design of control networks for China initiative accelerator driven system

Zhiyong He, Yuxi Luo, Yuhui Guo, Qiang Zhao, Wenjuan Cui, Yichuan He
Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China

Abstract

Six networks have been planned for the control systems used in China initiative accelerator driven sub-critical (ADS) system. To improve the network reliability, redundant Ethernet based on Ethernet ring protection (ERP) have been considered. ERP protocol provides protection for Ethernet traffic in a ring topology, while ensuring that no loops are within the ring. Finally, the Ethernet ring topology has been optimized by comparing the reliabilities of various rings.

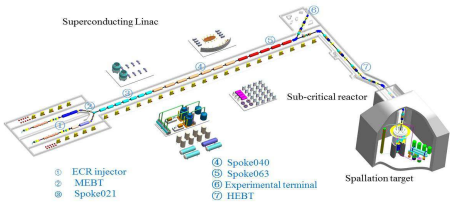

Fig. 1 China ADS facility

I China ADS system includes:

- **A Linac proton accelerator**

It includes two injectors and a main accelerator, with an energy of 250 MeV and a beam current of 10mA.

- **A spallation target**

A solid tungsten target with granular flow method will be used.

- **A sub-critical reactor.**

with a power level of 10 MW and an incore flux of 2×10^{14} *neutron* /cm^2/*s*.

II Control networks include:

- **A central operation network**

It is used for the operation of accelerator, target, and reactor. Reliable redundant Ethernet with Ethernet ring protection protocol is considered.

- **A reactor protection network**

It is used for the reactor safety and protection system. Both redundant Ethernet and wired line are planned.

- **A machine protection network**

An emergency shutdown of the accelerator will result in the shutdown of the reactor. The protection functions in MPS will be defined and designed very carefully in advance.

- **A personnel protection network**
- **A data archiving network**
- **A time communication network.**

III Ethernet ring protection:

- **Ethernet ring protection (ERP)**

ERP builds a logical ring topology while maintaining a loop-free forwarding mechanism by logically blocking a link port in the ring, referred to as ring protection link (RPL).

- **For example (Fig. 2):**

First, to block a link in the ring, e.g. the dashed line in Fig. 2. If a link fails, e.g. the link from switch 2 to 3, unblock the blocked line. Then, to recover the link from switch 2 to 3 and block it.

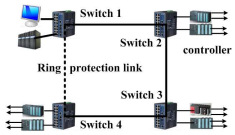

Fig. 2 Ethernet ring protection

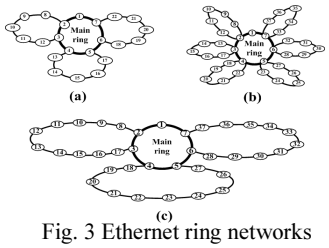

Fig. 3 Ethernet ring networks

IV Reliability of ERP network:

- **Simulation procedure:**
  - the random sampling is used to determine whether the *i*-th link fail.
  - Ethernet ring protection fail, if two or more links fail in a ring.
- **The reliability can be improved**
  - either by decrease the number of switches in each ring (Fig. 4 left);
  - or by increasing the number of rings (Fig. 4 right).

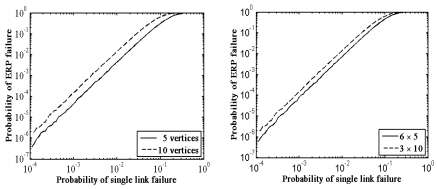

Fig. 4 Left: Reliability for the topologies in Fig. 3(a) and (c) are compared. 5 or 10 means the number of switches in a ring.

Fig. 4 Right: Reliability for the topologies in Fig. 3(b) and (c) are compared. 3X10 means three subrings and 10 switches in each subring.