NTT Press Releases

(Press Release)

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Nippon Telegraph and Telephone Corporation
National University Corporation Hokkaido University

Technology to prevent information and communications equipment trouble from cosmic rays

~Efficient soft error testing technology using a compact accelerator-driven neutron source~

Nippon Telegraph and Telephone Corporation (Headquarters: Chiyoda-ku, Tokyo, President & CEO Hiroo Unoura, NTT hereinafter) jointly with National University Corporation Hokkaido University (Sapporo city, Hokkaido, President Hiroshi Saeki, Hokkaido University hereinafter) has performed simulations of core network equipment trouble (soft errors[*1]) caused by cosmic rays (neutrons), errors which are predicted to increase in future, using Hokkaido University's compact accelerator-driven neutron source[*2], and has established testing technology that makes it possible to mitigate problems before they occur. Core network equipment is critical equipment used for Internet and telephone lines.
Because soft errors are a serious concern with high-function, high-performance core network equipment, not only does this technology enable failure rates to be predicted prior to actual use, but also enables efficient checking of error detection and operational countermeasures since error events can be expected, thus furthering improvements to reliability.
Furthermore, the high usefulness of compact accelerator-driven neutron sources has been reaffirmed through this research and development, and thus has promise for application across wider areas in future.

1. Background

Highly integrated and miniaturized semiconductor devices are required to meet the strong demands for smaller, more energy-efficient high-function, high-performance information and communications equipment. However, with these high levels of semiconductor integration, measures to cope with soft errors caused by neutron radiation originating from cosmic rays or alpha rays emitted from material impurities are issues facing the entire industry (Figure 1).
Until now, it has been possible to correct errors down to 1 bit with error correction functions such as ECC[*3], enabling malfunctions due to soft errors to be avoided. However, as semiconductor devices have become more miniaturized, they have become more susceptible to errors occurring with 2 bits or more. Thus, it has been predicted that prevention of malfunctions due to soft errors with conventional ECC will become problematic, and there are substantial costs expected with developing and implementing error correction functions that can deal with 2 or more bits.
Core network equipment must be able to process failures by detecting errors and switching over to backup systems so that communication services can be continued when these sorts of malfunctions occur.
NTT Network Service Systems Laboratories (NTT Labs hereinafter) has been involved in approaches such as desktop simulations of performance when an assumed-from-design malfunction occurs due to a soft error that cannot be corrected, and which are predicted to become more common in future. However, because the equipment at NTT labs is not capable of causing errors at the bit level, it has not been possible to experimentally verify failure processing for these types of malfunctions. To cause soft errors in this way, it's necessary to use a specialized neutron irradiation device, but it has been believed conventionally experimentation and verification has required a large-scale accelerator-driven neutron source in at least 100kW class.
Countering this situation, NTT labs predicted that it would eventually become possible to cause soft errors using a compact accelerator-driven neutron source due to the increased soft error rate accompanying semiconductor device miniaturization of recent years, and in its joint research with Hokkaido University, we have performed soft error experiments by using Hokkaido University's compact accelerator-driven neutron source which is able to secure more experimentation time and appropriate incidence rate, irradiating multiple devices by flexible arrangement compared to a large-scale accelerator-driven neutron source.

2. Findings

In this joint research, we aimed to confirm (1) replication of naturally occurring soft errors using a compact accelerator-driven neutron source, (2) prediction of the rate of malfunctions due to soft errors, (3) soft error tolerance, and (4) failure processing when malfunctions occur due to soft errors, by performing experiments with a parallel irradiation system[*4] configured to enable efficient irradiation and measurement of multiple devices (Figure 2).
We selected suitable measures such as restarting or resetting the semiconductor devices as recovery from the effects of the soft errors obtained experimentally, and performed impact assessment studies before and after measures were taken.

(1) Replicating naturally occurring soft errors with the compact accelerator-driven neutron source.

We confirmed that it's possible to reproduce soft errors using Hokkaido University's compact accelerator-driven neutron source (1 kW).

(2) Predicting the malfunction rate due to soft errors

We confirmed that the soft error rates derived from conventional simulations and the results of our irradiation experiments with the compact accelerator-driven neutron source were almost identical. This makes it possible to take steps to accurately predict soft error rates and proactively prevent problems before deploying new information and communications equipment.

(3) Soft error tolerance

We confirmed resilience to soft errors could be achieved in each device by taking prior measures.

(4) Failure processing for malfunctions due to soft errors

We confirmed the effectiveness of prior handling for failure processing when errors involving 2 bits or more occur, by detecting events that may occur with actual use of equipment currently under development. This makes it possible to efficiently take design and operational measures before deploying new equipment.

3. Looking forward

Being able to detect malfunctions due to soft errors that may occur when equipment is actually in use, and confirm accuracy of soft error prediction using the compact accelerator-driven neutron source, we aim to further improve reliability by including this highly effective test in the development and implementation processes that NTT labs undertakes in the course of developing communications and information equipment. We also plan to expand the range of applications of the compact accelerator-driven neutron source beyond core network equipment to other communications and information equipment where high functionality and reliability are required, and to increase the usefulness of the compact accelerator-driven neutron source soft error experiments and resilience to malfunctions due to soft errors.

Terminology

*1 Compact accelerator-driven neutron source

This small-scale 45MeV electron linear accelerator facility was installed at Hokkaido University in 1973 and has been operational since. This is a small-scale accelerator facility for performing a wide variety of neutron experiments that offers a high degree of freedom, and boasts a range of achievements over its more-than 30 year history. Recognized by the International Atomic Energy Association (IAEA) as a facility that should become a base for next-generation neutron science, the facility is also receiving requests from industry to expand the range of its uses.
Accelerator: a device that creates high energy states by accelerating charged particles such as electrons or protons.

*2 Soft error

Abnormal operation in electronic equipment that uses semiconductor devices such as LSI or memory chips, and which is caused by electric charges resulting from neutron radiation due to secondary cosmic rays that reach the Earth's surface, or alpha rays arising from radioactive impurities in materials. Soft errors are increasing due to advances in semiconductor integration and miniaturization of semiconductor processing technology, thus the importance of finding ways to deal these types of errors is growing.

*3 ECC

Abbreviation for Error Check and Correct. A type of error correction function, ECC enables error correction up to 1 bit, or error detection up to 3 bits by adding horizontal and vertical parity.

*4 Parallel irradiation system

This system can be lowered or raised remotely to control the beam and turn irradiation on or off, and enables efficient irradiation of many devices at once. From measured results of log acquisition time and the intervals between soft errors in device A, device B and device C, its clear that the parallel irradiation system offers about 3 times greater efficiency.

Attachment·Reference

- Figure1: Mechanism of soft error
- Figure2: Experimental setup

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