Model Testing Of Reactor Protection System Software Of Nuclear Power Plant

Hima Sagar Janagama
National Institute Of Technology
Surathkal , Mangaluru
Karnataka, India

Sai Krishna
National Institute Of Technology
Surathkal , Mangaluru
Karnataka, India

shwetha jayaprakash m
National Institute Of Technology
Surathkal , Mangaluru
Karnataka, India

Manikesh
National Institute Of Technology
Surathkal , Mangaluru
Karnataka, India

***Abstract*—In nuclear power plant (NPP) there will be a safety software and depending on its work and effectiveness, the nuclear power plant runs without any danger of disaster. An effective method to test the system with software plays an important role to ensure the safe operation of NPP. In this paper, a digital control system software test strategy based on real platform is proposed. In this paper we are taking RPS as our subject to test and our method checks the system function and software logic path characteristics and then it identifies the system state by threshold boundary analyzing, and designs a test method based on the random combination of logical combination paths and parameter value intervals, and builds a real platform test environment. this paper have considered few parameters like pressure of water, pressure of air as well as the temperature of the system. The test results show that the test strategy has significantly improved the coverage of paths and parameters.**

I. Introduction

A reactor Protection System (RPS) is a bunch of Nuclear safety and security parts in a thermal energy station designed to securely shut down the reactor and forestall the delivery of radioactive materials. The framework can trip automatically(initiating a hightail it), or it tends to be stumbled by the operators. Trips happens when the boundaries meet or surpass the limit setpoint. An excursion of the RPS brings about full addition (by gravity in compressed water reactors or high velocity infusion in boiling water reactors) of all control bars and closure of the reactor. The basic advanced innovation is a product in atomic powerplant and this product controls the thermal energy station. since this programming controls the NPP, glitch of the software can cause a hazardous debacle. Not just it controls the NPP, it has likewise a roundabout association with the yeild of the NPP. So testing that product is ought to be the primary concern while preparing the model.

II. Literature review

In this study, we use RPS as example. A reactor protection system (RPS) is a bunch of atomic wellbeing and security parts in a thermal energy station intended to securely close down the reactor and forestall the arrival of radioactive materials. The framework can ”trip” naturally (starting a hightail it), or it tends to be stumbled by the administrators. Excursions happens when the boundaries meet or surpass the breaking point setpoint. An excursion of the RPS brings about full addition (by gravity in compressed water reactors or rapid infusion in bubbling water reactors) of all control poles and closure of the reactor RPS is the most basic control framework in thermal energy station that creates security signals for gear in as indicated by the variety of functional boundaries to keeps the reactor from surpassing the predefined wellbeing limit, or relieve the harm by driving the reactor crisis trip (RT) and designing security highlights (ESF) [5]. Accordingly, for advanced RPS, the product is required an adequate test to guarantee the protected activity of thermal energy station. The RPS control instrument has the accompanying attributes:

• various activity types: including Normal, RT, ESF;

• various securities: at least one defensive activities, or no insurance activity;

• various trigger conditions: one security activity could be come about by more than one sort of trigger conditions, while one conditions could trigger more than one assurances. for instance, the LOW pressurizer tension can trigger RTB and wellbeing infusion autonomously, and the LOW coolant siphon speed with LOW coolant temperature will trigger feed water separation, and so on;

A. Pressurized Water Reactors

A portion of the deliberate boundaries for US compressed water plants would include:

• ”High power”, auctioneered between high atomic force and high differential temperature (delta T) between the channel and outlet of the reactor vessel (a proportion of the nuclear energy for a given RCS flowrate).

• ”High fire up rate” (dynamic under 10-4 percent power) at low force levels.

• ”High pressurizer pressure”

• ”Low reactor coolant stream”

• ”Thermal edge/low strain” (reactor power versus RCS pressure)

• ”High control pressure”
• ”Low steam generator level”
• ”Low steam generator pressure”
• ”Loss of burden” (principle turbine trip)

Every boundary is estimated by free channels to such an extent that activation of any two directs would bring about a programmed SCRAM or reactor closure. The framework likewise permits manual incitation by the administrator.

III. Methodology

A. Test Case Generation

This test depends on control capacities. In the first place, framework examination is performed to characterize the control elements of the objective framework, and afterward the center rationale trademark is the edge correlation of the control framework, and the edge limit of each control work is dissected. As per the edge limit and worth reach Design a bunch of experiments for this insurance work. • Target work examination: A gathering of data sources triggers a gathering of yields to characterize an objective capacity; • Threshold limit investigation: Find the limit set off by the objective insurance capacity, and gap the boundary esteem range into ordinary express (no security activities set off) and Protection state (assurance activities set off); • Test case plan: As show in Fig. 2. it is expected that the instrumentation range is from V0 to V1, VT is the edge, when the info esteem from V0 to VT, the control framework is working in typical state, else whenever input the information esteem from VT to V1, the control framework is working in assurance state. It is intended to take a worth in the ordinary state range as the contribution of the main experiment, and take a worth in the security state range as the contribution of the subsequent experiment. Perform experiment 1 and experiment 2 consecutively as a bunch of experiments for the insurance work test as one test.

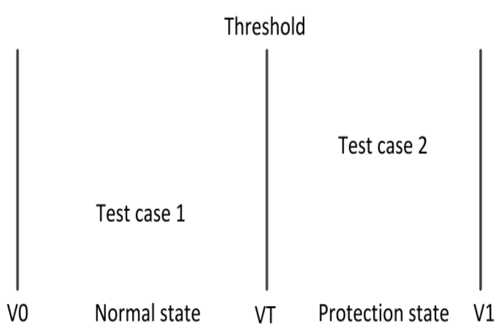

Fig. 1. Test case design

To guarantee the autonomy between each set of experiments, and not influence the testing of the last arrangement of insurance works, the framework should be reset after each set of experiments. Reset plan: • Set reset default esteems: the default upsides of all boundaries are inside the span that doesn’t trigger the security activity • Parameter esteem reset: reestablish all boundaries to their default esteems after the fruition of the past assurance work test • Logic reset: reset a few rationales, for example, RS goes back and forth, by planning manual activity esteems in experiments

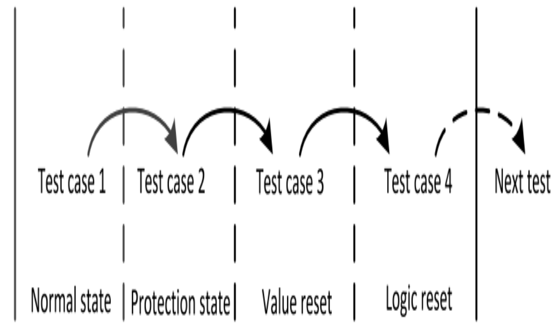

Fig. 2. Test-Cycle

Develop an algorithm with the goal that the way and boundary upsides of each test are haphazardly chosen. thusly, the arbitrary quality of securities set off in real thermal energy station activity can be tried.

B. Automation Test

The method of test cases generation and the random of path selection has been developed in the test platform, users could configure the test strategy and the test time of duration in test platform. By this design, logic path will be automation selected randomly, and the test cases will be automation generated in the designed cycle.

C. Test Software

this paper is using UPPAAL which is used for verification of the real time system and in this tool we can simulate and verify the model using queries to test both the best path and required state. In UPPAAL it is possible to specify invariant and to do reach-ability analyse the reach-ability analysis can be done with both reach-ability like forward and backward and both can make use of BFS and DFS the main purpose of the using this tool is to check both safety and bounded livenes this system or tool is mostly used for system that required communication and timing.

IV. Modelling

A. modeling of gas pressure

Gas pressure has two states, on is normal and another one is protected. please see figure number 3.

B. modelling of water pressure

water pressure has two states, on is normal and another one is protected. please see figure number 4.

C. modelling of controller

this recieves signals from all the sensors and decide to maintain the state of the system, i.e, either to run normal, protection mode or trip mode. please check figure number5.

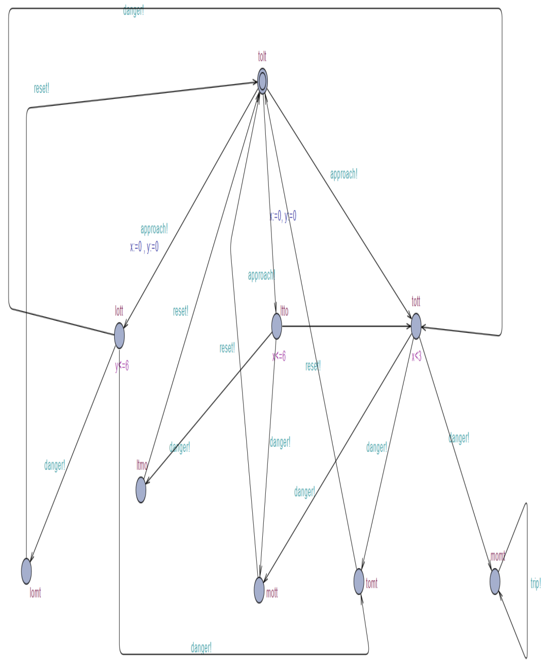

Fig. 3. modelling of gases

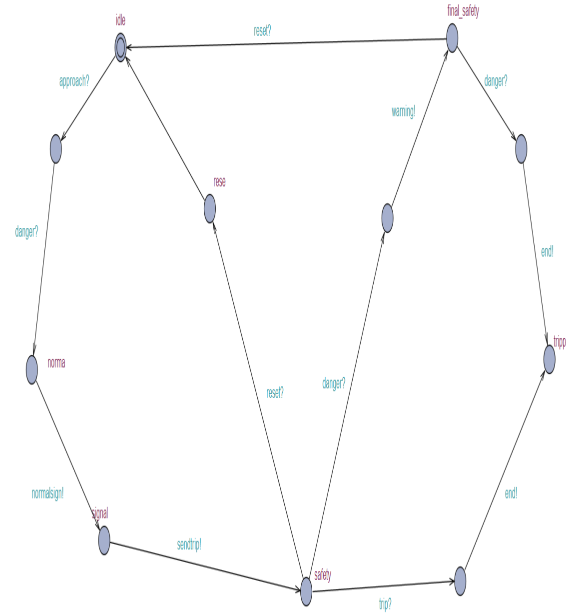

Fig. 4. modeling of controller

V. Results

this model checks all the possibilities of test cases, and detected states with accuracy and please check figure number 6.

VI. Conclusion

Through this projects we are able to do modeling of the nuclear power plant with the help of timed automata, and we are able to simulate it with UPPAAL tool, so that we can verify its properties in order to get the desired outputs to the nuclear power plants RPS according to the requirements specified. Timed automate are used here to model each part of the system,they are checked and verified initially, then combined together to check them as a whole system.Timed automate gives a help full method to verify the main required properties of the system with the help of simulation tools like UPPAAL.

VII. Acknowledgements

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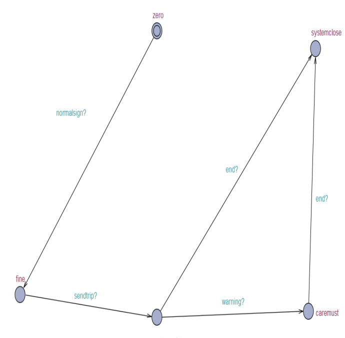

Fig. 5. modeling of water pressure

VIII. references

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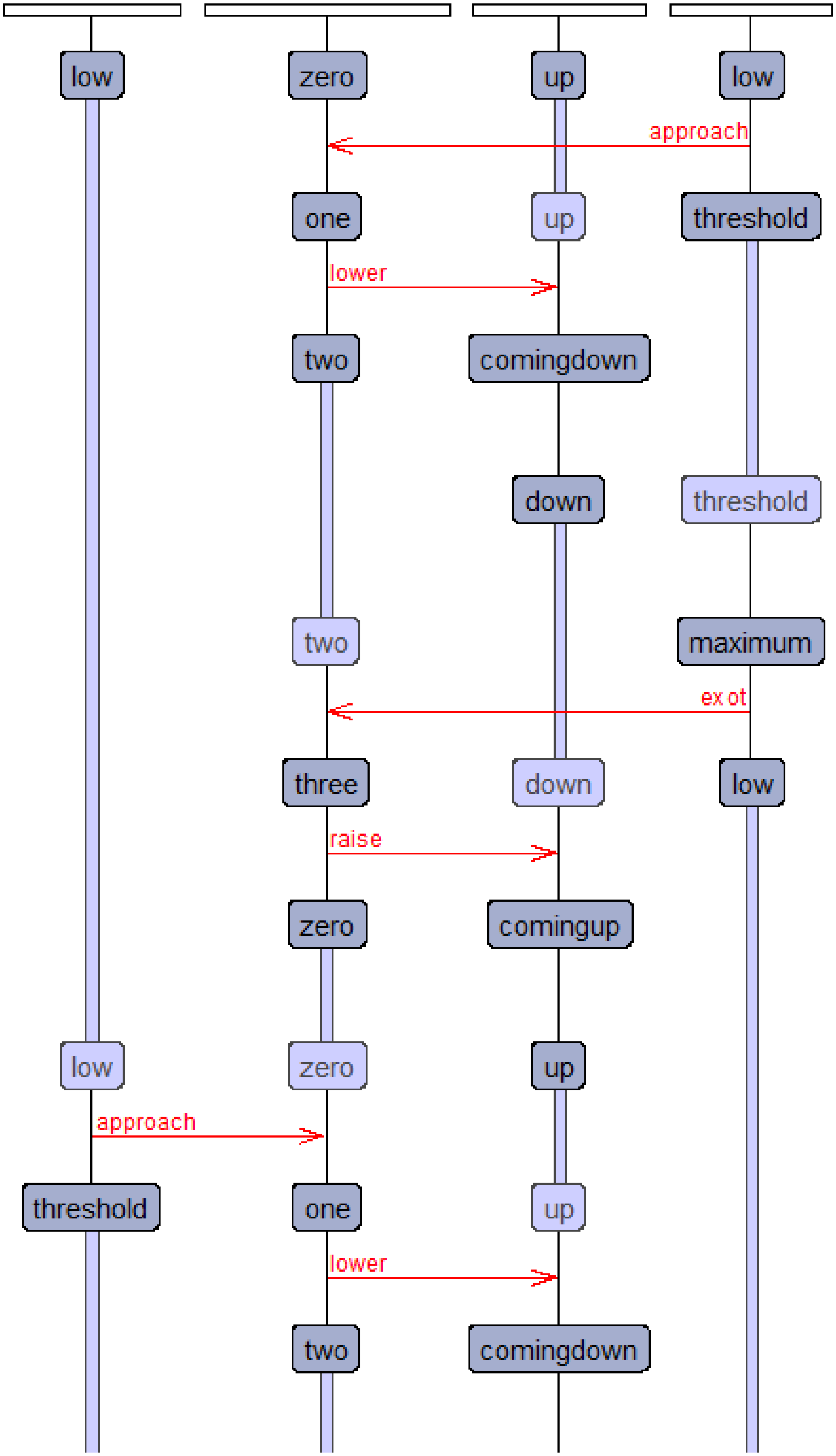

Fig. 6. simulated image of the model