DeltaV™ Sequence of Events

This document describes how the DeltaV system captures and communicates Sequence of Events messages. It also addresses how the system manages the time synchronization required to accurately sequence events that are read by different controllers in the DeltaV system. M-series SOE Input Cards and Controller are shown exemplary here. S-series SOE Input Cards and Controller are physically different regarding their housing and the 2-wide carrier Controllers are placed on, but they will behave the same way, as explained in this Document.

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Introduction

Understanding what happened before, during and after a process upset is fundamental in identifying what caused the upset to occur as well as in determining how it could be prevented in the future. Accurately recording the events that took place - in the precise order in which they occurred—allows those investigating the incident to have an exact picture of the chain of events that led to the upset. Within DeltaV, these types of events—especially those involving high-speed equipment—are captured by the Sequence of Events (SOE) input card and are displayed in Process History View. Controllers and workstations are synchronized throughout the entire DeltaV system using a Network Time Protocol (NTP) server. This allows SOE input cards to be distributed among multiple controllers, while ensuring that the events are properly synchronized.

Capturing Events

The DeltaV system receives process-upset signals using the SOE input card. There is no limit to the number of SOE cards that can be used. Every card has 16 discrete input channels and each channel is configured with four key pieces of information; Description, Channel type, Device Tag, and a State Named Set. The description and state named set are used to formulate the event message that is displayed in Process History View. The channel type determines how the signal is handled by the system and the device tag defines the name of the device sending the incoming signal.

Using the Channel type field, each channel can be configured as either a standard discrete input or as an SOE discrete input. Regardless of whether the input channel on an SOE card is configured as a standard discrete or an SOE discrete, it can be used as part of any control strategy, just like any other discrete signal coming into the system. A channel that is configured to capture SOE discrete inputs reads the incoming signal and determines when to generate an event based on the behavior of the signal. Events are generated every time a signal changes from one state to the other (Note: A 4ms filter is used to debounce the signal). Using the State Named Set configured for the channel, the state of the signal is translated from a discrete value into a more readable form and inserted into the event message. Event messages are sent from the SOE input card to the controller where they are then communicated to a designated Event Chronicle. From there, the event is distributed to other Event Chronicles throughout the entire DeltaV system.

Figure 1 — *M-series SOE input cards use the behavior of the input signal to determine when to generate event messages.*

Communicating Events

All of the controllers in the DeltaV network send their respective SOE messages to a designated Event Chronicle where the messages are stored in the event journal along with all of the other alarms and events being collected on that workstation. Even though the Event Chronicle on any DeltaV workstation may be used to collect SOE messages, DeltaV only allows one Event Chronicle at a time to be designated as the SOE collection node. The SOE collection node is responsible for:

- Ensuring that the SOE messages are stored,
- Sending confirmation to the SOE input cards when a message has been successfully stored, and
- Communicating the SOE messages to other Event Chronicles throughout the DeltaV system.

A property of each Event Chronicle is used to define whether that particular workstation will serve as the SOE collection node.

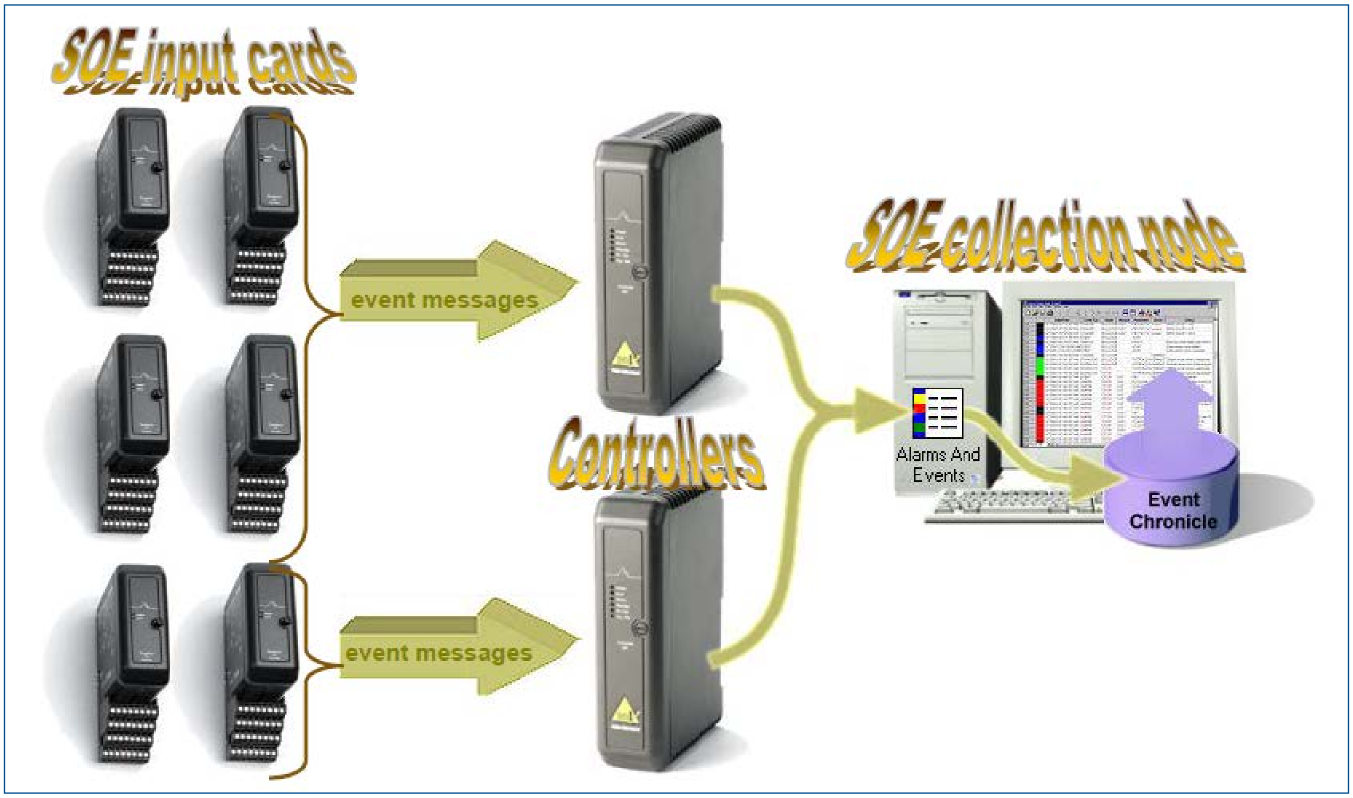


Figure 2 — *Event messages are sent to a designated Event Chronicle..*

Event messages are time-stamped by the SOE input card using a ¼ -ms resolution. The messages are passed in groups to the controller where they are then synchronized with messages coming from other SOE input cards before being sent on to the SOE collection node. Until the controller receives confirmation that an event has been successfully acknowledged by SOE collection node, the event will remain in a buffer on the SOE input card where it originated. Up to 32 events can be buffered on each SOE input card. If the buffer is already full and an additional event is generated then an overflow event is recorded. Also, in the event of a switchover, even if the events in the controller are lost, the secondary controller will be able to retrieve them from the buffer in each card and send them to the designated Event Chronicle.

Note: Because events are acknowledged before they are written to disk, the workstation where the events are stored must have a UPS or secure power source to ensure the events persist through power interruptions.

In addition to events generated by SOE inputs, the controller is also capable of producing other SOE-related event messages that are used to indicate that a specific condition has been met. The following table describes each of the additional messages.

Table 1. List of additional SOE-related events the controller can generate

Event Message	Description
Start Chattering	Generated whenever an SOE discrete input channel goes into chatter mode. *
Stop Chattering	Generated whenever an SOE discrete input channel leaves chatter mode. *
Card Queue Overflow	Generated whenever the SOE input card generates the 33rd unacknowledged event.
Controller Out of Time Synchronization	Generated whenever a controller that is receiving data from an SOE discrete input channel is more than 1 ms out of sync with the master timeserver. Controllers not being used to read SOE inputs will not generate these events.

** Each channel is configured to either detect or ignore chattering on the input signal. This message will only be generated when the channel has been configured to detect chattering.*

Once events are read by the controller, the controller finishes formatting the event messages before sending them on to the SOE collection node. It uses the respective State Named Sets and descriptions that were configured for each channel to formulate the event message that will be viewed in Process History View.

The controller also resolves the event message time stamps using a Network Time Protocol (NTP) server. Each controller in the network synchronizes with the NTP server to ensure that it is within +/- 1ms of the server. This ensures that events generated on different SOE input cards on different controllers are accurately sequenced.

Synchronizing the Network

In order to sequence all of the incoming events in the precise order in which they occurred, there must be a way to ensure that the elements of the system that are responsible for generating, time stamping and communicating these events are properly synchronized. For SOE messages generated in DeltaV, this is accomplished using an NTP server.

NTP is a standard communication protocol that allows computers to synchronize with a timeserver across a network. An NTP timeserver is used in DeltaV to ensure that the time clocks on all of the controllers and workstations are synchronized with each other based on a common reference time source. The degree to which the time clocks are synchronized depends on the NTP server used to provide the reference time. Any local DeltaV workstation may be used as an NTP server. By default, the ProfessionalPlus is designated to serve as the master NTP server for the entire network. In this configuration, the time synchronization accuracy for workstations and controllers can be expected to be +/- 50ms.

Because SOE messages require more accurate synchronization, an NTP server that uses a standardized reference time - such as Coordinated Universal Time (UTC) – is used. In this configuration, the reference time is typically communicated to the NTP server in the DeltaV network using a radio or satellite receiver (eg. Global Positioning System—GPS) or modem. NTP servers that utilize this method are referred to as stratum 1 NTP servers and provide the highest level of accuracy. These servers are capable of providing time synchronization accuracy of +/- 1ms for controllers and of +/- 10ms for workstations. If SOE input cards are present in the DeltaV network and the synchronization between controllers is less than +/- 1ms, the controllers will generate events indicating that they are out of sync with one another.

Note: NTP servers that utilize a reference time communicated from outside of the DeltaV network MUST be configured with specific, predefined IP addresses. Refer to the DeltaV Network Time Synchronization whitepaper for information describing what IP addresses need to be used.

In both configurations, there can also be a backup NTP server designated. If the master NTP server is unavailable then the backup server automatically takes over. For stratum 1 NTP servers, if there is no backup server available, then the DeltaV workstation that has been defined as the master NTP server will take over.

For additional information on how time synchronization within DeltaV is handled, refer to the DeltaV Network Time Synchronization white paper.

Displaying Events

Once the SOE collection node confirms that an event has been successfully stored, it forwards the event to every other Alarms and Events subsystem that has been configured to receive events associated with AREA_A. AREA_A is the default area that is associated with any alarm or event that is not directly related to a DeltaV module. Because an SOE input is not always used in a control strategy, SOE messages generated by that input cannot be automatically associated with a logical area. Therefore, they are treated like all other alarms and events generated by a controller and associated with AREA_A. (This area is, by default, assigned to every Alarms and Events subsystem on every workstation.) The result is that SOE messages are stored by the Event Chronicle on any workstation that has AREA_A assigned to its Alarms and Events subsystem.

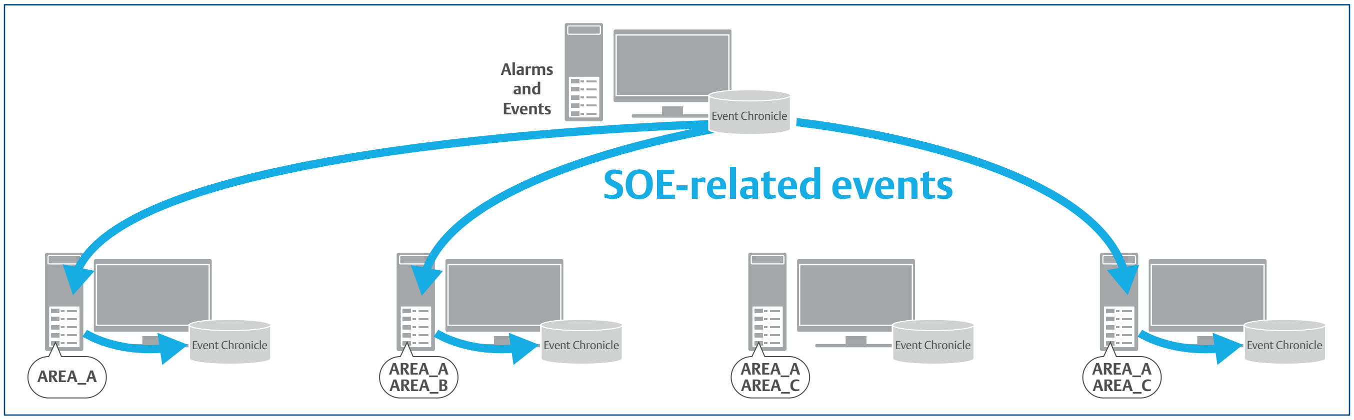
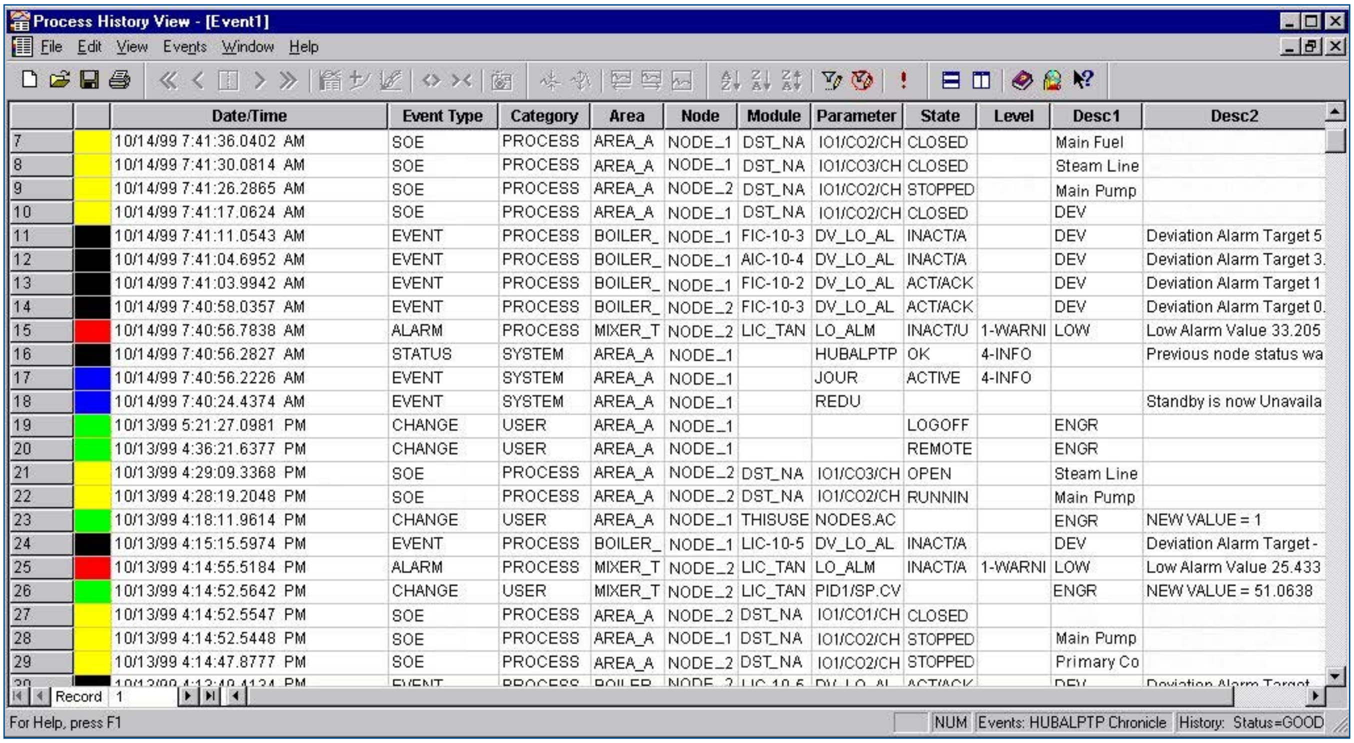


Figure 3 — *The Event Chronicle on the SOE collection node forwards SOE-related events to other Event Chronicles.*

Event messages for SOE are displayed in Process History View along with other alarms and events generated within the DeltaV system. SOE-related event messages have their own Event Type that distinguishes them from other alarms, events and changes stored in the Event Chronicle. This allows users to easily sort and filter on SOE-related event messages and to use color to distinguish these messages from other event types.



		Date/Time	Event Type	Category	Area	Node	Module	Parameter	State	Level	Desc1	Desc2
7		10/14/99 7:41:36.0402 AM	SOE	PROCESS	AREA_A	NODE_1	DST_NA	IO1/CO2/CH	CLOSED		Main Fuel	
8		10/14/99 7:41:30.0814 AM	SOE	PROCESS	AREA_A	NODE_1	DST_NA	IO1/CO3/CH	CLOSED		Steam Line	
9		10/14/99 7:41:26.2865 AM	SOE	PROCESS	AREA_A	NODE_2	DST_NA	IO1/CO2/CH	STOPPED		Main Pump	
10		10/14/99 7:41:17.0624 AM	SOE	PROCESS	AREA_A	NODE_1	DST_NA	IO1/CO2/CH	CLOSED		DEV	
11		10/14/99 7:41:11.0543 AM	EVENT	PROCESS	BOILER_	NODE_1	FIC-10-3	DV_LO_AL	INACT/A		DEV	Deviation Alarm Target 5
12		10/14/99 7:41:04.6952 AM	EVENT	PROCESS	BOILER_	NODE_1	AIC-10-4	DV_LO_AL	INACT/A		DEV	Deviation Alarm Target 3.
13		10/14/99 7:41:03.9942 AM	EVENT	PROCESS	BOILER_	NODE_1	FIC-10-2	DV_LO_AL	ACT/ACK		DEV	Deviation Alarm Target 1
14		10/14/99 7:40:58.0357 AM	EVENT	PROCESS	BOILER_	NODE_2	FIC-10-3	DV_LO_AL	ACT/ACK		DEV	Deviation Alarm Target 0.
15		10/14/99 7:40:56.7838 AM	ALARM	PROCESS	MIXER_T	NODE_2	LIC_TAN	LO_ALM	INACT/U	1-WARNI	LOW	Low Alarm Value 33.205
16		10/14/99 7:40:56.2827 AM	STATUS	SYSTEM	AREA_A	NODE_1		HUBALPTP	OK	4-INFO		Previous node status wa
17		10/14/99 7:40:56.2226 AM	EVENT	SYSTEM	AREA_A	NODE_1		JOUR	ACTIVE	4-INFO		
18		10/14/99 7:40:24.4374 AM	EVENT	SYSTEM	AREA_A	NODE_1		REDU				Standby is now Unavaila
19		10/13/99 5:21:27.0981 PM	CHANGE	USER	AREA_A	NODE_1			LOGOFF		ENGR	
20		10/13/99 4:36:21.6377 PM	CHANGE	USER	AREA_A	NODE_1			REMOTE		ENGR	
21		10/13/99 4:29:09.3368 PM	SOE	PROCESS	AREA_A	NODE_2	DST_NA	IO1/CO3/CH	OPEN		Steam Line	
22		10/13/99 4:28:19.2048 PM	SOE	PROCESS	AREA_A	NODE_2	DST_NA	IO1/CO2/CH	RUNNIN		Main Pump	
23		10/13/99 4:18:11.9614 PM	CHANGE	USER	AREA_A	NODE_1	THISUSE	NODES.AC			ENGR	NEW VALUE = 1
24		10/13/99 4:15:15.5974 PM	EVENT	PROCESS	BOILER_	NODE_1	LIC-10-5	DV_LO_AL	INACT/A		DEV	Deviation Alarm Target -
25		10/13/99 4:14:55.5184 PM	ALARM	PROCESS	MIXER_T	NODE_2	LIC_TAN	LO_ALM	INACT/A	1-WARNI	LOW	Low Alarm Value 25.433
26		10/13/99 4:14:52.5642 PM	CHANGE	USER	MIXER_T	NODE_2	LIC_TAN	PID1/SP.CV			ENGR	NEW VALUE = 51.0638
27		10/13/99 4:14:52.5547 PM	SOE	PROCESS	AREA_A	NODE_2	DST_NA	IO1/CO1/CH	CLOSED			
28		10/13/99 4:14:52.5448 PM	SOE	PROCESS	AREA_A	NODE_1	DST_NA	IO1/CO2/CH	STOPPED		Main Pump	
29		10/13/99 4:14:47.8777 PM	SOE	PROCESS	AREA_A	NODE_2	DST_NA	IO1/CO2/CH	STOPPED		Primary Co	

Figure 4 — *Process History View displays event messages generated by SOE inputs.*

Due to the design of the SOE input card and the use of an NTP server, SOE-related event messages are time stamped with a higher degree of accuracy and resolution than other alarms and events. In order to display these event messages with the most precision, Process History View should be configured to show 4 decimal places when displaying event times. This setting is configured by going to the Options menu on the Process History View toolbar and choosing the Event Time Preference tab as shown in the following figure.

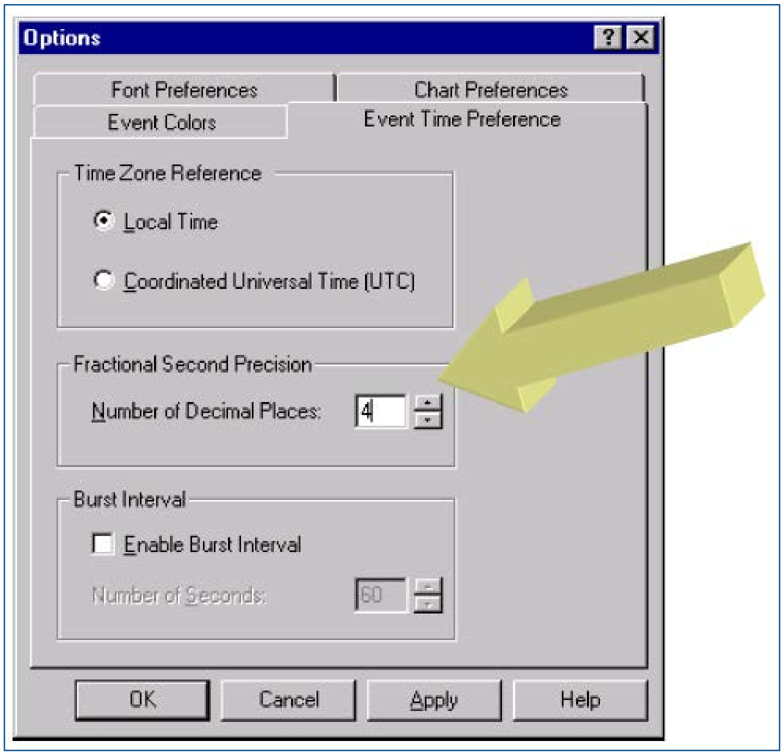


Figure 5 — *Increase the number of decimal places shown to accurately display timestamps for SOE-related event messages.*

Events displayed in Process History View can be automatically sent to a printer as well. From within Process History View, the DeltaV Logger application is used to send any alarm or event read by the Alarms and Events subsystem to a local line printer*. Data going to the printer can also be filtered so that only certain types of events will be logged (e.g. only log events whose Event Type is "SOE"). Users may choose between this functionality and the on-demand printing capabilities of Process History View to generate and produce SOE reports. Additionally, the data can be exported and used within other desktop applications. The export file format is simple delimited text and can be used with standard packages such as MS Access or MS Excel.

Summary

From the dedicated input cards to the tightly synchronized time clocks, the DeltaV system is built to handle every aspect of SOE management. Capturing, synchronizing, communicating and reporting SOE-related events is easy because SOE has been integrated into the standard architecture of the DeltaV system with which users are already familiar. Therefore, the need to layer on additional third-party hardware and software designed to handle these high speed events is eliminated. Finally, as with all other data in DeltaV, the events can be shared with other users or applications outside of the system, making it even easier to distribute and analyze information used to investigate process upsets.

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