Reliability Study for Protection Function in Process Bus based Substation considering various Network Structure

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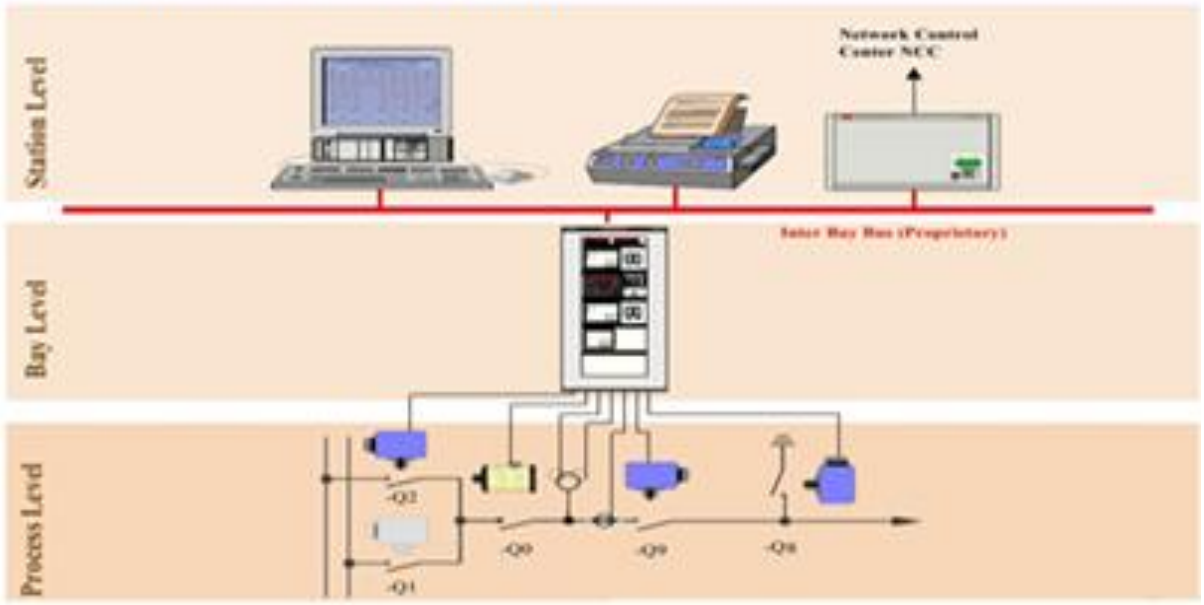
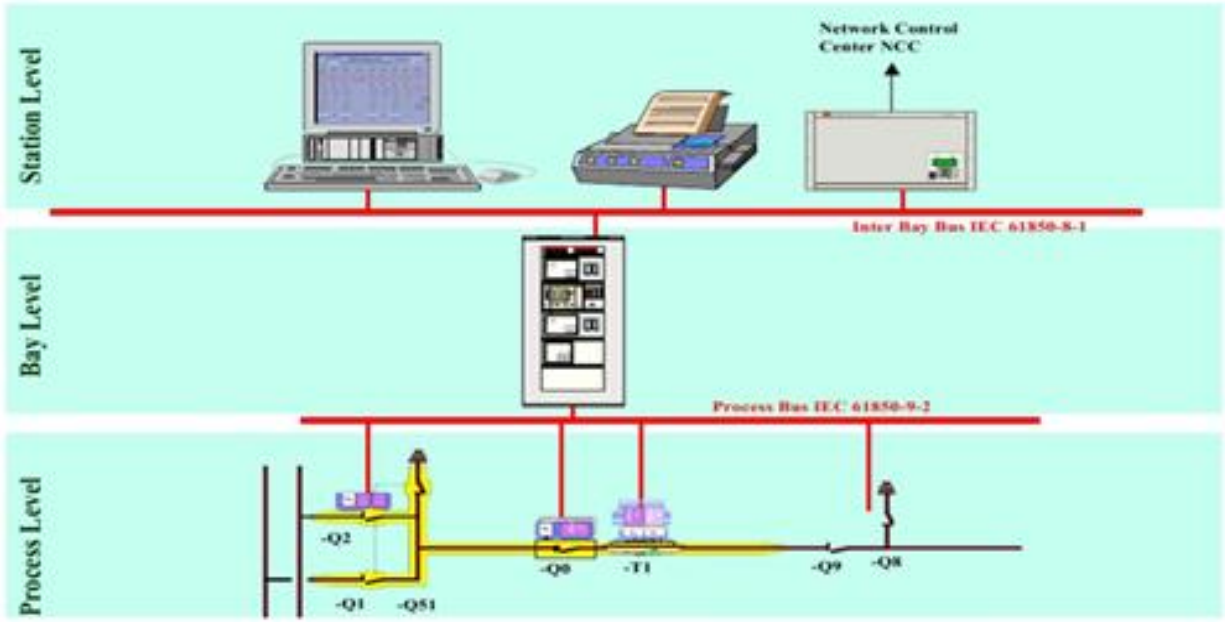
- ➢ Digital Substation .

Modern Substation Structure



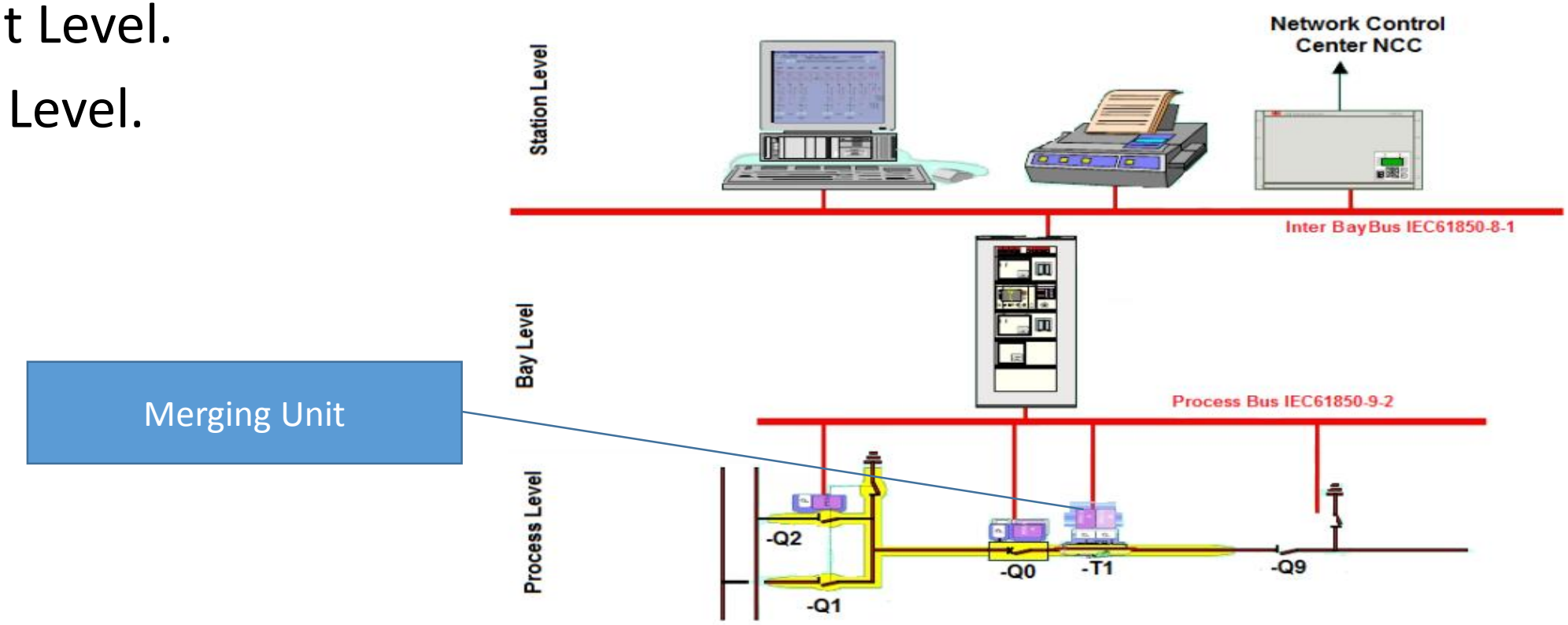
Process Bus Based Substation (Digital Substation)



Introduction:

Structure of the process bus :

- Substation Level.
- Bay/Unit Level.
- Process Level.

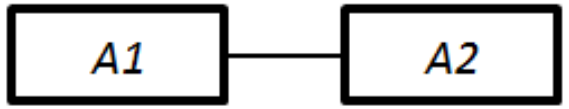


❑ Why the Study was carried out?

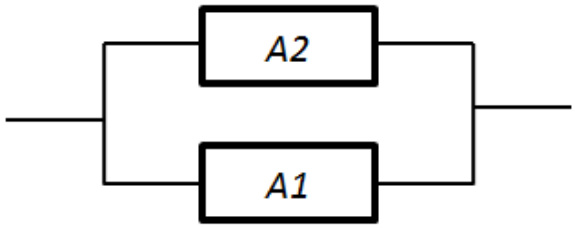
- Strong trend towards Fully Digitalized substation .
- No Specific Network Structure nor demand for redundancy in IEC61850.
- Reliability besides Availability are Dominating considerations in the current and future substation design.
- Studying of the Protection function Reliability in Digital Substation.

❑ What is the Methodology?

➢ Reliability Block Diagram (RBD).



$$A_{Series} = A1 \,.\, A2$$



$$A_{Parallel} = A1 + A2 - A1 \,.\, A2$$

The parameters that been measured to represent the reliability of a general system would be:

- ***MTTF*** is Mean Time To Failure.
- ***MTTR*** is Mean Time Between Failure.
- **A** is Availability

$$\mathrm{A} = \frac{MTTF}{MTTF + MTTR}$$

❑ What is the Methodology?

➢ Based on the Above Calculation and Assumptions the result will be as following per Each Equipment(**MTTR** = 8 Hr. (Assumption):

Component	MTTF/y	Availability
Protection IED (P.IED)	150	0.999993911757006
Control IED (C.IED)	150	0.999993911757006
Merging Unit (MU)	150	0.999993911757006
Ethernet Switch(ES)	50	0.999981735493416
(CT/VT)	150	0.999993911757006

What is the Case Study?

- Investigating the reliability and availability of the System Under the operation of breaker failure protection (BFP) function based on different configurations for the T1-1 (Single Bus) small transmission substation.

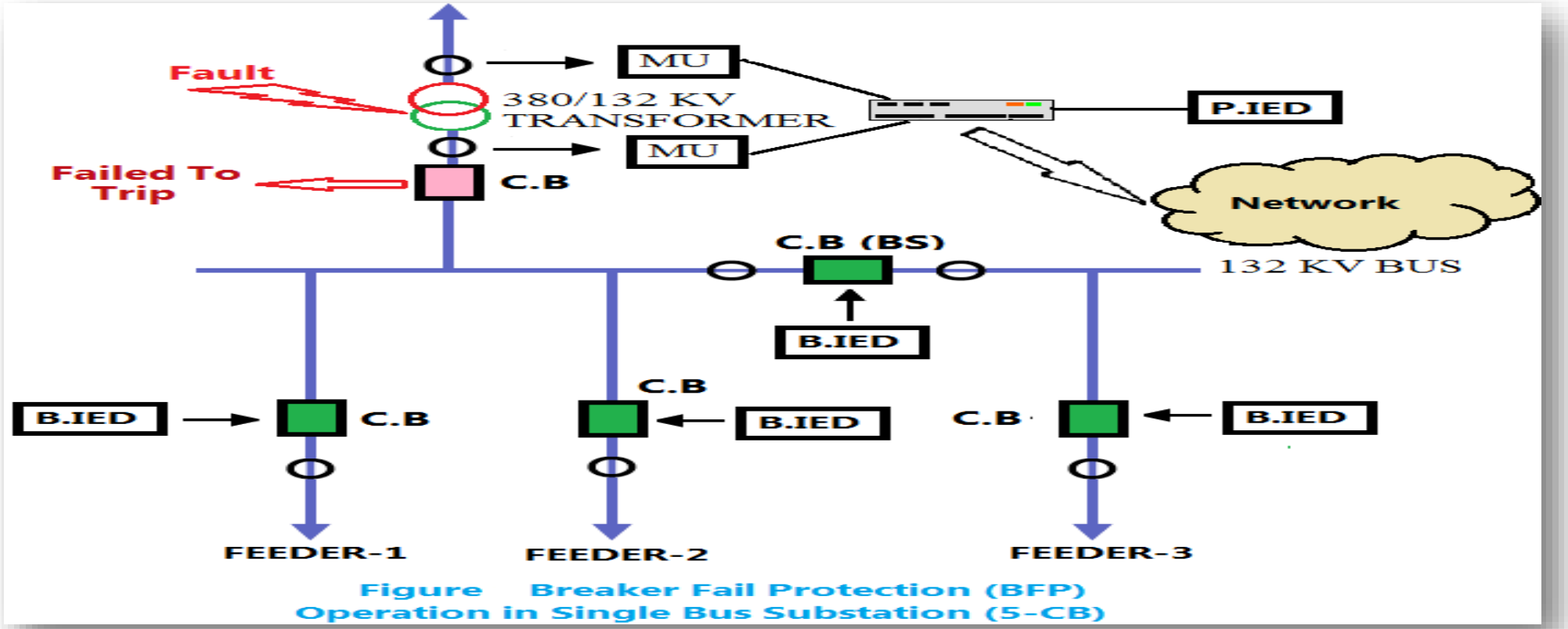


Figure Breaker Fail Protection (BFP) Operation in Single Bus Substation (5-CB)

What is the Case Study?

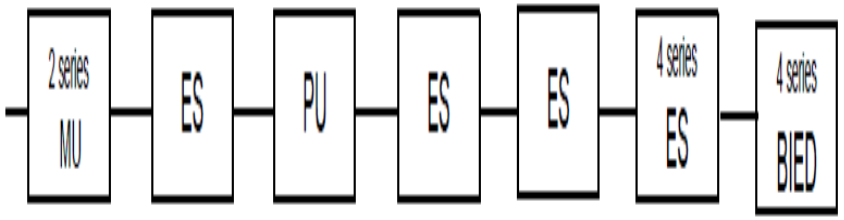
The impact of the different configurations and redundant network on the reliability and availability has been Investigated for:

- *Cascaded architected.*
- *Ring architecture.*
- *Star ring architecture.*
- *Redundant ring architecture.*

What is the Case Study?

- ***Firstly, Cascaded architected***

Figure 1 Cascaded Structure.



The reliability and the availability values for the cascaded system as follows:

MTTF= 5.357142857142857 y ***A=*** 0.99982954398491 1

What is the Case Study?

- ***Secondly, ring architecture***

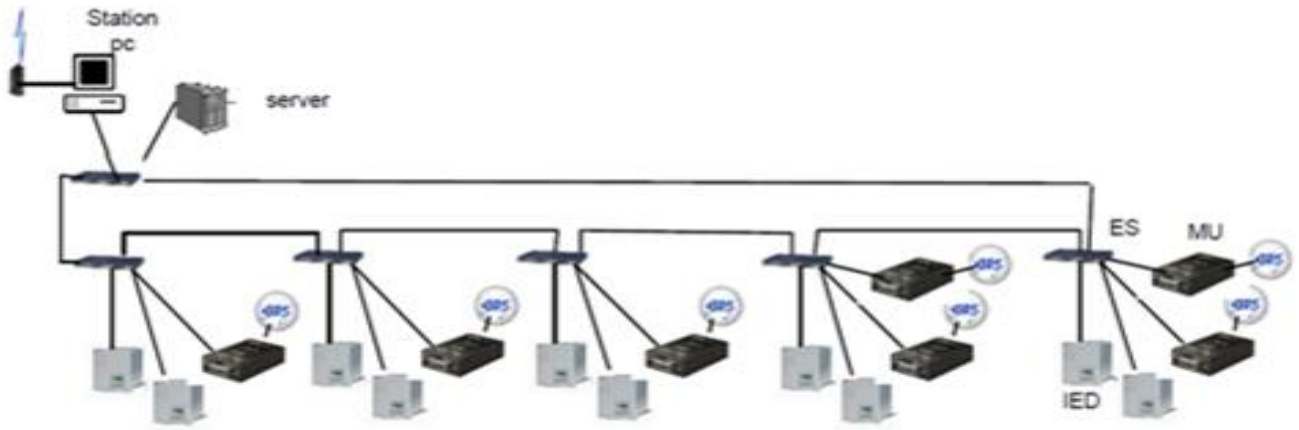
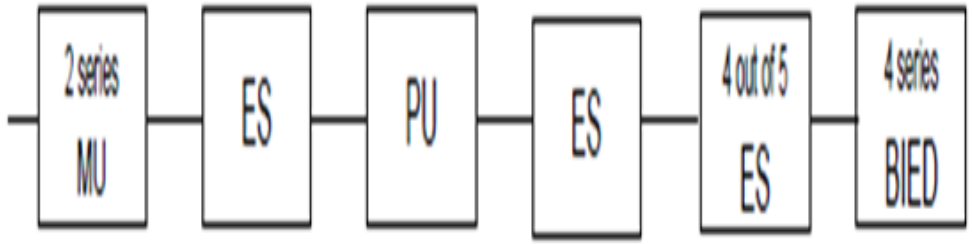


Figure 2 Ring Structure



The reliability and the availability values for the ring architecture system as follows:

MTTF=7.62711864406779y A= 0.999920852619063

What is the Case Study?

- ***Thirdly, star ring architecture***

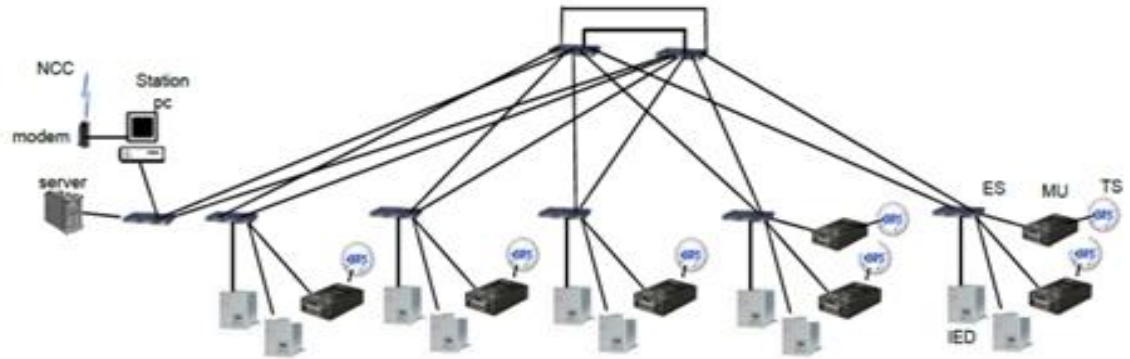
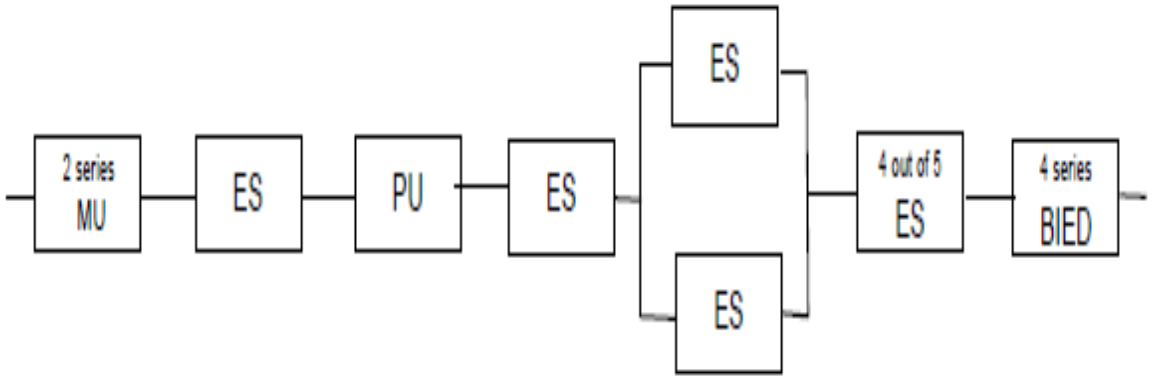


Figure 3 Star Ring Structure



The reliability and the availability values for the star ring architecture as follows: **MTTF=** 6.923076923076923 y **A=** 0.999920852285497

What is the Case Study?

Last, redundant ring architecture:

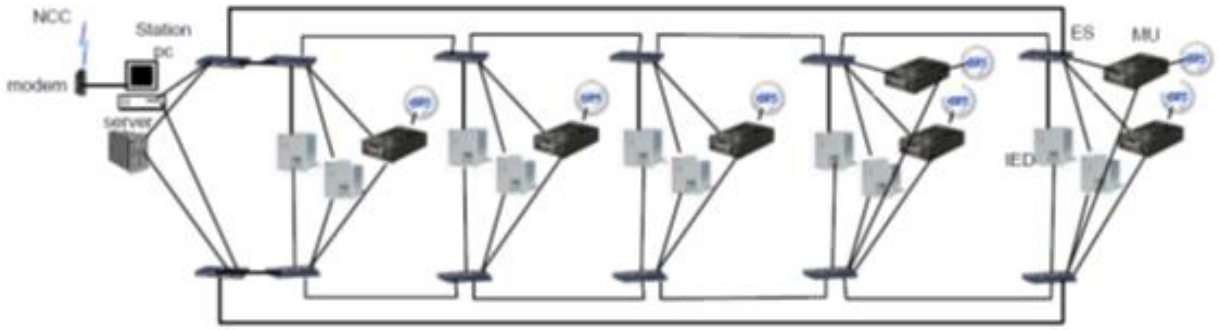
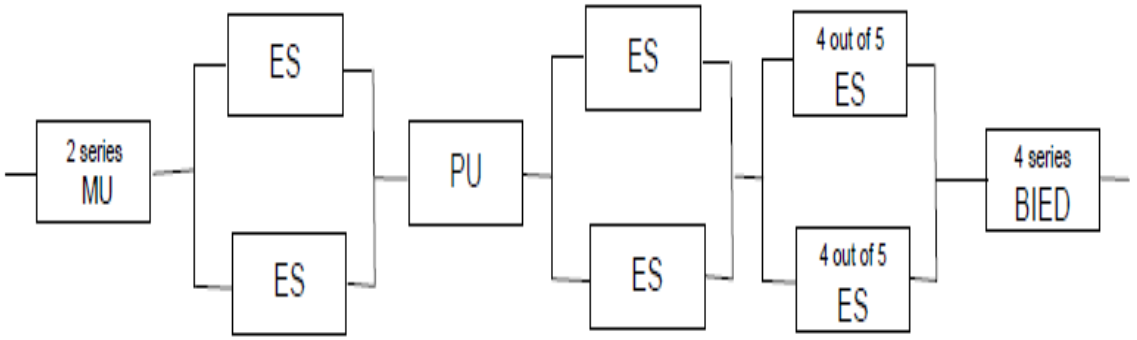


Figure 4 Redundant Ring Structure



The reliability and the availability values for the redundant ring architecture as follows :

MTTF= 9.712230215827336 y **A=** 0.999957382410279

What are the Results?

- From the four practical architectures Chart 1 presents the summary of our investigation (MTTF, availability) values.

	Cascaded	Ring	Star-ring	Redundant-ring
MTTF (years)	5.357142857	7.627118644	6.923076923	9.712230216
Availability	0.999829544	0.999920853	0.999920852	0.999957382

❑ Conclusion:

- According to the values of the MTTF and availability in Chart 1 we observed that the cascaded architecture provides the least values since it has non-redundant Ethernet switches. The advantages that can be achieved by this configuration are less expensive and simple configuration.

- In case of comparing the Ring architecture values with the cascaded we can see that there is improvement in the reliability and availability values.

- In case of the ring-star there is improvement compared with the cascaded architecture.

❑ Conclusion:

- Finally, redundant ring it provides the higher values in which that increased the reliability compared with the cascaded by 4.3551 y and the availability by 1.2783842536800 98e-004

- Introducing redundancy in the Ethernet network has greater impact on improving system reliability and availability. However, on the other hand it increases system complexity and cost. Therefore, it needs more practical and careful based on its implementation.

THANK YOU

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