OVERVIEW OF THE IEEE STANDARD DEFINING A COMMON FORMAT FOR EVENT DATA EXCHANGE – COMFEDE – IEEE C37.239-2010

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Abstract – Sequence of Events (SOE) are crucial in the operation and post mortem analysis of performance of the power system. At this time, each communication protocol as well as each vendor's implementation of event reporting is different. The IEEE COMFEDE standard provides an XML-based format into which any vendors' and any protocols' sequence of event format can be mapped. COMFEDE extends the concept of SOE by defining the concept of Payload data. Additionally, COMFEDE defines an XML Schema against which any implementation can be validated. The XML format enables multiple COMFEDE files to be combined in a time-sequenced format.

Keywords: Sequence of Events, SOE, Payload Data, XML, SOE Schema, SOE Namespace

I. INTRODUCTION

The monitoring and subsequent analysis of Sequence of Events in the utility has existed since the earliest galvanometer-based fault recorders. In these early systems, both status and operating quantities were connected to the monitoring system so that the operational voltages and current and subsequent event response could be captured along with the resulting event. As static relays came onto the scene, they provided "buffered" low level outputs that could be connected into these monitoring systems.

Over time, a specialization of these monitoring systems was created which was known as the Sequence of Events recorder. These devices *only* monitored status changes (i.e. – on to off) but included a time stamp of when the event occurred.

When the digital relay came onto the scene, it mimicked the functionality of both the SOE recorder and the fault recorder. About 20 years ago, the industry recognized the need to standardize the format of the *oscillography* data that was captured by digital devices; however, the SOE data was left up to the individual vendor. As standardized protocols evolved (e.g. DNP and IEC 61850), they defined standard mechanisms for reporting events but the vendor specific formats still existed. There was a clear need to be able to aggregate all the various device SOE data as well as the ability to augment the event data with relevant additional information about the event.

II. IDENTIFICATION OF REQUIREMENTS

The IEEE Power System Relay Committee identified the need for a standard SOE format to address the integration of SOE information for multiple sources as well as the need for the SOE format to include additional "payload" data. The WG started by defining the requirements for this new reporting format. The basic requirements identified were:

- A mechanism for encoding SOE information – including a time stamp and the quality of the time stamp (GPS clocks do fail)
- Ability to map any existing SOE format into this new format
- Ability to integrate LOG data from IEC 61850
- Ability to identify the location of the SOE event

- Ability to identify different event types such as
    - System event
    - Internal IED Event
    - Setting Change Event
    - Communication event
    - IED Failure event
    - Test Event
- Ability to include additional or "payload" data (e.g. a fault report, analog values, or a file name)
- Ability to communicate the "quality" of the data
- Ability to support multiple languages
- Adaptive to other domains

III THE SOLUTION

In order to meet the stated requirements, a structure based on the eXtensible Markup Language - XML – was chosen. As identified, COMFEDE enables the integration of SOE records, fault reports, 61850 Logs, and other "additional" information as may be desired in a report. This integration concept can be seen in figure 1.

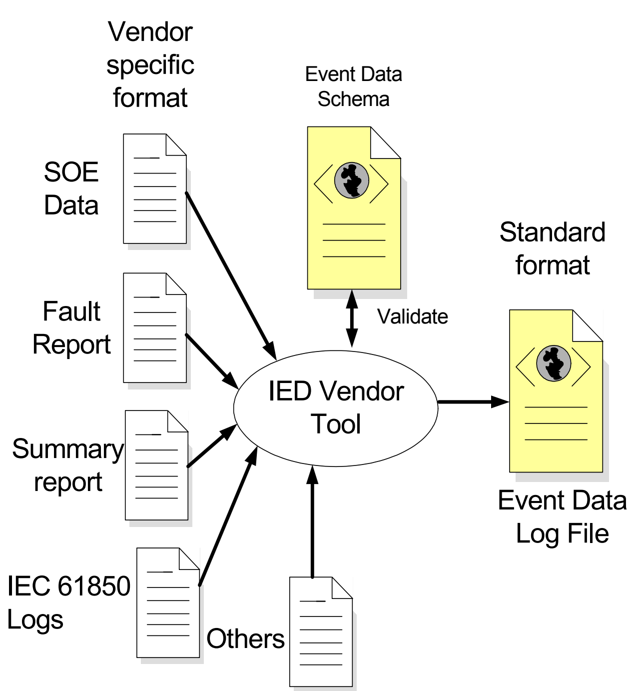


Figure 1
Exporting Data to COMFEDE

Given that there are multiple COMFEDE files available from multiple devices, these files can be merged and a single integrated SOE file produced (see figure 2).

XML is a structured language that uses "tags" and structures to identify and transport information. For example, given that you wanted to identify the first, last, and middle name of a person, one could define an XML structure that looks like:

```
<Name>
      <First>George</First>
      <Middle>Peter</Middle>
      <Last>Harrison</Last>
</Name>
```

The XML structure uses user-defined "tags" to identify the information in the file. One structural element of an XML tag is that every data element must have an opening tag and a closing tag. Tags are encased using the "<" and ">" symbols. The closing tag contains the symbol "/" in front of the closing tag name.

The data tag <Name> would be defined to imply that the information contained within the open/close tags contains information about the name of an individual. Inside the <Name> tag, the First, Middle, and Last names of an individual are specified.

The tags used to identify the stored information are part of an XML dictionary called a Name Space. As such, different name spaces can use the exact same tag but have a different definition. The name space used for COMFEDE is defined in:

http://www.pes-psrc.org/subcommittee/H/COMFEDE

The Name Space for COMFEDE exists at a certain version today, but it is envisioned that as the standard is used, extensions to the name space will be made. As such, the standard allows for versioning of the Name Space to allow for this expansion capability. Although XML *does* define a transport mechanism, it is not specified in this standard. All COMFEDE files end in the extension “CED”.

Another characteristic of XML is the ability to “check” an XML file for conformance to the Name Space, structure, and content. The definition of the items to check is known as a Schema. The schema specifies which data items MUST be present, how many instances of each data item can or must occur, and a value range of the data item.

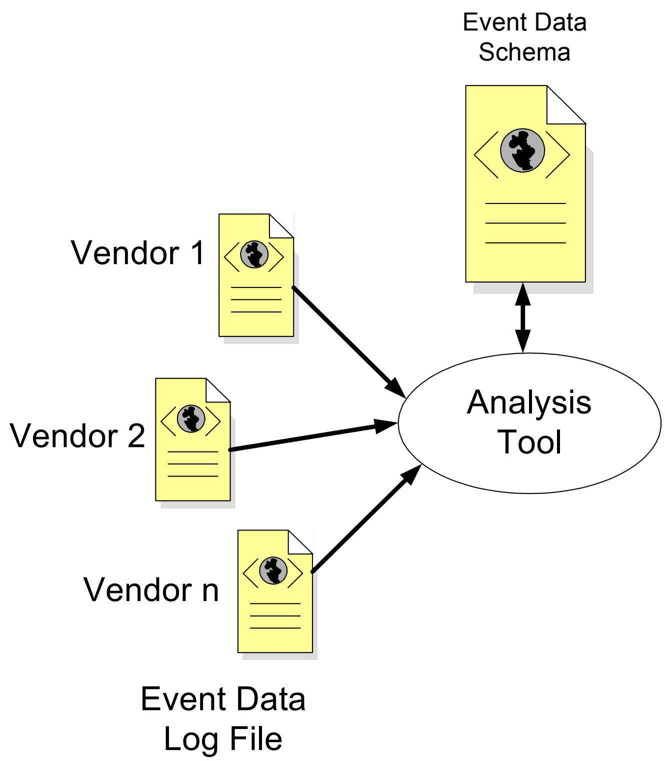


Figure 2
Integrating Multiple COMFEDE Files

The COMFEDE document defines a Schema as “a collection of definitions whose names belong to a particular name space”.

IV COMFEDE Models

One of the concepts that COMFEDE inherits from IEC 61850 is the use of a schema and standard models for the organization and presentation of information. The overall schema for COMFEDE is shown in figure 3. A few of the standard models are presented here so the reader can get an understanding of the organization of COMFEDE data.

Location Model

When data is collected, it is always associated with a location. COMFEDE borrows much of the Location model from 61850 but augments it with additional information to clarify cross-utility data sharing. Note that only a few items are Mandatory (M) and the rest are optional (O). The Location model is:

Attribute Name	M/O
Name Plate	M
Company Name	M
Company Identification Code[1]	O
Operating Company Name	O
Station Name	M
Voltage Level (in kV)	O
Bay Name	O
Latitude	O
Longitude	O
Time Offset from UTC	O

1 The Company Identification in North America is defined as the NERC Utility ID code

Note that all events are to be referenced to UTC time; however, any local offset can be communicated through the Location Model. In addition to the time stamp, COMFEDE includes the same Time Quality nibble that is defined in the IEEE C37.118-2005 Synchrophasor Standard. The Time Quality nibble (4 bits) is an indication of the “quality” of any time stamp. If the nibble is “0000”, the clock is “locked” or “tracking a satellite” and the clock ***should*** be providing time to the level of accuracy to which

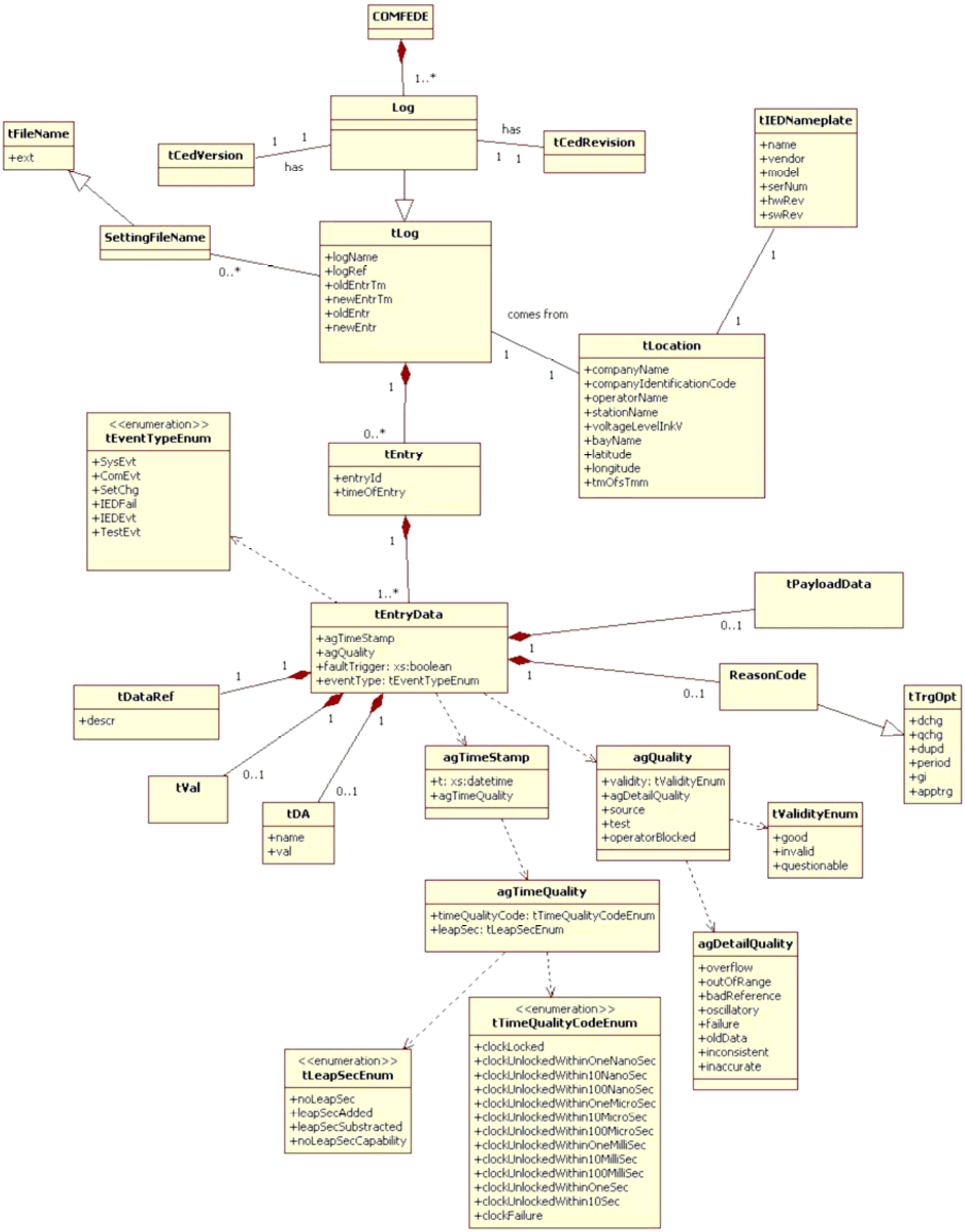


Figure 3
Structure of the Schema

the clock is specified. Once satellite lock is lost, the nibble should change to a value other than “0000”. The resultant value is selected by the manufacturer and is a function of the stability of the internal oscillator. Note that this information is passed to the IED through Time Quality bits encoded in the IRIG-B time code message or the IEEE 1588 TQ field. Table 1 shows the assignment of the Quality bits.

Table 1 – Time Quality Code

Binary	Hex Value	Worst-case time accuracy
1111	F	Clock Fail
1011	B	Clock Unlocked – time within 10^{1} sec
1010	A	Clock Unlocked – time within 10^{-0} sec
1001	9	Clock Unlocked – time within 10^{-1} sec
1000	8	Clock Unlocked – time within 10^{-2} sec
0111	7	Clock Unlocked – time within 10^{-3} sec
0110	6	Clock Unlocked – time within 10^{-4} sec
0101	5	Clock Unlocked – time within 10^{-5} sec
0100	4	Clock Unlocked – time within 10^{-6} sec
0011	3	Clock Unlocked – time within 10^{-7} sec
0010	2	Clock Unlocked – time within 10^{-8} sec
0001	1	Clock Unlocked – time within 10^{-9} sec
0000	0	Clock Locked – best time

At a location, there is an Intelligent Electronic Device, which will have a Name Plate description. Taken from IEC 61850, the Name Plate has the data attributes of:

Attribute	M/O
Name of the IED	M
Vendor of the IED	M
Model Number	O
Serial Number	O
HW Rev #	O
SW Rev #	O

The XML Schema for the Nameplate looks like:

```
<xs:complexType name="tIEDNameplate">
<xs:complexContent>
<xs:extension base="tBaseElementForExtension">
<xs:attribute name="name" type="tName" use="required"/>
<xs:attribute name="vendor" type="tName" use="required"/>
<xs:attribute name="model" type="tName"/>
<xs:attribute name="serNum" type="tName"/>
<xs:attribute name="hwRev" type="tName"/>
<xs:attribute name="swRev" type="tName"/>
</xs:extension>
</xs:complexContent>
  </xs:complexType>
```

Note the term <use=”required> for the Name and Vendor attributes. All the fields have the attribute type of “tName” which is defined in the schema to be a “Normalized Text String”, that is, no Carriage Return or Line Feed.

A Log has “entries” and each entry has:

- Entry ID (a counting integer)
- Time of Entry into the Log

Each entry has Entry Data associated with it. Entry data includes:

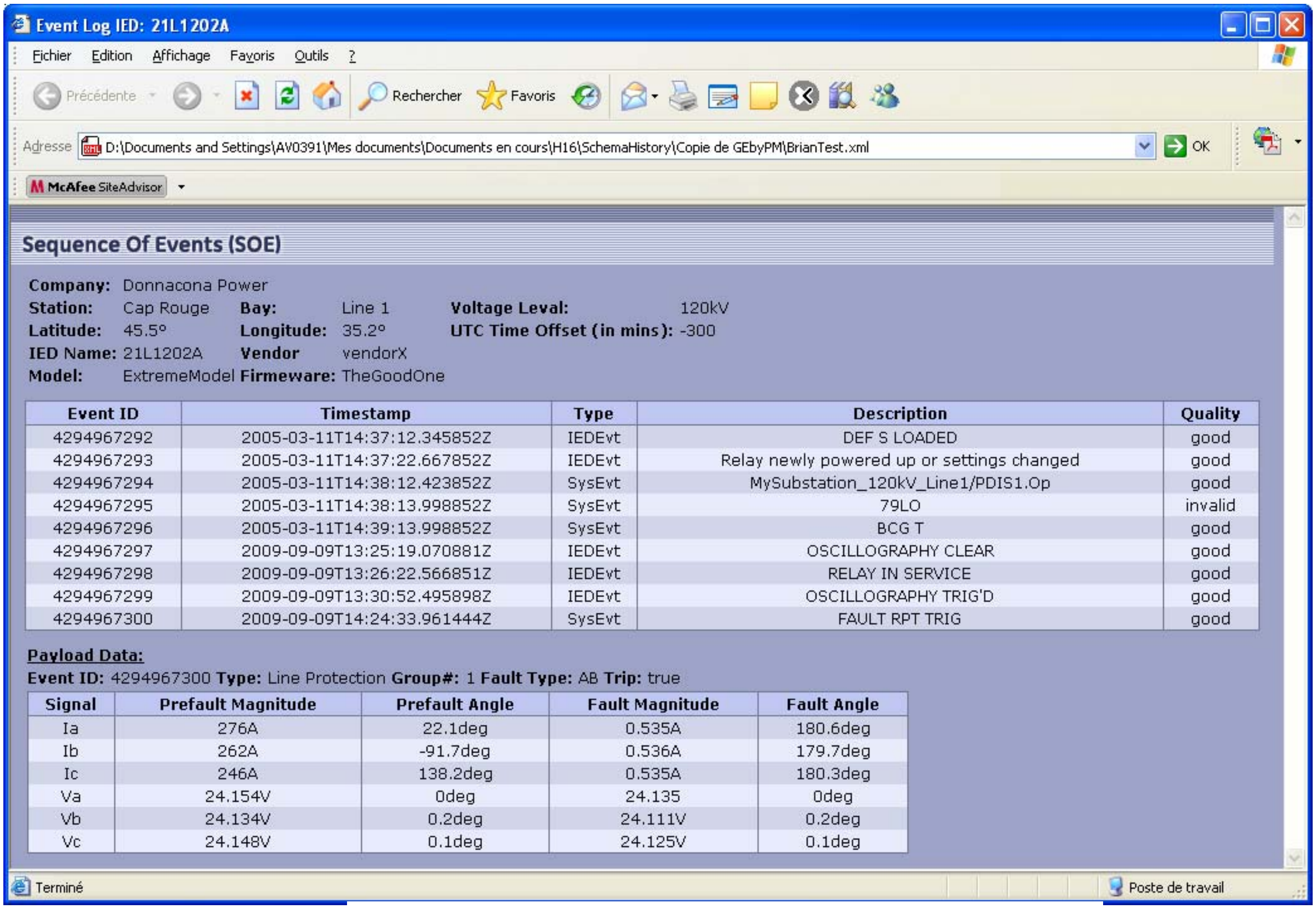
- Time Stamp of the event
- Time Quality (see table 1)
- Fault Trigger bit (optional)
- Event Type

Certain events, such as a Fault, have associated with the event “additional information” about the event. In the case of a fault event, there is information that describes the fault event. COMFEDE provides a mechanism to convey this extra information that is defined as PAYLOAD Data.

Payload data can include information such as:

- A COMTRADE file name
- Measurement data
- Fault Type
- Fault report
- Line Frequency
- Device Targets
- Breaker Report
- Etc.

Payload data is optional.



Sequence Of Events (SOE)

Company: Donnacona Power
Station: Cap Rouge **Bay:** Line 1 **Voltage Leval:** 120kV
Latitude: 45.5° **Longitude:** 35.2° **UTC Time Offset (in mins):** -300
IED Name: 21L1202A **Vendor** vendorX
Model: ExtremeModel **Firmeware:** TheGoodOne

Event ID	Timestamp	Type	Description	Quality
4294967292	2005-03-11T14:37:12.345852Z	IEDEvt	DEF S LOADED	good
4294967293	2005-03-11T14:37:22.667852Z	IEDEvt	Relay newly powered up or settings changed	good
4294967294	2005-03-11T14:38:12.423852Z	SysEvt	MySubstation_120kV_Line1/PDIS1.Op	good
4294967295	2005-03-11T14:38:13.998852Z	SysEvt	79LO	invalid
4294967296	2005-03-11T14:39:13.998852Z	SysEvt	BCG T	good
4294967297	2009-09-09T13:25:19.070881Z	IEDEvt	OSCILLOGRAPHY CLEAR	good
4294967298	2009-09-09T13:26:22.566851Z	IEDEvt	RELAY IN SERVICE	good
4294967299	2009-09-09T13:30:52.495898Z	IEDEvt	OSCILLOGRAPHY TRIG'D	good
4294967300	2009-09-09T14:24:33.961444Z	SysEvt	FAULT RPT TRIG	good

Payload Data:
Event ID: 4294967300 **Type:** Line Protection **Group#:** 1 **Fault Type:** AB **Trip:** true

Signal	Prefault Magnitude	Prefault Angle	Fault Magnitude	Fault Angle
Ia	276A	22.1deg	0.535A	180.6deg
Ib	262A	-91.7deg	0.536A	179.7deg
Ic	246A	138.2deg	0.535A	180.3deg
Va	24.154V	0deg	24.135	0deg
Vb	24.134V	0.2deg	24.111V	0.2deg
Vc	24.148V	0.1deg	24.125V	0.1deg

Figure 4
COMFEDE File as Viewed through an XML Style Sheet

V Data Visualization

The use of XML as a description language enables the development of an XML "style" sheet – known as an XSLT file - that defines the mapping of the data in the XML file onto any web browser. This style sheet is highly customizable and a browser can support Java applications for advanced functionality . An example of a COMFEDE file as rendered by one version of a style sheet is shown in figure 4.

VI Conclusions

The Common Format for Event Data Exchange IEEE C37.239 – COMFEDE – is a new IEEE standard for the conveyance of event and associated or Payload data. The format is defined using the eXtensible Markup Language and enables the migration of event records from legacy and 61850 – based devices into this new format. Its foundation in XML enables future extensions as well as migration into other name spaces

VII Reference

IEEE Standard for Common Format for Event Data Exchange (COMFEDE) for Power Systems. IEEE C37.239-2010.