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MODELING THE LIGHTING SYSTEM OF THE NANTERRE 3 SMART BUILDING

Anas HOSSINI
LINEACT CESI
Paris Saclay University
Nanterre, France
ahossini@cesi.fr

Leïla KLOUL
DAVID Laboratory
Paris Saclay University
Versailles, France
leïla.kloul@uvsq.fr

Maël GUIRAUD
LINEACT CESI
Paris Saclay University
Nanterre, France
mguiraud@cesi.fr

Benjamin COHEN BOULAKIA
EFREI research Lab
Paris Saclay University
Vilejuif, France
benjamin.cohen-boulakia@efrei.fr

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ABSTRACT

A smart building is an intelligent structure equipped with advanced technologies that enable optimized management of its infrastructures, such as energy, lighting, security, and IT networks, through the integration of automated and interconnected systems. These buildings represent a system of systems with complex interactions, where the failure of one system can impact other interconnected systems. In this paper, we present a modeling of the IT, Network, and Lighting systems of the smart building using fault trees. We also introduce a new type of event called a connection event to model the interactions between these systems. These connection events illustrate how a failure in one system can trigger a cascade of effects in other interconnected systems, thereby enhancing our understanding and ability to manage these complex interactions in smart buildings.

1 Introduction

The Nanterre 3 (NR3) Smart Building is a two-storey structure affiliated with CESI-Nanterre, an Engineering School in Paris, France [1]. This smart building features an *electrical room* housing the centralized electrical system, a *server room* centralizing the computer system, four multipurpose rooms, and one office. Each room has a lighting system and an HVAC (Heating, Ventilation, and Air Conditioning) system. Both systems consist of physical and logical components, incorporating multiple sensors capable of interacting with each other and with sensors in different rooms.

2 Modeling the Smart Building Systems

The Fault Tree Analysis (FTA) is a method that uses a tree structure to represent the basic events (causes of failures) and their combinations leading to the occurrence of a dreaded event, namely the failure of the whole system. The combinations of the basic events are realized using logic gates. The advantage of this approach lies in its ability to quantify the probability of the undesirable event. Additionally, it aids in identifying the critical paths- the shortest routes- that lead to the event's occurrence.

In the following, we model each system of the smart building by a fault tree.

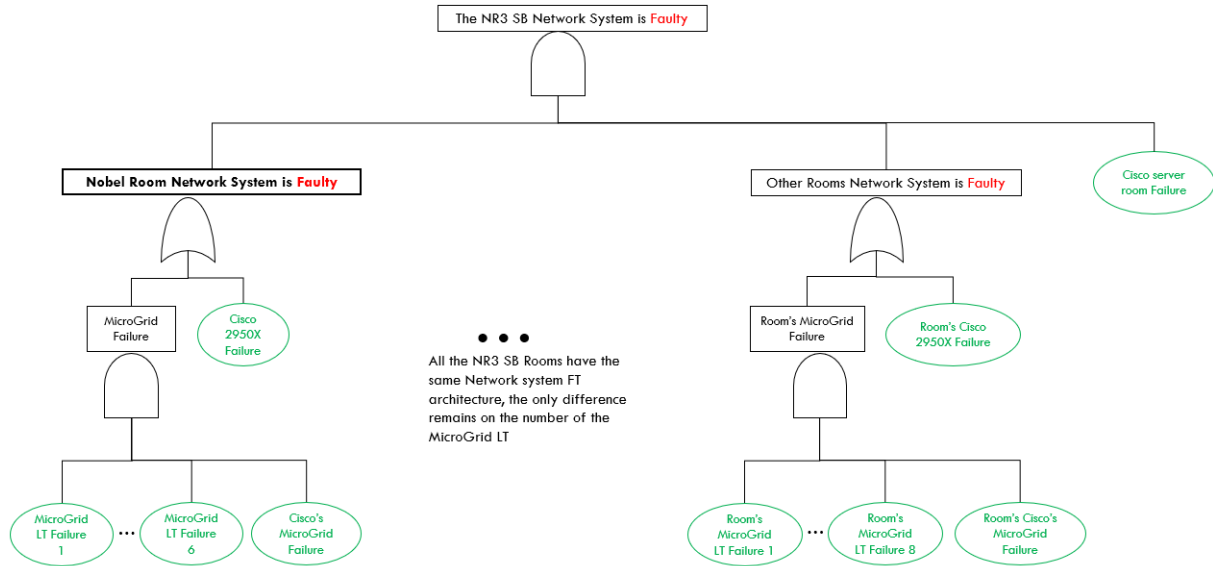


Figure 1: Network System Fault Tree representation

2.1 The Network System

The fault tree of the NR3 SB network system is shown in Figure 1. In this Fault Tree, the SB Network System fails due to the failure of all the room's network systems and the Cisco switch of the server room.

2.1.1 IT System Fault Tree

The fault tree of the NR3 SB network system is shown in Figure 2 The connection event *Cisco server room failure*, shown in green, represents the failure of this component within the network system, which directly causes the failure of the IT system. The basic events depicted in blue indicate the failure of IT system components.

2.1.2 Lighting System Fault Tree

The fault tree of the Nobel room lighting system is shown in Figure 3.

The events in bold represent the failures that directly induce the failure of the whole lighting system of the room and are obtained by applying the Minimum Cut Set (MCS) method.

In this FT, the dreaded event is the lighting system does not work (the bulbs do not light up) and it can be due to one of the following failures:

- The failure of all the bulbs in the room.
- The failure of all the IR and Lux sensors.
- The failure of the Internal switch (Cisco 3650CX).
- The failure of the Floor switch (Cisco 2950X).
- The failure of all the Microgrids LT.
- The failure of the Cisco's Microgrid.
- The failure of the IT system.
- The failure of the VM lighting

References

- [1] Anas Hossini, Leïla Kloul, and Benjamin Cohen Boulakia. Fault prediction in a smart building lighting system. *European Safety and Reliability Conference (ESREL)*, 2023.

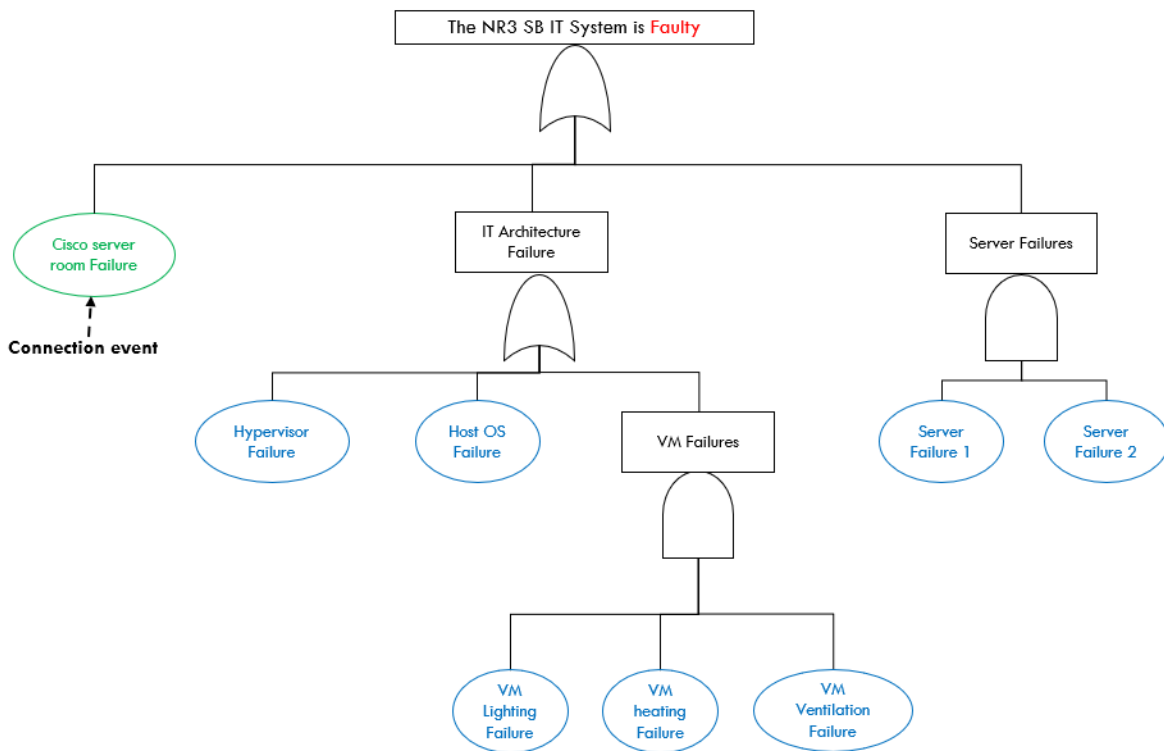


Figure 2: IT System Fault Tree representation

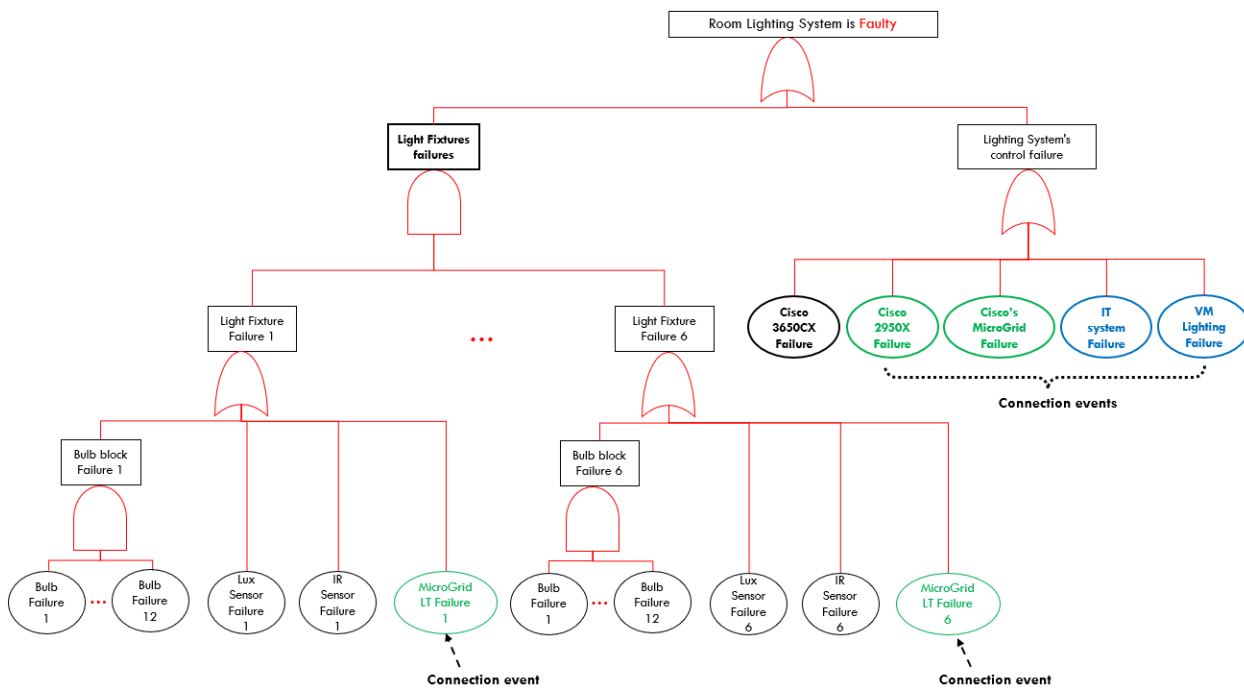


Figure 3: Nobel Room Lighting System Fault Tree representation.