Mitigation measures for Alpha radiation effects on flight hardware

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Abstract: - At 40000 feet in the air, there is continuous bombarding of alpha radiation from sun on flight hardware .Since the integrity of data in storage systems is critical , there needs to be a way to make sure that data stored on Flash memory is correct each time the data is accessed. Although there are error correction codes to handle that , they do at most times handle only on bit correction .

Index Terms—.Alpha radiation, Cyclic redundancy Check ,Flash memory, In-flight entertainment

I. INTRODUCTION

Proposed solution would include monitor of the blocks on flash memory before landing and as soon as we detect a bit flip , we reload the good original image before reboot to prevent Bad DATA CRC. In a way , we are doing targeted recovery to prevent the hardware from being inoperable.

What is Flash memory?
Flash memory is used to store data . Flash memory is divided into two types: NOR and NAND

- NOR has byte level access - NOR memory offers expensive but faster random read access, allowing for fast boot times. NOR is most often used in mobile phones
- NAND has block level access- NAND memory offers higher densities, lower cost-per-bit, and fast write performance, which is more suitable for data storage.
- Flash memory can be used in many everyday products such as laptop computers, flash drives, digital cameras, phones, and iPods
- When you turn on these devices, it is likely that they will boot up from Flash memory, since flash memory does not need a power supply to hold information.
- In Flash memory ,data integrity problems are an issue when it comes to storage and retrieval of data.

Flash memory can be corrupted three known ways
1) The first way is wear out, this happens when the life of the flash memory block has been over used, which is about 100,000 erase cycles.

Wear out causes permanent errors and blocks will no longer be useable once this number has been passed
2) Program disturb happens when bits are unintentionally programmed in a block
3) Read disturb happens when data is read in incorrectly. Program and read disturb are correctable using error correcting codes
4) The fourth and least likely , often ignored, corruption that occurs is due to solar radiation .

SINGLE EVENT UPSET

SEU or single-event upset can be caused by alpha particles from solar radiation. There are ECC (Error code correction) chips which can be used (SOLOMON HEMMING/BCH). However , they can at most handle only single bit correction Depending on intensity of radiation , there could be single or multiple bit flips
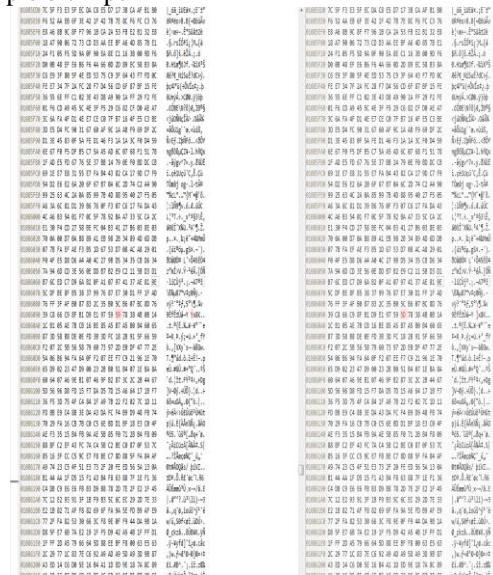
(bytes marked in red indicate flipped data)

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Concept development

- Since , the image to be loaded is stored on flash and is accessed only on next reboot , there needs to be a way to verify the image is still good before shutdown.
- For this , we opted for md5sum of mtdblocks and compared against a known good image whenever there is a shutdown.
- We also copied the hex image using dd commands and did a hex compare using cmp commands against known good images.
- If both these test passed, then only the system would proceed with graceful shutdown.
- Otherwise , we withhold the shutdown and insource the image onto flash memory from hard drive.
- Obtaining a lab to inflict solar radiation in a controlled manner. We went to San Diego chemo-therapy centre to use the setup to precisely bombard flash memory with alpha particles.
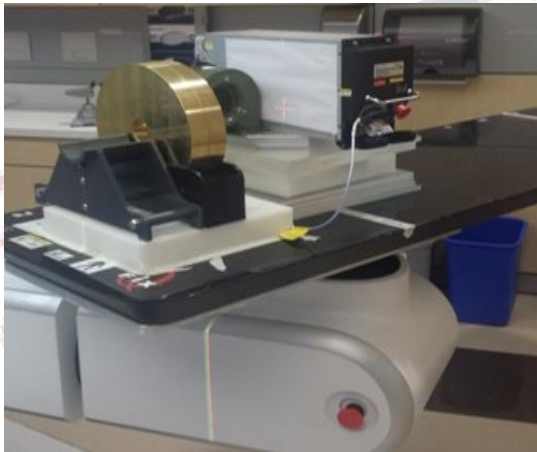- We used to vary the intensity and reboot the unit to check impact alongside corruption.\

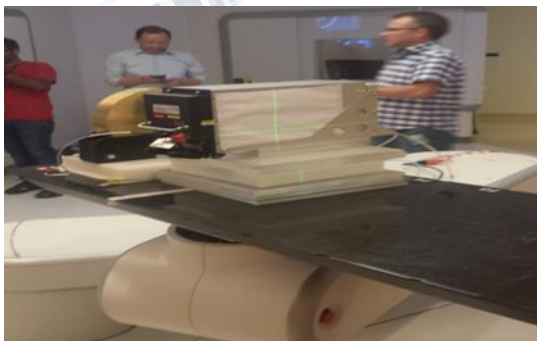*Fig. 1 Lead cylinder to precise proton beam*

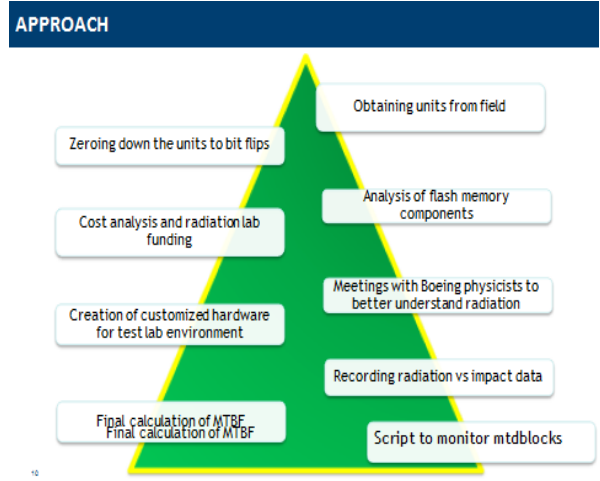*Fig. 2 Cross hair indicating precise path of proton beam*

Fig. 3 Flow chart with overview of approach

RESULTS

- At varying levels of radiation intensity , we were able to prove that there is single and multiple bit flips in flash memory.
- The original proposed solution was to shield the hardware with lead . But this would involve re-design costs .
- Since our solution was software based, we eliminated shipping costs. Also , the monitoring mechanism easily fits into current architecture .
- This particular hardware costs $2,50,000 . By implementing this , we would increase MTBF (mean time between failure) by 23% thereby increasing the in-service period substantially.