diagnosis.

IAP application can manage a lot more diagnosis types. IAP has been delivered to numerous clients who have different network organization (transmission/distribution) and different requirements. Thanks to the high configurability of the IAP system, there is no need to modify the software code of IAP.

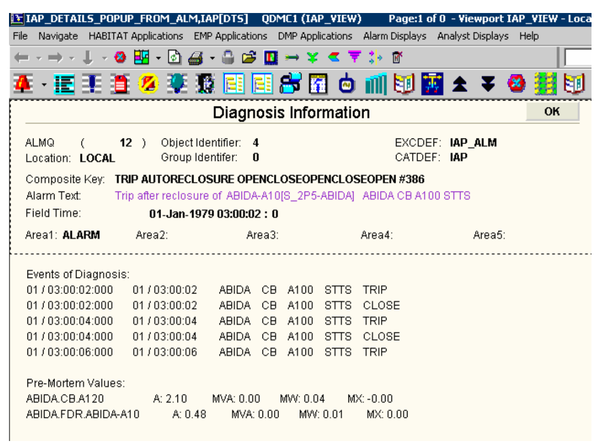

Fig. 5 Diagnosis detail for the tripping of a breaker after two auto-reclosures.

CONCLUSION

The advantage of IAP application defined in this paper is the simplicity and great capacity of expression of the chronicle formalism.
The “chronicle” model is the key to IAP processing. It gives IAP a tremendous advantage in comparison with alternative methods:
Automatic knowledge acquisition. The chronicle file is created automatically by an offline application from the current network and SCADA databases. The IAP offline application models the use the power system protective relay operation behavior to create the chronicle file.
Speed. The chronicle recognition algorithm allows rapid treatment of all events.
Transparency. IAP does not use heuristic algorithm, so it is easy to anticipate the logic of the diagnosis procedure. Indeed, the fault situation is immediately identified by recognizing the symptom pattern. A tester can read the chronicle file to understand the diagnosis origin; there is no need to test all situations on the system to validate the accuracy of IAP’s diagnoses.
Adaptability. Chronicle format is well adapted to model complex scenarios, mixing events correlation and topological constraints.
Extensibility. Client can create additional chronicles following their own methods and rules. These additional chronicles can be produced manually, by a tool or by modifying the code of IAP offline.

The IAP application has been delivered successfully on several in service EMS / DMS.

REFERENCES

[1] D. Kirschen, B. Wollenberg, 1992 “Intelligent Alarm Processing in Power System,” *Proceedings of the IEEE, Vol.80*, No. 5, pp.663-672.

[2] B. Wollenberg, 1986 “Feasibility study for an Energy Management System Intelligent Alarm Processor” *IEEE Transactions on Power Systems,* vol. 1, No. 2 pp. 241-247.

[3] Z.Z. Zhang, G.S. Hope, O.P. Malik, 1989 “Expert Systems in Electric Power Systems – A Bibliography Survey,” *IEEE Transactions on Power Systems*, Vol. 4, No. 4, October.

[4] R. Candy, 2004 "Application of object orientation and artificial intelligence to disturbed state alarm processing in an electrical transmission system," Ph.D. dissertation, Faculty of Engineering and the built environment, Univ. Witwatersrand, Johannesburg.

[5] C. Dousson, M. Ghallab, 1994 "Suivi et reconnaissance de chroniques," *Revue d’intelligence artificielle*, Vol.8, N°1, pp.29-61.

[6] J. Taisne, 2006 "Intelligent Alarm Processor based on Chronicle Recognition for Transmission and Distribution System" *Proceedings PSCE Atlanta.*