Remote Access of Intelligent Electronic Devices and Automatic DR Collection at Centralised Control Centre: A Novel Experience

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SUMMARY

POWERGRID (A Central Transmission Utility) has played a role of key catalyst in rapid growth of Indian Power Sector over last decade. POWERGRID wheels around 50% of total power generated in India on its transmission network. As on May 2020, POWERGRID owns 248 Substations having 163,743 ckm of transmission line and 412,459 MVA transformation capacity.

With the rapid expansion of transmission assets at an annual growth of ~15% in 2010, POWERGRID envisaged paradigm shift in operational philosophy with the conceptualization of National Transmission Asset Management Center (NTAMC) project. POWERGRID's flagship project (NTAMC) is equipped with multiple intelligent systems for centralized control and monitoring of remote substations, located over pan India. Normally, protection engineers in a substation download the disturbance records (DR) & events from relays for manual analysis of the fault. Along with centralised SCADA system, the need for development of a system was envisaged for remote access of protection IED and automatic DR collection to support fast decision making by operators at remote control centre. **This paper covers the challenges faced and experience earned during implementation of Remote Accessibility system (RAS).**

The project is executed with the integration of approx. 9000 no. of IED installed at remote substations, geographically spread all over the India. It includes various make and model of relays- supporting RS232, RS485 & Ethernet communication over Copper wire, RJ45 & fiber optic connection over different protocols. Also, relays at conventional type of substations were isolated i.e. not connected to any common communication network, while relays at SAS based substations were connected to substation ring network.

In NTAMC project, numerical relays were integrated mainly for two functions i.e. automatic DR collection and remote access of IED. The remote access was envisaged for reading relay logs & other parameters and enabling remote configuration using OEM specific configuration

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tool at control centre. The following important functions were covered in RAS system implementation:

a) Immediate collection of DR files at control centre, depending on communication type supported by IED.
b) Redundancy of hardware & ports has been ensured at substation as well as control centre level.
c) The collected DR files from relays are converted to standard COMTRADE format (if it is in proprietary format eg .areva, SPA etc).
d) Access over encrypted network from substation to control centre is provided for accessing the data & reports in a secure manner.
e) Availability of collected DR files ensured in hierarchical structured view for easy navigation.
f) RAS avoids the possibility of loss of DR files from relay due to flushing of files because of limited storage in the relays. RAS stores the DR files up to 10 years.

The paper will cover the integration details with various types of numerical IEDs and customised solutions to overcome the unique challenges faced during the integration of IED for automatic DR collection and remote access from control centre. **This paper will also cover the challenges faced during execution of the project:**

a) Unique & customised design of software & hardware
b) Non uniformity of communication capability of various make & model of relays.
c) First time implementation on large scale having relays of various make & model and different protocol support which resulted in multiple patches & fine tuning for prolonged period
d) Non-uniformity in signal names and type of Disturbance recorders
e) Management of multiple versions of relay specific configuration tools and restriction of multiple access of a particular relay
f) Partial configuration of relay communication port for data exchange on supported protocol

Remote Accessibility System (RAS) seems the next technological change to fulfil the requirement of rapidly growing power systems.

KEYWORDS

National Transmission Asset Management Centre-NTAMC, Remote Accessibility System-RAS, Automated Fault Analysis System-AFAS, Supervisory Control and Data Acquisition System- SCADA, Station Data Concentrator- SDC, Serial over Ethernet converter/Terminal server- TS, Fallback switch, Disturbance Record-DR, Common Format for Transient Data Exchange- COMTRADE, Intelligent Electronic Device- IED, Simple Network Management Protocol- SNMP.

1. INTRODUCTION

National Transmission Asset Management centre (NTAMC) is conceptualized for remote operation of vast number of geographically distributed substations of the POWERGRID. The

remote operation and monitoring of substation equipment from a centralized location reduces the expert manpower required locally and increases the overall visibility of the system.

Along with the Supervisory Control and Data Acquisition System (SCADA) which is used for remote operation of switchgear and monitoring of substation assets, Remote Accessibility System-RAS is main subsystem in NTAMC which enables remote access of the relays and auto-downloading of DRs to control centre.

The Numerical relays/IEDs installed at each substation monitor the system parameters, sense a fault in transmission network and isolate any fault section. Along with this the relays also generate a disturbance record (DR) during the fault or disturbance. The DR consists of analog system parameters during pre-fault, fault and post-fault conditions, and the digital information of various protections operated and switchgear operations during fault.

Immediate availability of the disturbance record is essential for expert analysis and thereby to take quick decision for the power system element restoration. Earlier the DR used to be manually downloaded from the relays using proprietary software installed in a laptop/PC. Later this is mailed to experts for analysis. This takes more time and also requires round the clock availability of experts in each substation to handle different software of various make relays and availability of the manpower in odd hours to collect the DR.

In NTAMC project, numerical relays were integrated mainly for two functions i.e. automatic DR collection and remote access of IED. The remote access was envisaged for reading relay logs & other parameters and enabling remote configuration using OEM specific configuration tool at control centre.

The Remote Accessibility System (RAS) automatically downloads DR from different make and model of relays supporting different communication media and operating over different protocols and sends to control centre immediately. The collected DRs are renamed to standardized naming format to have uniformity and for inter system operability.

The downloaded DRs can be easily accessed from a web portal and the healthiness of relays communication and other RAS equipment can be monitored. The acquired DR files are also shared with Automated Fault Analysis System (AFAS) for automated analysis and sending alerts.

2. CHALLENGES FACED:

Being the first project to be implemented on such a larger scale, during implementation many challenges were faced in integrating around 9000 IEDs of substations distributed across the country.

The Major challenges faced during the project execution are briefed below:

i. Hardware redundancy at Site

Redundancy is maintained at various levels in substation to ensure continuous availability of relay data and access to control centre.

Two Station Data Concentrators are installed at each substation for redundancy which works in active – standby mode. The active SDC collects the DR from relays and forwards to control centre. The DR files also synced with the standby SDC. Automatic switchover will take place whenever the server side or relay side physical connection is disconnected with the current active server or it becomes faulty.

IEDs which support RS485 are directly connected to both the SDC. For the IEDs with RS 232 interface, the relay is connected to two Serial over Ethernet converters via a fallback switch for redundancy. If the first Serial over Ethernet converter fails, SDC will switchover the connection to the second converter and the fallback switch also automatically route the data to second Serial over Ethernet converter.
Redundancy is not planned for remote parameterization of serial relays considering it to be a less frequent activity.

ii. Hardware redundancy at Control centre

The redundancy of RAS system is maintained at control centre end by installing a set of two identical servers each at NTAMC and Backup NTAMC, which is located at different location. The database and the data files are continuously in sync in all the four servers. The switchover is automatic between servers at a control centre.

The web portal used for downloading the DR can be accessed using a single URL irrespective of the active server. It ensured redundancy of web portal without any manual intervention.

iii. Non uniformity of communication capability of various make & model of relays

The major challenge faced during the project implementation is integration of different make and model of relays with different communication capabilities. The conventional type of substations have relays that are communicating in proprietary protocol such as SPA, Courier, SEL fast messages and standard protocol like IEC 103 and IEC 61850 for DR collection and these relays are not connected to any common communication network. This necessitated the physical connection of relays in different panels to a common point i.e. RAS Ethernet Switch. Various intermediate equipment such as Serial over Ethernet converters (terminal servers) and fallback switches, and protocol or media converters are used for interfacing with relays operating over proprietary protocol or communicating over fiber media.

Integration details and customised solutions used for DR collection and Remote accessibility of various make and model relays is briefly explained below.

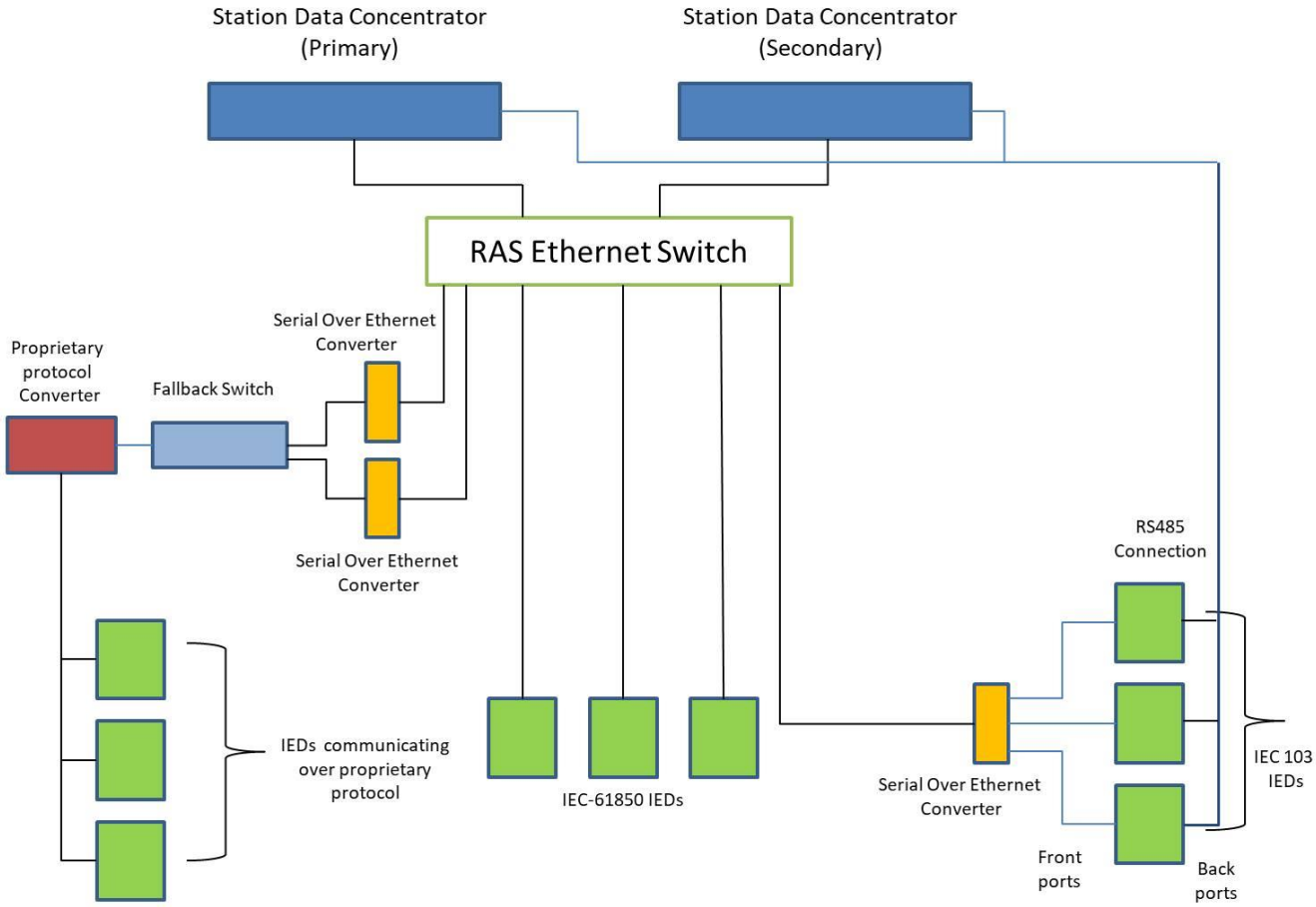

Figure 1 Connection diagram of different Protocol Relays at Substation

a) **SPA relays**

In SPA relays the IED's rear ports over fibre medium are looped together and connected to a SPA-ZC 22 protocol converter. The SPA Bus connection module provides a RS232 link as its output. This is connected to two Serial over Ethernet converters/Terminal Servers (TS) through a fallback switch for redundancy. Both DR collection and remote parameterization takes place through the rear port in SPA relays.

In normal communication, the SPA communication is active in the SDC for the DR collection. Whenever the Remote parameterization packet is reached in the designated TCP port, SDC will stop the SPA communication and forward the parameterization packet to the physical port that is connected to the SPA bus. Once the parameterization is completed SDC will switch back to the normal SPA communication.

As the collected DR is in proprietary format, the DR is converted to COMTRADE format in SDC and renamed to predefined file naming format.

b) IEC 103 Relays

In IEC 103 relays for DR collection, rear port of IEDs is looped together and connected directly to the RS-485 port of the both SDCs. Front port of IEDs is used for remote

parameterization. The front port of relay connected to Terminal server which is connected to SDC through Ethernet interface.

c) Courier Relay

For DR collection in courier relays, the rear port of the IEDs are looped together and the K-BUS loop is connected to a KITZ converter. The RS-232 output of KITZ converter is connected to a fallback switch for providing a redundant link to two Terminal Servers. The Terminal Servers are connected to SDCs over Ethernet interface for DR collection.
For remote parameterization, the front port of the IEDs is used, which are connected to SDC through Terminal servers.
For uncompressed DR generated by courier relays, the DR is stored in the SDC in COMTRADE format.
In case of compressed DR generated by courier relays, DR file is received in .areva format and same is converted to COMTRADE format with predefined file naming format in the RAS server.

d) SEL Protocol relays

For DR collection from SEL proprietary protocol relays, the rear port of the IEDs is connected to a fallback switch. The fallback switch provides a redundant link to the two Terminal Servers. The SDC fetches the DR data from SEL relays through the terminal servers. Front port of the relay connected to the SDC through Terminal server which is used for remote parameterization.

e) IEC 61850 Relays

In SAS based substations, the IEC61850 relays are connected to the substation ring network. In conventional substations common connection is established by connecting the IEC 61850 relays with RAS Ethernet switch. SDC fetches the DR from relays through Ethernet interface via IEC 61850 protocol. The remote parameterization also takes place through the same port.

iv. Unique & customised design of software & hardware

As no solution was readily available before the project, the software and hardware used were customised based on the specific requirement to integrate various make & model of relays. This also necessitated multiple patches to address the issues faced with the progress of the project. Web based access is given to client PCs present in geographically distributed control centres and substations for easy access of the DR collected from various relays of different substations. The relays and the substations are arranged hierarchically as per the organization structure for easy access of the desired relay among the vast number of relays integrated. Standardized naming convention is used for each DR collected for inter-operability with the other systems such as AFAS.

v. Issue of Non-Unique IP address relays across substations

The IP address of each IEC 61850 relay across substations may not be unique. To address this issue an external interface IP /NAT IP is used. When the remote access request is received from any working station through RAS Server, SDC will translate this unique NAT IP to the actual IP at the substation and pass on the data packet to the relay.

vi. DR Collection after connection loss

In case there is any telecom connectivity issue with a particular substation to control centre, the DRs triggered in the relays are still collected by SDC at the substation. These DR collected can be accessed at substation using a FTP browser. Once the connectivity with the Control centre is restored, the pending DR will be transferred to the server.
Similarly if any relay is temporarily disconnected from the SDC, the DR will be collected once the connection is restored.
This is achieved by maintaining a list of DR that are fetched from relay in the SDC and comparing with the total DR available in relays.

vii. Management of multiple versions of relay specific configuration tools

For remote access of relays, management of multiple versions of relay specific configuration tool is a major challenge faced during project implementation. As the vast number of relays which are installed over the years are diverse by make and model and also by version. This required installing large number of relay configuration tools in the PC. Some of these tools support older Operating Systems (OS) only.
Usage wise distributed software installation and virtualization of multiple OS in single machine has been done to achieve the requirement.

viii. Restriction of multiple access of a particular relay

As the nature of project, the implemented features are accessible from different control centres and substations at different locations. So it is necessary to restrict the access of a particular relay to a specific user at a time. This is achieved by maintaining the database entry for each relay access. Once the connectivity is established for remote parameterization, the relay cannot be accessed by any other user. Similarly user can access single relay at a time for remote parameterization.

ix. Partial configuration of relay communication port for data exchange on supported protocol

The IEDs present at conventional substations were originally not configured for Auto DR downloading. During project execution it was required for many relays port to be configured for data exchange on supported protocol. In some Substation Automation System (SAS) based substations, addition of RAS required to increase the number of clients as the existing limit was exhausted.

x. Health Monitoring of connected IEDs & Equipment

Ensuring the connectivity and healthiness of the relays and other RAS equipment is necessary to keep them ready for operation during faults and collection of DR to the control centre. The availability of devices i.e. SDC and terminal servers, and also the IEDs is monitored in RAS application using Simple Network Management Protocol (SNMP). If there is any device not reporting to RAS it can be easily identified from web portal and necessary action can be taken.

xi. Secure access of System

The traffic between RAS servers and clients is encrypted and sent over a secured Network to have secured connection between control centre and substations. To have secured transmission of the data from substations to control centre, firewalls are used at control centre. User access is restricted through password and different rights are assigned for different users. Only authorized persons can access the relay and audit trail is maintained with different activities performed by users for later verification.

xii. Analytics to assess the functionality of the system

Using the web portal along with downloading the DR and healthiness monitoring of relays, we can also have the statistical representation of the DR received such as number of DR received per hour or per day in a particular substation or a region. From these it can be easily identified if there is any frequent DR triggered in a particular relay because of contact chattering or other reasons and action can be taken to rectify the issue. Also readiness of the IED can be ensured by periodically triggering the DR and observing the DR collected. If no DR is received in the recent past issue may be with the physical connection, relay configuration or the healthiness of the relay.

Both the DR trigger time and received time can be viewed from the web portal, which is helpful in finding the issue with relay time synch.

xiii. Non-Uniformity in signal names

The signal naming is not automatically received in DR from relays of certain protocols. The number of signals and the sequence is not uniform across the relays. To overcome this issue, the signals are manually configured in Station Data Concentrator as per the sample DR collected from each relay.

3. FUTURE ENHANCEMENT:

For the enhancement of the system, blocking of the spurious DR triggered as a result of relay/field equipment contact chattering at the SDC level requires further fine tuning of the solution which is along with other new features is continuously being looked into for future development. These excess DR triggered caused burden on RAS and the subsequent AFAS system and results in memory consumption.

4. CONCLUSION:

The paper discussed about the POWERGRID experience in integration of different make and model of relays in Remote Accessibility System under NTAMC project. Various challenges faced during project execution are shared and the methods used to overcome them are discussed.

Overall RAS system helping the remote system operators to take quick decision in restoration of Power system elements and reduced the round the clock requirement of expert manpower at different substations.

BIBLIOGRAPHY

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