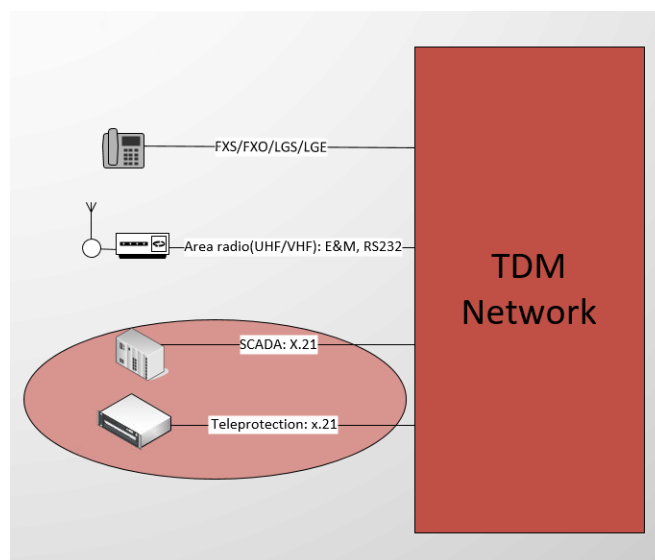


**Question 3.5:** As packet-switched networks are becoming increasingly adopted as the main technology for power utilities’ telecommunications networks, describe some challenges in preventing the adoption of a fully packet switched network for utilities.

In the context of this contribution, a pure network is viewed as a network which is based on packet, with all services transported natively as packet with no Time Division Multiplexing (TDM) emulation requirements. Migrating to such a network has several benefits for EPU which include:

- Reduced migration costs as the TDM emulation over packet is costly;
- Reduced power and space requirements (reduction in number of chassis) ;
- Reduction in a number of chassis will result in reduced maintenance costs;
- Reduced latencies, TDM emulation adds on the end-to-end network latencies;
- Simplified packet network configurations (e.g. no jitter buffer settings)
- Simplified network configurations mean reduced potential for errors;
- A network supported by any operator trained on packet networks with no need for scarce TDM skills, allowing the EPU to receive a centralised remote support from the OEM;
- EPU’s will not be prone to bugs which only affect a small niche of equipment users, with a high potential of not being detected because of less legacy services user base; and,
- Mitigation of complex faults with small user base and limited database of lessons learnt

As illustrated above, it is without doubt that adoption of pure packet network is beneficial to EPU’s. However, it is not an implementable approach for most of the utilities as the EPU networks are not green field but require integration with the existing legacy IEDs and systems. Figure1 below shows a combination of legacy interfaces deployed by Eskom, with the utility terminating not less that 200 X.21 circuits in the main control centres. These interfaces combined with IP interfaces push the number of chassis per site and must be catered for.



**Figure1: Deployed legacy interfaces**

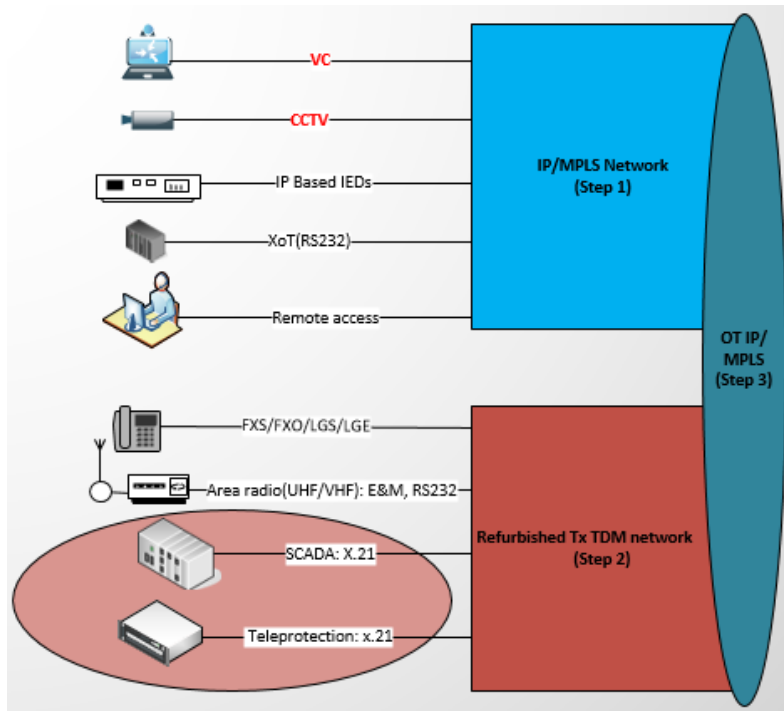
As an alternative to adopting a pure packet network, this contribution presents a staged approach adopted by Eskom which has a potential to take a brown field EPU to a pure packet network without compromising the power grid.

Eskom established a strategy to migrate all its OT services to an IP/MPLS network. The approach adopted by Eskom is rather a carefully phased approach to ensure that the integrity of the power grid is protected. The approach can be summarised in following steps:

- Step 1: Run an IP/MPLS network which hosts all other OT services excluding SCADA and teleprotection
- Step 2. Refurbish the Transmission TDM network which carries SCADA and teleprotection
- Step 3: Establish an OT IP/MPLS network to converge all OT services as the end state

Eskom currently has an IP/MPLS network which runs IP based OT services excluding SCADA and teleprotection, with a refreshed Transmission TDM network carrying SCADA and Teleprotection services. This phased approach has the following benefits:

- Step 1: This step gives the utility an opportunity to gain experience on the packet networks using the services with less stringent requirements. As part of this phase Eskom embarked on an ongoing process of training its staff on IP and enhancing cyber security skills in the business which is critical for support of a packet-based network. A special Work Group was established to identify all services which were historically provisioned on the TDM network but support IP, with a drive to migrate all these services to this network. This network offers the utility a platform to carefully pilot (limited scale) stringent OT services, with Eskom in the process of piloting SCADA on this network.
- Step 2: This step ensures that the Transmission SCADA and teleprotection services continue to be carried over an OEM supported TDM network with no abrupt changes on the legacy protocols and interfaces. This step offers the utility time to rigorously test critical SCADA and teleprotection services over packet. This phase offers the utility time to answer the question on whether SCADA and teleprotection migration to pure packet is possible, by piloting IP based SCADA and teleprotection protocols. Several questions which include decision on the protocol to be used and assessment of maturity of cyber security standards must be answered.
- Step 3: As illustrated in Figure 2 below, OT IP/MPLS presents the end state with all OT services converged to packet. Cutover of services is planned to be carefully phased, starting from the less stringent to the most stringent service. SCADA and tele-protection will first be piloted before a full cutover is done. At this stage the utility has the following cutover decisions to make which are informed by the pilot results:
  - Emulating TDM services over packet and lose the listed end-to-end packet network benefits;
  - Adopt a pure packet network with all services migrated to pure packet. Some utilities at this stage might consider using TDM to packet converters to keep the network pure packet but this must be done with care as these present additional point of failures on the network; and,
  - A hybrid approach e.g. an IED with one interface over packet and the other over TDM is another intermediate cutover step which can be considered. This step can offer protocol redundancy if for example one leg is IEC101 and the other is DNPoIP. This gives the business time to build confidence on packet networks.



**Figure2: Current parallel networks and the end-state**

In conclusion, a pure packet network is desirable when migrating the EPU TDM networks to packet however, because of the existing legacy-based services, Eskom has rather taken a phased approach. At the end the utility must decide to either emulate the TDM services over packet, move only IP services to packet resulting in a pure packet network or a hybrid approach. The phased approach gives all the stake holders an opportunity to learn and build confidence on packet networks based on results and experience. Eskom ensured that its requirements specifications and the already performed lab tests which proved packet networks to be suitable for SCADA and teleprotection cater for the TDM emulation worst case.