

**Storage Management – Swap Space an RAID** 

**Dr Rahul Nagpal**Computer Science



# Storage Management – Swap Space and RAID

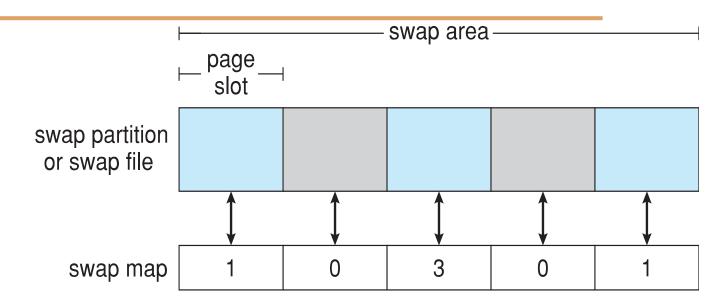
**Dr. Rahul Nagpal**Computer Science

### Swap-Space Management



- Swap-space Virtual memory uses disk space as an extension of main memory
  - Less common now due to memory capacity increases
- Swap-space can be carved out of the normal file system, or, more commonly, it can be in a separate disk partition (raw)
- Swap-space management
  - 4.3BSD allocates swap space when process starts; holds text segment (the program) and data segment
  - Kernel uses swap maps to track swap-space use
  - Solaris 2 allocates swap space only when a dirty page is forced out of physical memory, not when the virtual memory page is first created
    - File data written to swap space until write to file system requested
    - Other dirty pages go to swap space due to no other home
    - Text segment pages thrown out and reread from the file system as needed
- What if a system runs out of swap space?
- Some systems allow multiple swap spaces

## Data Structures for Swapping on Linux Systems





#### **RAID Structure**



- RAID redundant array of inexpensive disks
  - multiple disk drives provides reliability via redundancy
- Increases the mean time to failure
- Mean time to repair exposure time when another failure could cause data loss
- Mean time to data loss based on above factors
- If mirrored disks fail independently, consider disk with 1300,000 mean time to failure and 10 hour mean time to repair
  - Mean time to data loss is 100,  $000^2$  /  $(2 * 10) = 500 * <math>10^6$  hours, or 57,000 years!
- Frequently combined with NVRAM to improve write performance
- Several improvements in disk-use techniques involve the use of multiple disks working cooperatively

RAID (Cont.)



- Disk striping uses a group of disks as one storage unit
- RAID is arranged into six different levels
- RAID schemes improve performance and improve the reliability of the storage system by storing redundant data
  - Mirroring or shadowing (RAID 1) keeps duplicate of each disk
  - Striped mirrors (RAID 1+0) or mirrored stripes (RAID 0+1) provides high performance and high reliability
  - Block interleaved parity (RAID 4, 5, 6) uses much less redundancy
- RAID within a storage array can still fail if the array fails, so automatic replication of the data between arrays is common
- Frequently, a small number of hot-spare disks are left unallocated, automatically replacing a failed disk and having data rebuilt onto them

### **RAID Levels**



(a) RAID 0: non-redundant striping.



(b) RAID 1: mirrored disks.



(c) RAID 2: memory-style error-correcting codes.



(d) RAID 3: bit-interleaved parity.



(e) RAID 4: block-interleaved parity.



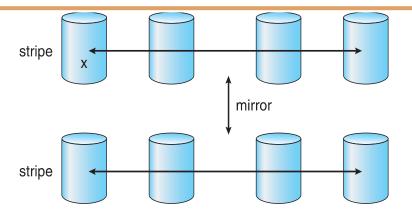
(f) RAID 5: block-interleaved distributed parity.



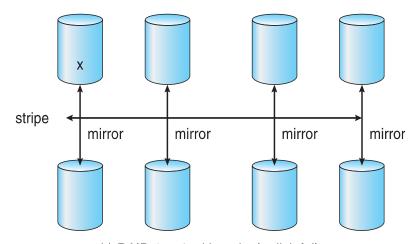
(g) RAID 6: P + Q redundancy.



RAID (0 + 1) and (1 + 0)



a) RAID 0 + 1 with a single disk failure.



b) RAID 1 + 0 with a single disk failure.



#### Other Features



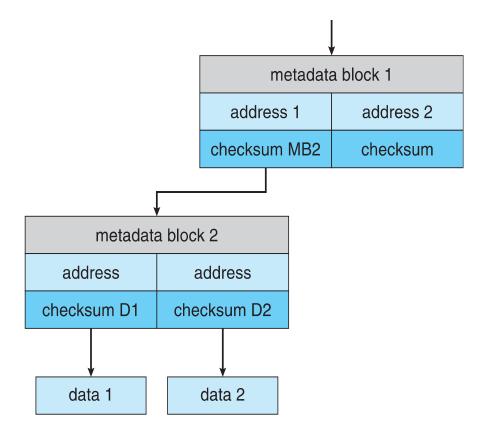
- Regardless of where RAID implemented, other useful features can be added
- Snapshot is a view of file system before a set of changes take place (i.e. at a point in time)
  - More in Ch 12
- Replication is automatic duplication of writes between separate sites
  - For redundancy and disaster recovery
  - Can be synchronous or asynchronous
- Hot spare disk is unused, automatically used by RAID production if a disk fails to replace the failed disk and rebuild the RAID set if possible
  - Decreases mean time to repair

### **Extensions**



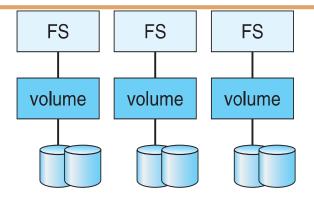
- RAID alone does not prevent or detect data corruption or other errors, just disk failures
- Solaris ZFS adds checksums of all data and metadata
- Checksums kept with pointer to object, to detect if object is the right one and whether it changed
- Can detect and correct data and metadata corruption
- ZFS also removes volumes, partitions
  - Disks allocated in pools
  - Filesystems with a pool share that pool, use and release space like malloc() and free() memory allocate / release calls

# **ZFS Checksums All Metadata and Data**

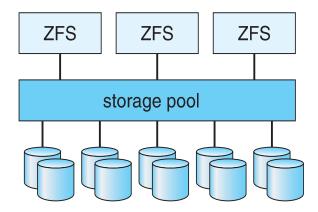




## Traditional and Pooled Storage



(a) Traditional volumes and file systems.



(b) ZFS and pooled storage.





# **THANK YOU**

**Dr Rahul Nagpal** 

**Computer Science** 

rahulnagpal@pes.edu