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SLIDE ONE (Title slide)

The move from wires to datasets places a significant requirement on the choice of LAN architecture.
The physical architecture is one aspect whilst the virtual architecture is another.

Overall though we must consider the requirements from a protection point of view being to ensure absolute security and reliability of operation.

SLIDE TWO

In Australia, the National Electricity Rules sets out the fundamental principles of those protection requirements (although they do lead to some debate every now and then).

The NER was written in 2005 and is now at version 111, but the protection principles have not changed.

The NER first stipulates that there must be **protection redundancy**.

Although the NER was drafted before the advent of real time protection communication networks supporting GOOSE and Sampled Values, there was enough foresight (or luck) that it also states the redundancy requirement must also encompass **the communication system that supports the protection functionality**.

Arguably most protection engineers would have had a fear that reliance on a comms system is bound to cause failures just when we need it to operate.

Note that this does **NOT** state complete physically segregated duplication as the means of achieving that redundancy,
just that there must be AT LEAST two mechanisms such that at least one can operate under all circumstances of a single failure.

Wire based systems effectively had no option but to have complete physically segregated duplication.

However LAN based systems provide new possibilities that not only meet the requirements but significantly reduce the number of times the power system has one protection system not working, and that takes the pressure off staff rushing to site at “3 am in the morning” and potentially making mistakes because they have had little time to plan the rectification works.

This is therefore beyond just reliability.
It provides automatic RESILIENCE – how quickly are things able to be returned to a fully functioning state.

Early networks really only had RSTP ring networks to provide some form of "self-healing" of the LAN, but this could easily experience over 100 milliseconds of lost messages… several lifetimes for protection!!

However IEC 62439-3 introduced two so-called bumpless mechanisms as HSR and PRP that ensures GOOSE and Sampled Values will still be exchanged even if one part of the LAN fails – of course if the IED fails that upsets the entire X or Y system, but that is why we have X and Y IEDs that continue to operate independent of each other.

(As no doubt others will state, HSR rings use IEDs with two comms ports and has the advantage of not requiring external LAN switches. However this is offset by the fact that all IEDs in the loop must support the maximum data rate bandwith around the ring. As such there are "natural" and IED limits that may mean rings have to be limited to as low as 25 IEDs and interconnected by means of duplicated QUAD BOX. There are also concerns about islanding the X or Y protection if the sequence of X and Y around the ring is not very carefully implemented and maintained.)

PRP also uses IEDs with (at least) two comms ports.
Each port is connected to two independent physical LANs.

If we apply "simple duplication" philosophy, we would therefore have two X LANs and two Y LANs, needing four sets of switches to configure, four sets of cables to manage etc.

And to note that the physical segregation of the X and Y LANs creates all sorts of difficulties for SCADA/HMI operation, cross-signalling for Autoreclose, sequence of event records etc. sometimes reverting to wires to transfer signals X to Y or vice-versa

However we can optimise the PRP LANs to just require the two sets of LA switches and control message flow using VLANs.

SLIDE THREE

The total number of ports in the LANs is still the same as having four LANs, but we now have far more flexibility in how and where messages are routed.

Applying suitable VLAN policies still allows us to retain the independence of the X and Y systems in normal operation – critical for when maintenance and test activities are being planned in concert with a live operating system

SLIDE FOUR

If we now apply the Failure Mode Effects Analysis philosophies, we now see that failures of

the Fibre,
the Comms Modules
the Power Supplies and
even CPU of the LAN Switches

yields virtually no disruption to the correct operation of either the X or Y protection.

The comms system is no longer a basis of the X or Y system not operating

The only catastrophic failure is a failure of the X or Y IED itself … as it has always been the case with wire based systems.

SLIDE FIVE

The last thing to note is a comment in paper B5-203 about the compatibility of IEEE 1588 PTP clocks and RSTP rings based on the forwarding rules of some of the clock messages.

Rod Hughes has queried this with some of the IEEE 1588 Working Group who have provided some ad-hoc comments confirming that correct configuration of the switches would yield correct operation of PTP over RSTP