# Lossy Compression for Checkpointing: Fallible or Feasible?

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As HPC applications scale to hundreds of thousands of processors and higher, large checkpoints not only consume a lot of space, making it costly to fit them in memory or burst buffers, but it also takes a significant amount of time to transfer them to stable storage. To address this challenge, we propose using lossy compression to reduce checkpoint size and studying the trade-off between the loss of precision and the compression ratio.

## Goals

- Given the failure rate of a machine, how lossy can the checkpoints be (determining the compression ratio)?
- If the application suffers from multiple failures, does it matter how they are spread throughout the run?

## Approach

### Compression technique to reduce checkpoint size

- For scientific applications, lossless compression typically reduces the checkpoint size by 15-50% .
- With lossy compression, the compression ratio can be improved to 3-5x.

### Selective lossy compression

```
checkpoint function()
compression_on(myNumParticles, 32)
store, x_position
store, y_position
store, z_position
compression_on(myNumParticles, 16)
store, x_velocity
store, y_velocity
store, z_velocity
compression_off()
store, iType
```

Lossy level control.

Selective precision level for different types of data. We found this is useful in our experiments: for certain runs of ChaNGa, compressing position fields with lossy level 16 causes program to hang.

Turn compression off: do not compress control data.

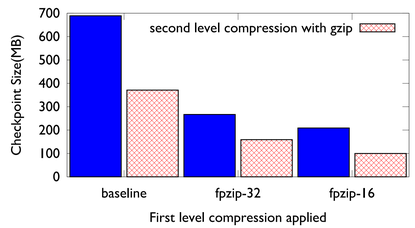
**Fig. 1**

## Preliminary Results

### Experimental setup

- Application: ChaNGa, an N-body cosmology simulation
- Dataset: dwf1
- Lossless compression: gzip
- Lossy compression: fpzip, a lossy compression library based on predictive coding and quantization.

### Compression ratio

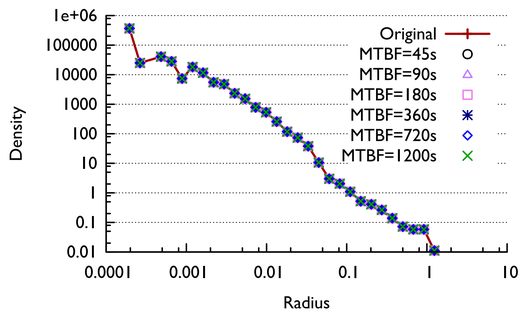



| | Compression Ratio |
|---|---|
| gzip | 1.85 |
| fpzip-32 | 2.58 |
| fpzip-32 + gzip | 4.33 |
| fpzip-16 | 3.29 |
| fpzip-16 + gzip | 6.89 |

**Fig. 2**

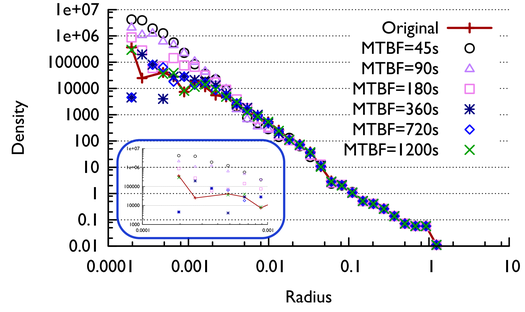
### Effect of failure rate

We examined the dark matter density profile at the end of the run to verify correctness. We injected failures using a uniform distribution through one-hour run of ChaNGa.




Using fpzip 32-bit compressor:
32 least significant bits are discarded.

**Fig. 3**



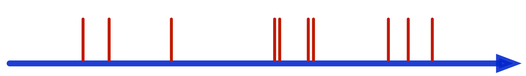

Using fpzip 16-bit compressor:
48 least significant bits are discarded.

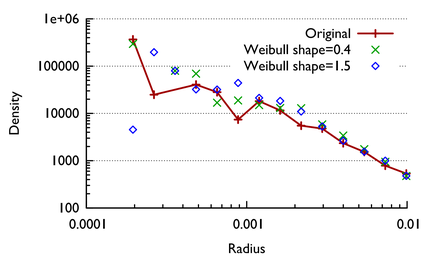
**Fig. 4**

### Effect of failure distribution

Weibull distribution
shape parameter 0.4, decreasing failure rate.

shape parameter 1.5, increasing failure rate.






fpzip 16-bit compressor is used. ChaNGa is more sensitive to failures at the later stage of the simulation.

**Fig. 5**

## Future Plan

- Extend to different application classes, like linear algebra, chaotic applications.
- Study the mixture of lossy and lossless compression based on semantic information.

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