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## How to Size Main Memory for ZFS Deduplication

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**How to determine if enabling ZFS deduplication, which removes redundant data from ZFS file systems, will save you disk space without reducing performance.**

### What Is ZFS Deduplication?

In Oracle Solaris 11, you can use the deduplication (`dedup`) property to remove redundant data from your ZFS file systems. If a file system has the `dedup` property enabled, duplicate data blocks are removed as they are written to disk. The result is that only unique data is stored on disk and common components are shared between files, as shown in Figure 1.

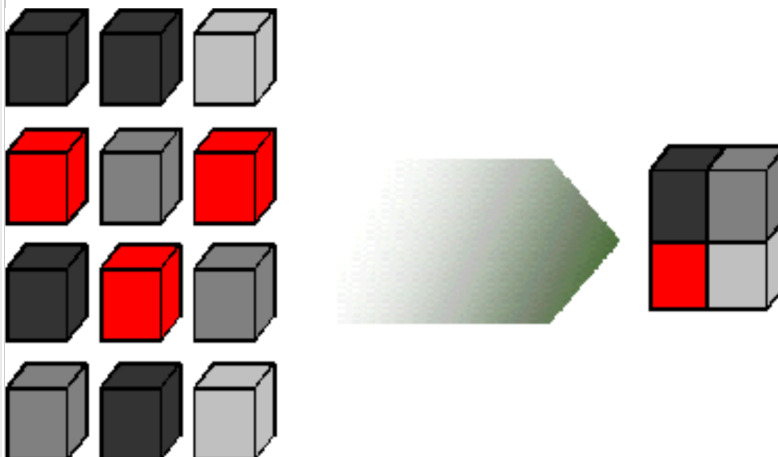


Figure 1. Only Unique Data Is Stored on Disk

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In some cases, this can result in tremendous savings in disk space usage and cost. Deduplication is easily enabled for a file system, for example:

```
# zfs set dedup=on mypool/myfs
```

Deduplication can result in considerable storage space savings for certain types of data, such as virtual machine images. Other types of data, such as text, might more efficiently be stored using data compression, which is also available in ZFS.

Before starting to use deduplication, there are two issues that need to be investigated:

Is it worth using deduplication on this particular data?

Does the server have enough memory installed to undertake deduplication?

Guidance on these two issues is given below.

### Is it Worth Using Deduplication on this Particular Data?

To determine if your data would benefit from deduplication space savings, use the ZFS debugging tool, `zdb`. If your data is not "dedup-able," there is no point in enabling `dedup`.

Deduplication is performed using checksums. If a block has the same checksum as a block that is already written to the pool, it is considered to be a duplicate and, thus, just a pointer to the already stored block is written to disk.

Therefore, the process of trying to deduplicate data that cannot be deduplicated simply wastes CPU resources. Deduplication in ZFS is in-band. The deduplication occurs when you write to the disk. This is when the (unnecessary) CPU load will be incurred.

For example, if the estimated deduplication ratio is greater than 2, you might see deduplication space savings. In the example shown in Listing 1, the deduplication ratio is less than 2, so enabling `dedup` is not recommended.

#### Listing 1: Determining the Deduplication Ratio

```
# zdb -s tank
```

Simulated DDT histogram:

bucket	refcnt	blocks	allocated	LSIZE	PSIZE	DSIZE	blocks	referenced	LSIZE	PSIZE	DSIZE
1	2.27M	239G	188G	194G	2.27M	239G	188G	194G			
2	327K	34.3G	27.8G	28.1G	698K	73.3G	59.2G	59.9G			
4	30.1K	2.91G	2.10G	2.11G	152K	14.9G	10.6G	10.6G			
8	7.73K	691M	529M	529M	74.5K	6.25G	4.79G	4.80G			
16	673	43.7M	25.8M	25.9M	13.1K	822M	492M	494M			
32	197	12.3M	7.02M	7.03M	7.66K	480M	269M	270M			
64	47	1.27M	626K	626K	3.86K	103M	51.2M	51.2M			
128	22	908K	250K	251K	3.71K	150M	40.3M	40.3M			
256	7	302K	48K	53.7K	2.27K	88.6M	17.3M	19.5M			
512	4	131K	7.50K	7.75K	2.74K	102M	5.62M	5.79M			
2K	1	2K	2K	2K	3.23K	6.47M	6.47M	6.47M			
8K	1	128K	5K	5K	13.9K	1.74G	69.5M	69.5M			
Total	2.63M	277G	218G	225G	3.22M	337G	263G	270G			
dedup =	1.20	compress =	1.28,	copies =	1.03,						
dedup * compress / copies =	1.50										

### Does the Server Have Enough Memory Installed to Undertake Deduplication?

The reason this question needs to be answered is that the deduplication tables consume memory and eventually spill over and consume disk space. At that point, ZFS has to perform extra read and write operations for every block of data on which deduplication is attempted. This causes a reduction in performance.

Furthermore, the cause of the performance reduction will be difficult to determine if you are unaware that deduplication is active and can have adverse effects. A system that has large pools with small memory areas will not perform deduplication well. Some operations, such as removing a large file system with `dedup` enabled, will severely decrease system performance if the system doesn't meet the memory requirements.

Calculate memory requirement as follows:

Each in-core deduplication table (DDT) entry is approximately 320 bytes.  
Multiply the number of allocated blocks by 320.  
Here's an example using the data from the `zdb` information in Listing 1:

In-core DDT size (2.63M) x 320 = 841.60M of memory is required

### Conclusion

After you evaluate the two constraints on deduplication, the deduplication ratio and the memory requirements, you can make a decision about whether to implement deduplication and what the likely savings will be.

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