

Successful Validation of Hitless Failover using Active/Active IP/MPLS Paths with Siemens Line Differential Protection

Validation motivations

- Protection application communications have strict requirements for network resilience, latency, jitter and delay symmetry
- TDM support is being discontinued in the industry
- Therefore, utilities are looking for network migration to IP/MPLS with high availability

IP/MPLS benefits

- TDM service functionality on-par with SONET/SDH
- IP/Ethernet services for IEC61850 and GOOSE/R-GOOSE-based grid applications
- Deterministic quality of service (QoS)
- Improved bandwidth efficiency and flexibility
- Support of synchronous Ethernet and IEEE1588v2
- Extensible to field area network with LTE/5G and satellite
- Service-readiness for IT and cloud applications such as IoT and CCTV

Validation objectives

- Can IP/MPLS provide hitless failover that keeps consistent delay and delay symmetry?
- Can IP/MPLS maintain low delay asymmetry for the forward and reverse paths of relay communications before and after the failover?

Validation equipment

- Siemens SIPROTEC 5 7SL87 line differential protection relays
- Nokia 7705 Service Aggregation Routers (SAR)
- 1 pulse per second (1pps) time source (used only to check asymmetry on the relays, not needed for relay operations)

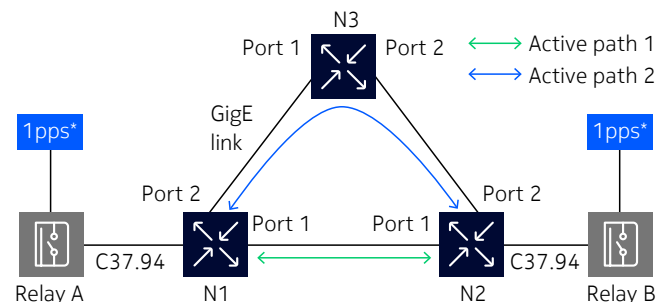
IP/MPLS services and protocol in use

- Services: Cpipe for circuit emulation
- Resiliency: Hitless active/active path failover to maintain delay and delay symmetry
- QoS: Asymmetric delay control (ADC) to ensure delay symmetry
- Control protocols: RSVP-TE, T-LDP and OSPF
- Synchronization: IEEE1588v2 PTP, synchronous Ethernet

Test network topology

- A 3-node 7705 SAR network with redundant paths
- Two Siemens 7SL87 Current Differential Protection Relays
- Relay interface: IEEE C37.94 with 8 timeslots

* 1PPS used only to check asymmetry on the relays, not needed for relay operation



Results

Test case	Pass requirement	Observation	Result
Normal operation	No C37.94 communication disruption	Delay: 2.039 ms, symmetric	PASS
Break link N1 – N2	No C37.94 communication disruption	Delay unchanged: 2.039 ms, symmetric	PASS
Restore link N1 – N2	No C37.94 communication disruption	Delay unchanged: 2.039 ms, symmetric	PASS
Break link N1 – N3	No C37.94 communication disruption	Delay unchanged: 2.039 ms, symmetric	PASS
Restore link N1 – N3	No C37.94 communication disruption	Delay unchanged: 2.039 ms, symmetric	PASS
Break links N1 – N2 N1 – N3	C37.94 communication stopped with both links broken	Communication stops	PASS
Restore links N1 – N2 N1 – N3	No C37.94 communication disruption	Communication resumes after both links restored Delay same as before: 2.039 ms, symmetric	PASS

Conclusions

With hitless active/active path failover and ADC, 7705 SAR provides hitless resiliency for safety-critical current differential protection communication over IP/MPLS.