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SMV TO COMTRADE DATA CONVERSION

SUMMARY

New achievements in the field of communication technology enabled an innovative approach in the solving of the existing problems in the power system. The IEC 61850 norm provides a standardized communication among the secondary equipment devices. Numerical relays have limited internal memory in terms of data storage and limited capability in subsequent analysis. Therefore the feasibility of making high resolution long term records using open-source hardware and software is tested. The observed restrictions on the driver in the SMV to COMTRADE data conversion are documented in this paper.

Key words: COMTRADE, IEC 61850, process bus, SMV

1. INTRODUCTION

Modern communication between transformer substation is achieved through optical connections. In the initial stage of digital substation development, a number of advanced numerical devices have emerged very quickly, however, without the possibility of interaction or connectivity. Devices of various manufacturers, and often the devices of the same manufacturer from different generations, could not communicate without expensive and complicated communication protocol conversion devices. The development of IEC 61850 is a step towards solving this problem and has been one of the biggest challenges in the field of automation [1].

Figure 1shows three levels of digital substation architecture and the historical development.

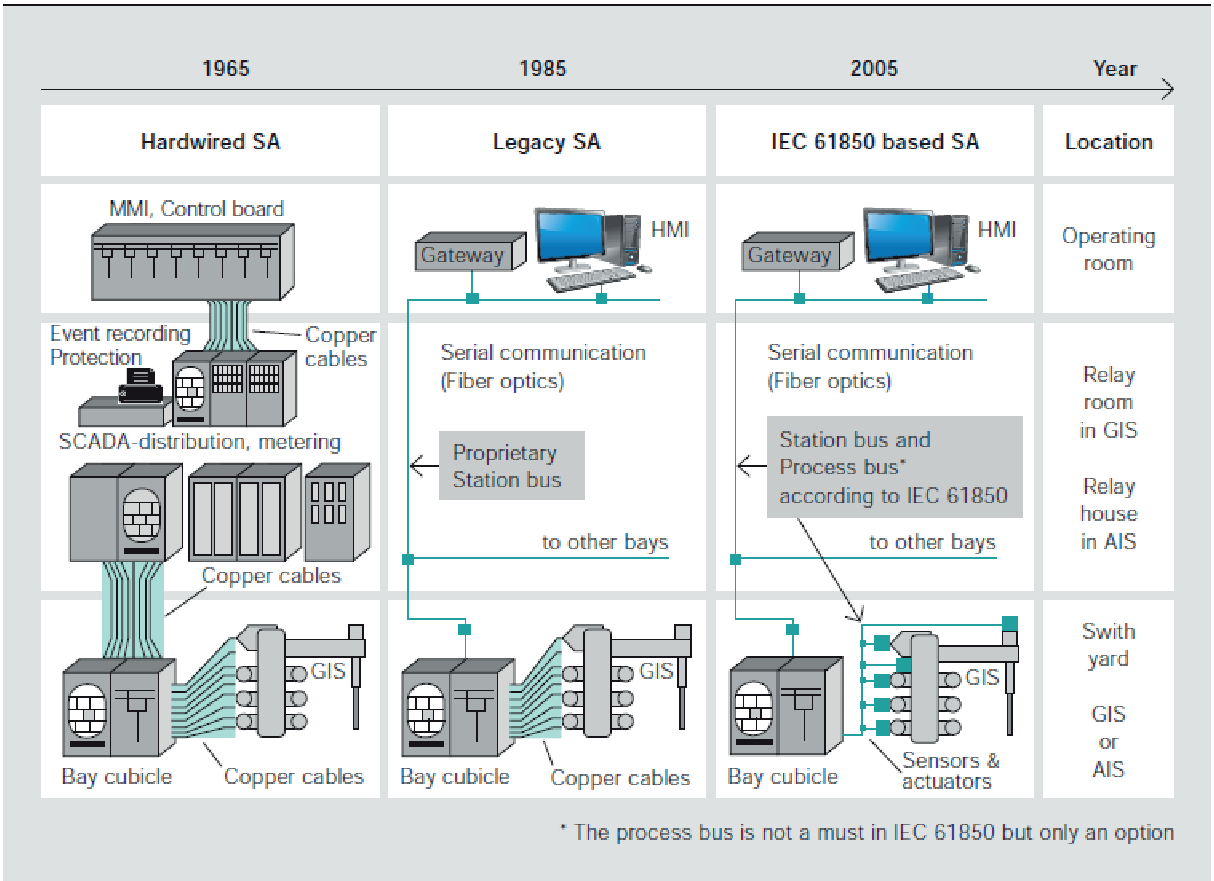

Figure 1. Digital substation development [2]

Norma IEC 61850 standard defines standardized object models, their names, parameters, and meanings that are required for all functions used in transformer substation. These unique features can significantly reduce the cost of designing, installing, commissioning, and generally running the power system.

IEC 61850-8-1 part defines the communication in station bus level and allows peer-to-peer communication by exchanging the GOOSE (Generic Object Oriented Substation Event) message between the connected LAN (Local Area Network).

IEC 61850-9-2 part describes how analogue current and voltage signals can be transmitted as Sampled Values through unconventional metering transformers or conventional metering transformers with the merging unit.

Measured data needs to be converted from analog to digital values, which is done with the help of a merging unit. The merging unit can be located within a measuring transformer or a stand alone unit that allows the use of conventional metering transformers [3][4].

The existing primary equipment is intended to be used as long as it is functional by merging the unit serving as a medium and a protocol converter [5].

1.1. Sampled measured values - SMV

Sampled values are transmitted as SMV (*Sampled Measured Values*) frames.

Figure 2shows the Ethernet frame containing SMVs.

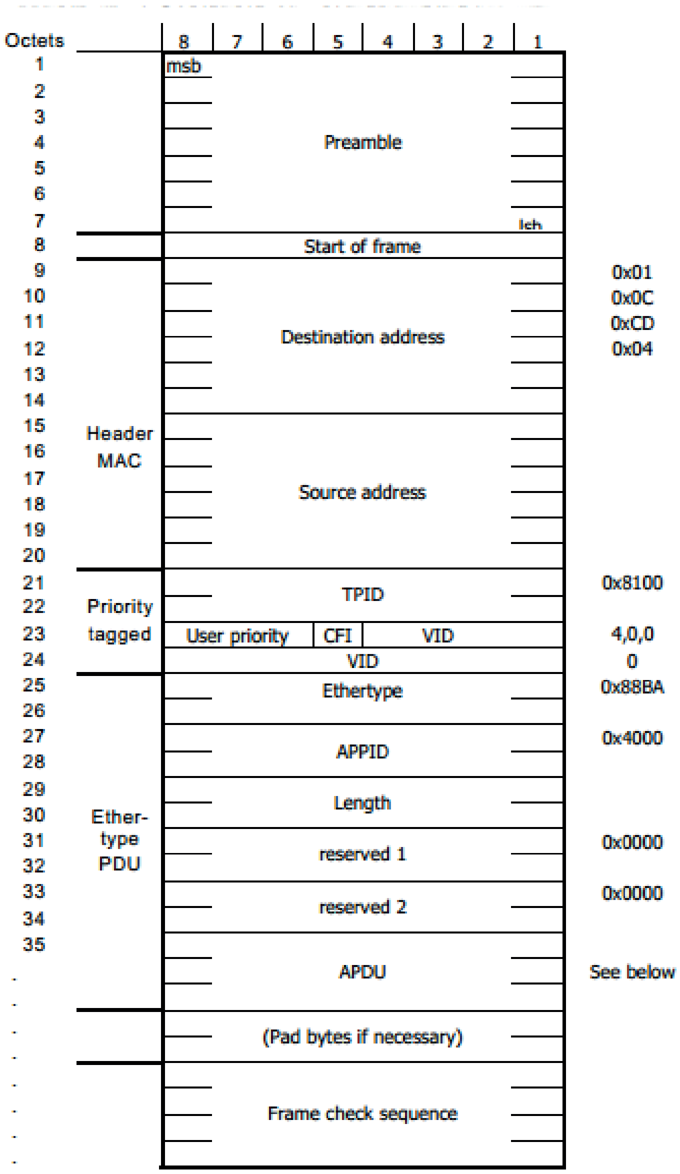

Figure 2. SMV Ethernet frame

The ethernet frame starts with preamble octets, MAC addresses and Ether type. APDU part contains the data.

Figure 3 shows the APDU segments.

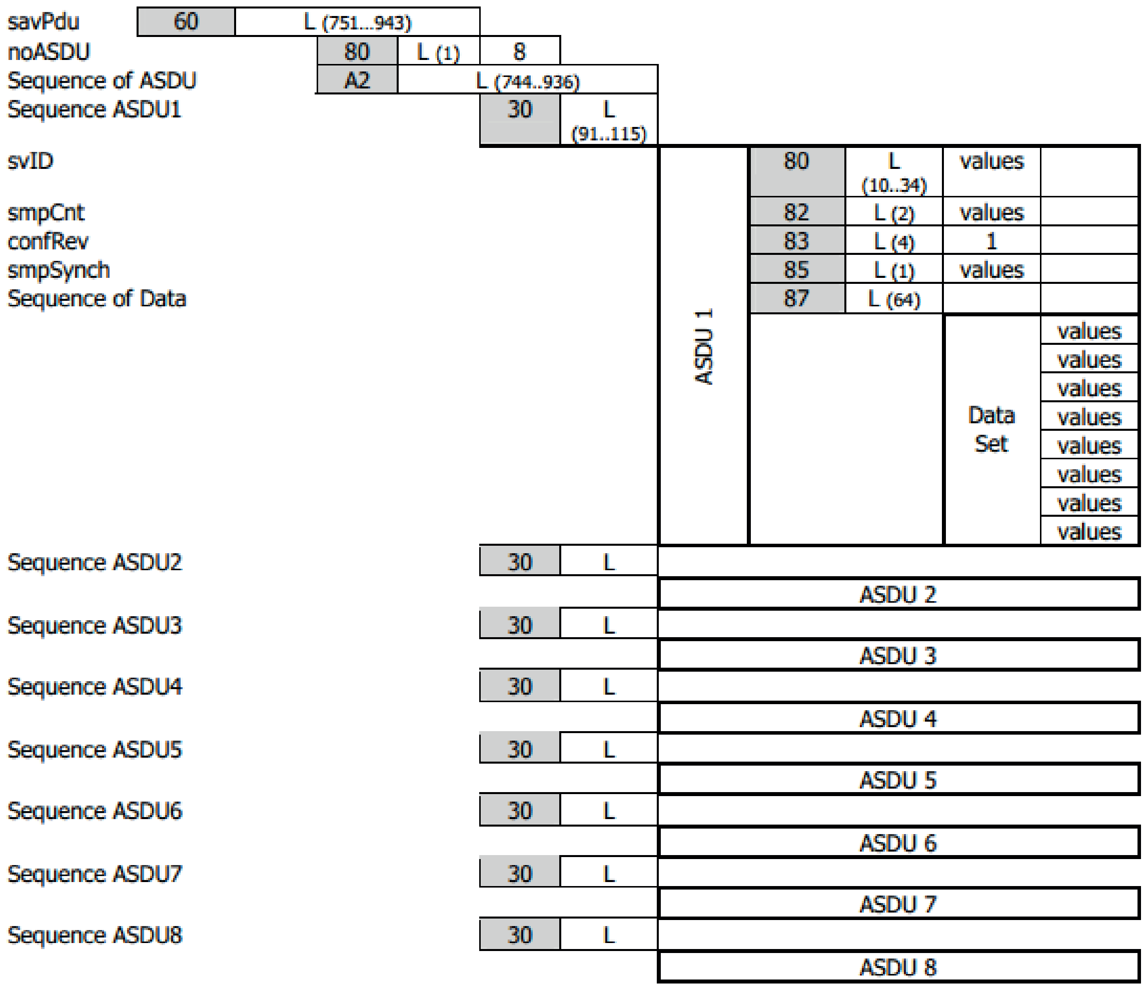

Figure 3. APDU

There may be one or eight ASDU parts in the APDU part, depending on the sample purpose. The total APDU depends on the number of ASDUs as well as on the value of the sample representing the sample value identifier and can be in the range of 10 to 34 octets. Current and voltage values are found under Data Set, the segment shown inFigure 3, under the values. Each voltage and current value is contained in two octets, where the first represents the amount, and the second quality of a certain value.

This paper deals with SMV frames intended for protection. The number of packets per second is 4000 and each packet received contains information on the size and quality of three phase currents and voltages, as well as zero current and zero voltage.

1.2. COMTRADE

COMTRADE (**Com**mon format for **Tra**nsient **D**ata **E**xchange for power systems) is a file format for storing oscillography and status data related to transient power system disturbances.

The *.DAT file contains the digitized sample data in an ASCII text format. The *.CFG file contains configuration data on what is in the *.DAT file including information such as signal names, start time of the samples, number of samples, min/max values, and more.

The feasibility of a functional program device to write string contained in SMV data frames directly from the Ethernet process bus to COMTRADE files will be verified. The motivation is to create a larger resolution and duration record than the standard fault logs in numeric relays.

2. SMV TO COMTRADE REAL TIME DATA CONVERSION

Omicron device was used to generate sampled values. Figure 4. shows the test environment. The Windows computer is connected to the testing device and is required for its configuration and management. Communication between computers and Omicron is "Ethernet proprietary". Omicron sends the SMV data frames via the LAN network cable to the Ethernet switch, from where the data is read on the Linux computer [6].

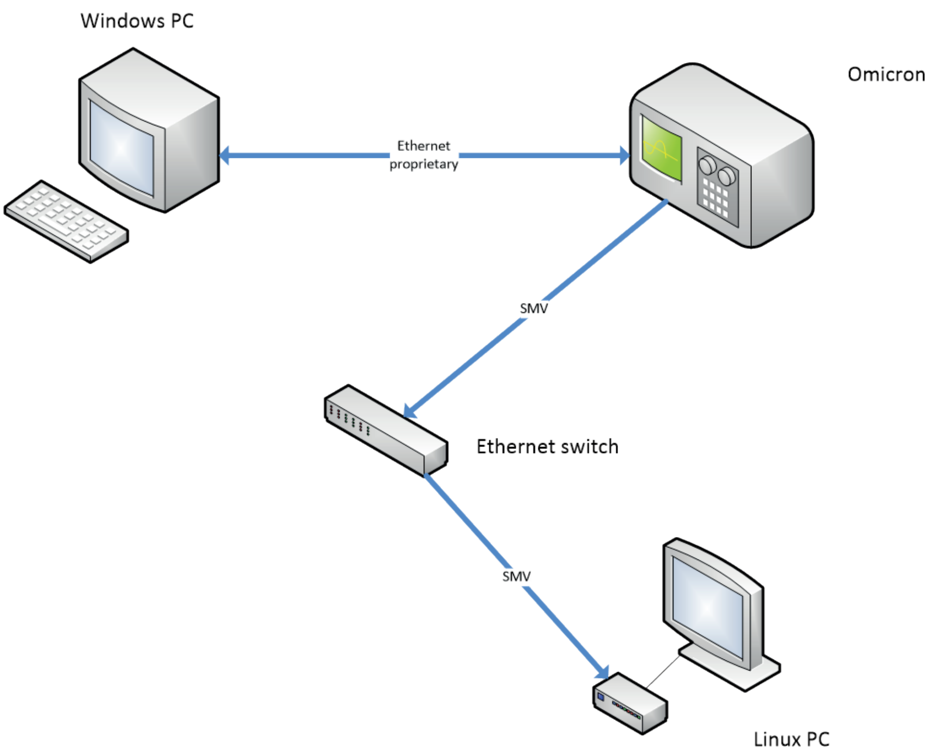

Figure 4. Test environment

2.1. SCAPY library

Using the *sniff* function integrated within the Linux SCAPY library we read ethernet data frames and converted them to COMTRADE file format.

Software is called from the terminal:

sudo python <software_name> -i <interface> [-s <file size>] [-t <cfg refresh time>]

Necessary argument is –i, interface. Additional arguments are –s (data file size)and –t (time to refresh configuration file). Default values of additional arguments are s = 1MB i t = 10s.

Function that reads the data frames can have several parameters:

sniff(prn = None, lfilter = None, count = 0, store = 1, offline = None, L2socket = None, timeout = None)

A function can be applied to the data frame (*prn*), data frame can be filtered (*lfilte*r) or stored (*store*). We can also limit the number of frames to be read (*count* = 0 – unlimited).

We applied a function *write_to_files*that analyzes theframe and rewrites it in COMTRADE file format. A new data file is created when the current one reaches its size limit. Configuration file is refreshed every 10 seconds.

Upon inspecting the data file we observed frame loss as shown in bold.

387,93003,0,0,0,0,0,0,0,0,3504,0

388,93214,0,0,0,0,0,0,0,0,3505,0

389,93516,0,0,0,0,0,0,0,0,**3506**,0

390,95008,0,0,0,0,0,0,0,0,**3512**,0

391,100001,0,0,0,0,0,0,0,0,**3532**,0

We tested the sniff function with the arguments *count* and *timeout*. First we assigned *timeout* argument – 10 seconds. In that time frame OMICRON sent 40 000 data frames, but our function managed to read only 5170 frames as shown in Figure 5.

Figure 5. Scappy test

Second we assigned the *count* argument. We measured time in which the function will read 40 000 date frames that Omicron sends in 10 seconds. It took 1:21,15 minutes.

2.2. PCAPY library

We tried using different Python library and we changed the way function writes the frames to COMTRADE data file. We write 100 frames into a *string* that we write into a data file. We reduced frame loss, but it wasn't eliminated.

2.3. Feasibility check

Both PCAPY and SCAPY libraries use *tcpdump* function in order to read the data frames. The *tcpdump* tool itself has frame loss.

Upon inspecting the driver *sunxi_emac*we found out its*data rate*is between 4 and 6 $MByte/s$.

One data file with 16000 samples has a frame loss of 23,45%.

Complete frame consists of octets:

$$L_{uk} = L_{preambula} + L_{SDF} + L_{MAC\_odredište} + L_{MAC\_izvor} + L_{tag} + L_{EtherType} + L_{podatak} + L_{CRC} = 7 + 1 + 6 + 6 + 4 + 2 + 1500 + 4 = 1530$$

L_{uk} – frame octet number

$L_{preamble}$ – preamble = 7

L_{SDF} – start = 1

$L_{MAC\_destination}$ – destination address = 6

L_{MAC_source} – source address = 6

L_{tag} – tag = 4

$L_{EtherType}$ – ethernet type = 2

$L_{podatak}$ – data length = 1500

L_{CRC} –CRC = 4

Interpacket gap of 12 octets makes for the frame length of 1542 octets.

Table 1 shows theoretical and real frame bandwidth calculated from eq (1):

$$Frame\ bandwidth = \frac{data\ rate}{L_{uk}} \qquad (1)$$

Table 1. Frame bandwidth

	Real	Theoretical
Data rate	4 – 6 MB / s	12.5 MB / s
Frame bandwidth (L=1542)	2592 – 3892 frames / s	8106 frames / s

Although the driver's *data rate* is big enough the problem is the frame frequency. Sunxci_emac driver is optimized for sending large data frames with much slower refresh rate to read the incoming frames.

3. CONCLUSION

The standard IEC 61850 provides standardized communications using the latest advances in communications technology. The use of new technologies provides innovative approaches to solving problems, but it also carries certain risks that are not negligible in the power system. To reduce the risk, it is necessary to gain experience in using new technologies, which is possible only on real objects.

The motivation was to create a longer duration record of a larger resolution than the standard logs of numeric relays that have limited internal memory for the amount of data they can store for subsequent fault analysis.

It was necessary to check the feasibility of the functional program device that writes the data string contained in the SMV data frames directly to the COMTRADE file after reading it from the EtherNet process bus.

The calculations have shown the limit on the Ethernet driver for a large amount of data coming in a short time span.

Reprogramming of driver is recommended, which comes out of the domain of this paper.

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