Alarm flood reduction using multiple data sources

Vicent Rodrigo Marco
Lunds Univeristet
Department of Automatic Control
Lund, Sweden

I. Introduction

Alarm systems are crucial elements in process plants since they monitor the operation and alert the operator when the plant reaches an undesired state that requires his assessment or action. Alarm systems send signals to the monitoring screens in order to draw the operator's attention. These signals are called alarms.

In the past, each alarm was wired to the control room. Since setting an alarm was costly and the space in the control room was limited, every alarm was well thought through. With the introduction in the industry of Distributed Control Systems (DCS), the situation changed. Nowadays, alarms are located in scrollable tables on the monitoring screen. Therefore, there are no space limitations. Additionally, adding new alarms to the alarm system is as easy as adding few lines of code. Thence the costs are almost non-existent. This has led to an abuse of the use of alarms.

Furthermore, modern plants are highly interconnected due to steam recirculation, heat integration and complex control approaches that increase the efficiency of the plant. However, when there is a disturbance in the plant, it spreads fast through the material, energy and information connections triggering the alarm messages associated to the process signals in the path.

In this situation, the operator in the control room is overwhelmed by the large amount of alarms and each alarm cannot be properly investigated. This condition is known as "alarm flood" or "alarm shower". Under such situations the operator may easily miss a critical alarm. This causes, in the best-case scenario, an automatic shutdown or material losses. But it can even endanger the environment or put human life at risk.

The definition of an alarm flood given by the ISA 18.2 is:

"A condition during which the alarm rate is greater than the operator can effectively manage (e.g. more than 10 alarm per 10 minutes)."

II. Our Solution

The goal of the presented work is to lower plant incidents by developing a method for the reduction of alarm flood periods. The proposed solution reduces alarm flooding by grouping consequential alarms originated from the same process abnormality under a suggested causal alarm. The causal alarm of an alarm flood is the alarm connected to the asset that causes the disturbance originating the alarm flood.

The method uses a combination of three data sources: alarm log (record of previous alarm messages), process data (signals from the measurement points) and a topology model of the plant (representation of the plant connectivity).

The alarm log is analysed to identify alarm flood periods and construct alarm flood sequences, i.e., an ordered list of the alarms triggered during the process abnormality that caused the flood. Pattern analysis and hierarchical clustering are used to isolate groups of similar alarm flood sequences. It is assumed that if two alarm flood sequences are similar, they are originated by the same plant abnormality. Therefore, each group of alarm flood sequences characterises a process abnormality. From each cluster a list of the representative alarms of the process abnormality is extracted. This list is called fault template.

However, alarm logs cannot be used to identify the causal alarm within an alarm flood sequence. The first alarm in a sequence is not always the causal alarm since the time at which an alarm occurs is highly related to the settings of the alarm. This is the reason why multiple information sources are used.

The process data associated to the alarms in the fault template can be analysed in order to capture the precedence relationships between the signals. This kind of analysis is called root-cause analysis, and it is used in this method to isolate the signal closest to the root-cause of the abnormality. Later, a connectivity analysis is performed on the topology model to validate the root-cause suggestion of the signal analysis.

Once the asset that caused the flood is identified, the alarm associated to this asset is the causal alarm and all the alarms belonging to the fault template are grouped under the causal alarm.

The proposed solution was applied to real industrial data from an ethylene plant. The case study illustrated the applicability of the method. A reduction of alarm food periods within the ethylene plant was achieved.