NOKIA

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Successful validation of reliable and secure IP/MPLS communications for current differential protection

Investigation Rationale

- Protection application communications require low and symmetrical delay, small jitter and high security
- TDM services and network support are being discontinued and therefore requires migration
- Growing frequency and sophistication of cyber security threats

IP/MPLS Benefits

- TDM services functionality along with the additional benefits of a packet-switched network
- Deterministic quality of service (QoS) and inherent security based on label-switched paths (LSPs)
- Improved bandwidth efficiency and flexibility
- Supports multiple potential services: teleprotection, PMU data, SCADA messaging, voice telephony, video surveillance, IEC 61850 standard as well as IT applications

Investigation Objectives

- Understand impact of playout buffer asymmetrical delay on current differential protection
- Validation of an asymmetrical delay compensation method
  - Asymmetrical Delay Control (ADC)
- Study delay impact of a MPLS encryption method – Network Group Encryption (NGE)

Validation Equipment

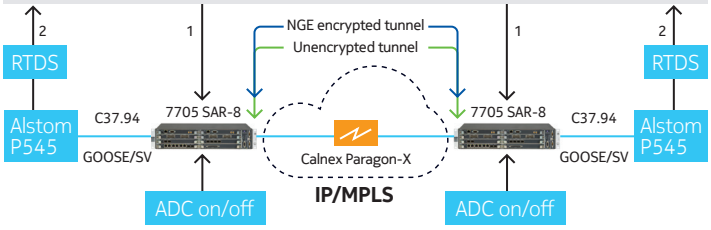
Nokia 7705 Service Aggregation Router (SAR), Alstom P545 relay, Real Time Digital Simulator (RTDS), Calnex Paragon-X

Test Configuration

- Through repeated initiation of TDM pseudowires, validate ADC's effectiveness in compensating for playout buffer asymmetrical delay
- Measure delay incurred with NGE

Automated script:

1. Toggle TDM pseudowire status (enable and disable)
2. Listening to RTDS GOOSE for trip or comms loss



Results

- Network jitter can cause protection relay false trips
- ADC completely neutralizes jitter's impact – zero false trips

MPLS settings			Jitter Gaussian distribution			Number of false trips	
Test	Packet size (bytes)	Buffer size (ms)	Fixed delay (ms)	Mean variable delay (ms)	Standard deviation (ms)	ADC off	ADC on
1	16	8	1.0	5.0	1.0	7 of 10	0 of 10
2	16	8	1.0	3.0	1.0	3 of 10	0 of 10
3	16	8	1.0	2.0	1.0	4 of 20	0 of 20
4	16	8	1.0	1.0	1.0	3 of 20	0 of 10
5	16	8	1.0	0.3	1.0	0 of 20	0 of 20
6	8	8	1.0	5.0	1.0	N/A	0 of 20
7	32	16	1.0	5.0	1.0	N/A	0 of 20
8	8	8	1.0	5.0	1.0	N/A	0 of 20
9	8	8	1.0	5.0	1.0	N/A	0 of 20
10	8	16	1.0	5.0	1.0	N/A	0 of 20

- NGE adds negligible end-to-end delay (20 µs)

	MPLS settings	Propagation delay (ms)	Typical trip time (ms)	Bandwidth required (Mb/s)
IEEE C37.94	No encryption	1.68	28.4	0.2-2.7
	With encryption	1.70	28.4	0.5-5.9
IEC 61850	No encryption	Not measured	24.9	~5.4
	With encrypton	Not measured	24.9	~5.4

Conclusions

P/MPLS network is fully qualified to transport encrypted safety-critical current differential protection communications.

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