Migrating OpenVMS Storage Environments without Interruption/Disruption

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2024 OpenVMS Bootcamp
Marriott Long Wharf
Boston, Massachusetts

Introduction

- 24 x 7; 366 days a year
- Backups are critical
- Halting production is "not an option"
- Cluster uptime needs to be measured in years, not months
- Technology change is inevitable; technology changes can be delayed; but not frozen

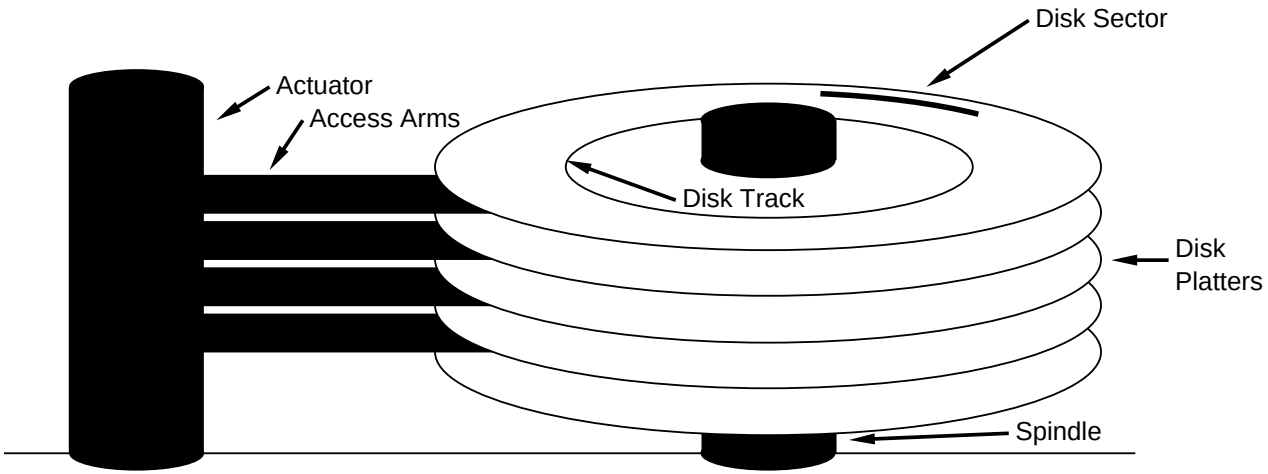
Host-based Volume Shadowing

- Migrate storage environments regardless of underlying technologies
- NO INTERRUPTION OF USERS
- Zero window cutover
- All references to DSn; not physical devices
- Changing data volumes does not require reboot

Today's Tools

- OpenVMS – Alpha/IA-64/x86-64
- Shadowing - storage management v redundancy
- Enterprise arrays
- Managing workload
- LD ("Logical Disk")

Disks are Disks



Or not

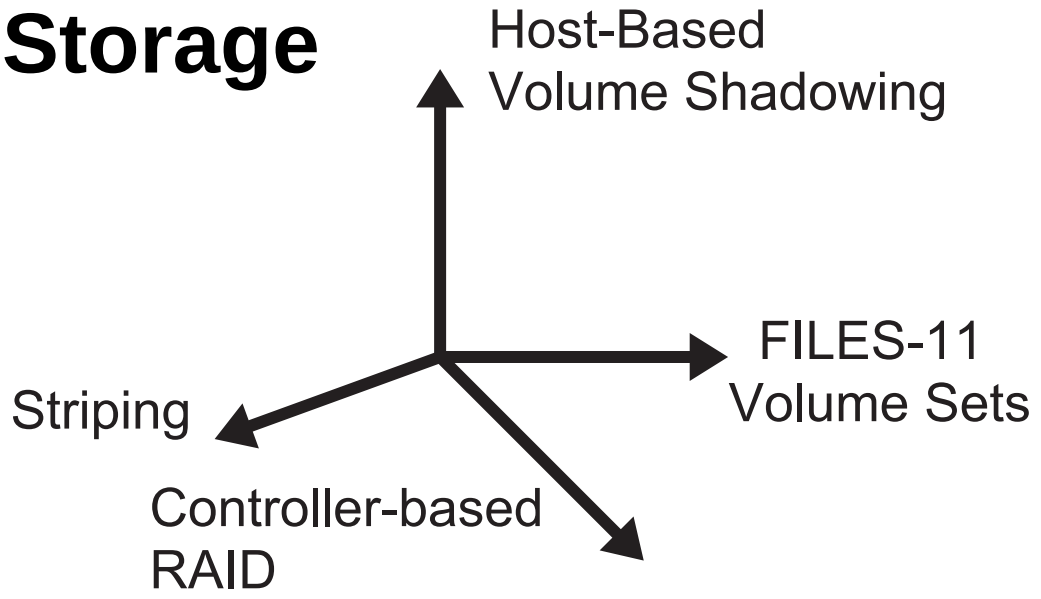
"The basic medium that carries a Files-11 structure is referred to as a volume. A volume (also referred to as a unit) is defined as an ordered set of logical blocks. A logical block is an array of 512 8-bit bytes. The logical block in a volume are consecutively numbered from 0 to n-1 ... "

– Files-11 On-Disk Structure Specification
Andrew Goldstein, 19 June 1975, Section 2.1

Storage Strategy

- Disruption/Downtime/Non-Availability – Evil
- Housekeeping load is undesirable, but tolerable if prudently scheduled
- Growth works; shrink does not

Independent Axes of Storage Configuration



- Host-based shadowing is independent of other techniques
- Each technique has its benefits and weaknesses
- Each technique has its place in your toolkit

Disruptive Events

- BITMAP.SYS expansion
- INDEX.SYS extension beyond one header
- Global changes in directory structure
- Global changes in file ownership/protection

BITMAP.SYS

- One bit/cluster on the disk, maximum size 65,536 blocks
- In today's terms. the bitmap is a negligible burden
  - each bitmap block represents 4,096 disk clusters
  - largest possible bitmap is 33.55MB
  - on a 1GB volume, there are approximately 2,000,000 blocks
  - the maximum bitmap is less than 0.00005% of the volume
- Maximizing the size of the bitmap is insignificant on large disks

INDEXF.SYS

- At least one header per file; possibly more
- Initial default allocation is 16; which leaves space for 10 files (6 entries are used by FILES-11 reserved files)
- INDEXF.SYS is limited to a single file header
- INDEXF.SYS will extend as needed, but fragmentation of extensions means that HEADERFULL will occur long before the volume fills
- Approach: Allocate HEADERS generously

Global Changes in Directory Structure

- Execution disruptive
- Profile disruptive
- Requires synchronization over potentially entire user base unlikely to be achieved
- Use rooted logical names to separate departments, applications, and other logical groupings of files

Global Changes in File Ownership/Protection

- Execution disruptive
- User confusion
- Problem report intensive

Overall Stategic Goals

- Avoid interruptions and unavailability at all costs
- Assimilate multiple generations of storage devices and configurations without interruption

Tactical Goals

- Avoid shortages of file headers in INDEXF.SYS
- Avoid volume reorganization caused by expansion of BITMAP.SYS

Implementation Tactics

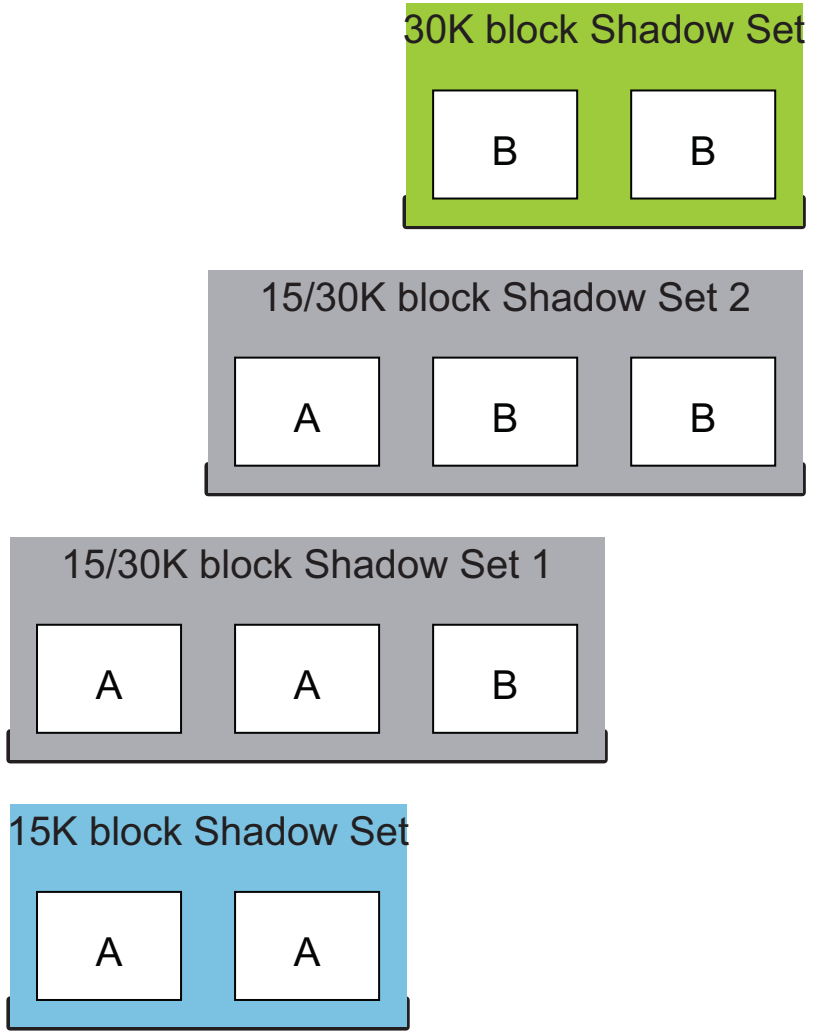
- Use OpenVMS Volume Shadowing to migrate volumes to larger volumes online
- Use INITIALIZE command to set the stage:
  - /LIMIT to force bitmap to allow for future expansion
  - /MAXIMUM_FILES to large value
  - /HEADERS to values commensurate with /MAXIMUM_FILES and /CLUSTER
- Test procedures using Logical Disks; experiment without:
  - /LIMIT to force bitmap to allow for future expansion
  - /MAXIMUM FILES to large value

Implementation Tactics (cont'd)

- Experiments on small, offline systems are infinitely cheaper than encountering problems working with live systems:
  - Small test systems are invaluable for testing SYSGEN parameters relating to shadowing
  - It is well worth using a DS (Alpha), rx1600/2600 (IA-64) or laptop VM instance (x86-64) for experiments
  - Performance often does not scale – up or down

The Plan

- Make up; then break up
- Straddling



Use LD to Create Logical Drives

```
$ ld create pseudodisk1.dsk/size=15000
$ ld create pseudodisk2.dsk/size=15000
$ ld create pseudodisk3.dsk/size=30000
$ ld create pseudodisk4.dsk/size=30000
$ ld create pseudodisk5.dsk/size=45000
$ ld create pseudodisk6.dsk/size=45000
```

Initialize and Build the Initial Shadow Set

```
$ ld connect pseudodisk1.dsk/symbol
%LD-I-UNIT, Allocated device is $1$LDA16:
$ allocate ld16 shadowmember1:
%DCL-I-ALLOC, _$1$LDA16: allocated
$ ld connect pseudodisk2.dsk/symbol
%LD-I-UNIT, Allocated device is $1$LDA17:
$ allocate ld17 shadowmember2:
%DCL-I-ALLOC, _$1$LDA17: allocated
$ initialize/shadow=(shadowmember1:,shadowmember2:)-
  /structure=5-
  /cluster=3/limit=3145728/erase shadowtest
$ deallocate shadowmember1:
$ deallocate shadowmember2:
$ mount/system
  dsa/shadow=(shadowmember1,shadowmember2) shadowtest
%MOUNT-I-MOUNTED, SHADOWTEST mounted on _DSA9999:
%MOUNT-I-SHDWMEMSUCC, _$1$LDA16: (ALFA) is now a
  valid member of the shadow set
%MOUNT-I-SHDWMEMSUCC, _$1$LDA17: (ALFA) is now a
  valid member of the shadow set
```

Create a Directory on the shadow set

```
$ create/directory disk$shadowtest:[gezelter]
$ show device disk$shadowtest

Device             Device           Error    Volume         Free  Trans Mnt
 Name              Status           Count     Label        Blocks Count Cnt
DSA9999:           Mounted              0   SHADOWTEST      14547     1   1
$1$LDA16: (ALFA)   ShadowSetMember      0   (member of DSA9999:)
$1$LDA17: (ALFA)   ShadowSetMember      0   (member of DSA9999:)
```

Move some files to the shadowset

```
$ copy *.*/exclude=(*.dsk;*,*.dir;*) disk$shadowtest/log
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]ACCOUNTS.TMP;27 copied to
disk$shadowtest:[GEZELTER]ACCOUNTS.TMP;27 (2 blocks)
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]ADDSHADOWMEMBER.COM;3 copied to
disk$shadowtest:[GEZELTER]ADDSHADOWMEMBER.COM;3 (1 block)
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]ALPHAFTPAKSJUNE.COM;1 copied to
disk$shadowtest:[GEZELTER]ALPHAFTPAKSJUNE.COM;1 (36 blocks)
                                    ...
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]TCPIP$FTP_SERVER.LOG;11 copied to
disk$shadowtest:[GEZELTER]TCPIP$FTP_SERVER.LOG;11 (1 block)
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]UNZIP.EXE;1 copied to
disk$shadowtest:[GEZELTER]UNZIP.EXE;1 (278 blocks)
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]X.TMP;1 copied to
disk$shadowtest:[GEZELTER]X.TMP;1 (1 block)
%COPY-S-COPIED, SYS$SYSDEVICE:[GEZELTER]ZIP.EXE;1 copied to
disk$shadowtest:[GEZELTER]ZIP.EXE;1 (194 blocks)
%COPY-S-NEWFILES, 22 files created
$ show device disk$shadowtest

Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
DSA9999:                Mounted              0  SHADOWTEST         6936     1   1
$1$LDA16:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
$1$LDA17:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
```

Detailed Look at the Shadow Set

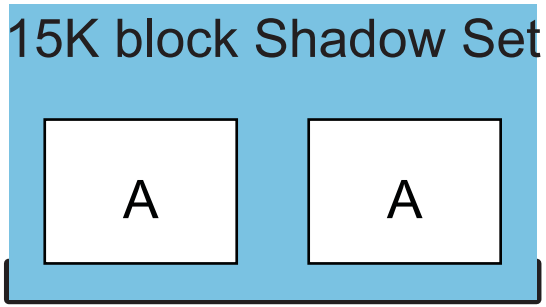
```
$ show device disk$shadowtest/full

Disk DSA9999:, device type Foreign disk type 1, is online, mounted, file-
  oriented device, shareable, available to cluster, error logging is enabled,
    device supports bitmaps (no bitmaps active).

    Error count                    0    Operations completed                366
    Owner process                 ""    Owner UIC                       [SYSTEM]
    Owner process ID        00000000    Dev Prot            S:RWPL,O:RWPL,G:R,W
    Reference count                1    Default buffer size                 512
    Total blocks               15000    Sectors per track                    11
    Total cylinders              124    Tracks per cylinder                  11
    Logical Volume Size        15000    Expansion Size Limit              3158016

    Volume label       "SHADOWTEST"    Relative volume number                 0
    Cluster size                   3    Transaction count                      1
    Free blocks                 6936    Maximum files allowed             393216
    Extend quantity                5    Mount count                            1
    Mount status              System    Cache name         "_$1$DKA100:XQPCACHE"
    Extent cache size             64    Maximum blocks in extent cache       693
    File ID cache size            64    Blocks in extent cache               228
    Quota cache size               0    Maximum buffers in FCP cache        1430
    Volume owner UIC  [SYSTEMS,GEZELTER]
                                        Vol Prot    S:RWCD,O:RWCD,G:RWCD,W:RWCD

  Volume Status:  ODS-5, subject to mount verification, erase on delete, file
      high-water marking, write-back caching enabled.
```

And the Shadow Set Members

```
Disk $1$LDA16:, device type Foreign disk type 1, is online, member of shadow
  set DSA9999:, shadow set virtual unit.

  Error count                    0    Shadow member operation count       583
  Allocation class               1

Disk $1$LDA17:, device type Foreign disk type 1, is online, member of shadow
  set DSA9999:, shadow set virtual unit.

  Error count                    0    Shadow member operation count       579
  Allocation class               1
```

First Crisis: Space Shortage

- There is a shortage of free space on DISK$SHADOWTEST
- Clearly no shortage of file headers
- Resolution:
  - switch to larger volumes without interrupting users and applications
  - straddle to the new, larger volumes; then release the smaller volumes

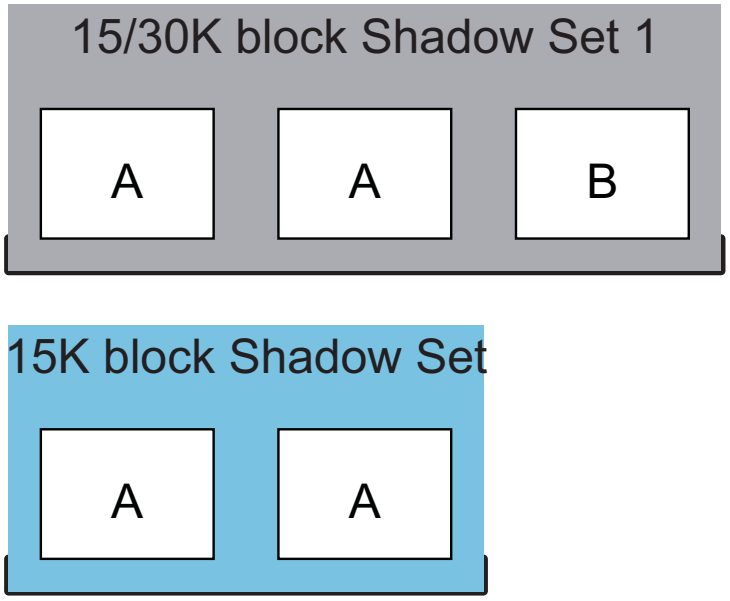


Create the New Shadow Set Member

```
$ ld connect pseudodisk3.dsk/symbol
%LD-I-UNIT, Allocated device is $1$LDA18:
$ allocate ld18 newmember
%DCL-I-ALLOC, _$1$LDA18: allocated
$ initialize newmember: scratch_disk
$ deallocate newmember
$ mount/system disk$shadowtest/shadow=newmember-
  /policy=verify_label shadowtest
%MOUNT-I-MOUNTED, SHADOWTEST mounted on _DSA9999:
%MOUNT-I-SHDWMEMCOPY, _$1$LDA18: (ALFA) added to the shadow set
  with a copy operation
%MOUNT-I-ISAMBR, _$1$LDA16: (ALFA) is a member of the shadow set
%MOUNT-I-ISAMBR, _$1$LDA17: (ALFA) is a member of the shadow set
$
%%%%%%%%%%  OPCOM  23-AUG-2005 06:25:22.61  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVINICPY, initiating copy operation on
  _DSA9999: at LBN: 0, I/O size: 127 blocks, ID number: 0400076E.

%%%%%%%%%%  OPCOM  23-AUG-2005 06:25:37.64  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVNORMAL, successful completion of copy
  operation on device _DSA9999: at LBN: 15000, ID number:
  0400076E.
```

Then Release one of the Smaller Volumes

```
$ DISMOUNT LD16
%%%%%%%%%%  OPCOM  23-AUG-2005 06:25:39.81  %%%%%%%%%%
$1$LDA16: (ALFA) has been removed from shadow set.
%%%%%%%%%%  OPCOM  23-AUG-2005 06:25:40.62  %%%%%%%%%%
DSA9999: shadow set has been reduced.
```



Complete the Straddle: Add the Second Stage 2 Volume

```
$ ld connect pseudodisk4.dsk/symbol
%LD-I-UNIT, Allocated device is $1$LDA19:
$ allocate ld19 newmember
%DCL-I-ALLOC, _$1$LDA19: allocated
$ initialize newmember: scratch_disk
$ deallocate newmember
$ mount/system disk$shadowtest/shadow=newmember-/policy=verify_label
  shadowtest
%MOUNT-I-MOUNTED, SHADOWTEST mounted on _DSA9999:
%MOUNT-I-SHDWMEMCOPY, _$1$LDA19: (ALFA) added to the shadow set with a copy
  operation
%MOUNT-I-ISAMBR, _$1$LDA17: (ALFA) is a member of the shadow set
%MOUNT-I-ISAMBR, _$1$LDA18: (ALFA) is a member of the shadow set
$
%%%%%%%%%%  OPCOM  23-AUG-2005 06:26:46.71  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVINICPY, initiating copy operation on _DSA9999: at LBN:
  0, I/O size: 127 blocks, ID number: 0400076B.
$
%%%%%%%%%%  OPCOM  23-AUG-2005 06:27:00.70  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVNORMAL, successful completion of copy operation on
  device _DSA9999: at LBN: 15000, ID number: 0400076B.
$ DISMOUNT LDA17
%%%%%%%%%%  OPCOM  23-AUG-2005 06:27:30.90  %%%%%%%%%%
$1$LDA17: (ALFA) has been removed from shadow set.
%%%%%%%%%%  OPCOM  23-AUG-2005 06:27:32.70  %%%%%%%%%%
DSA9999: shadow set has been reduced.
```

Now Check the Space Situation

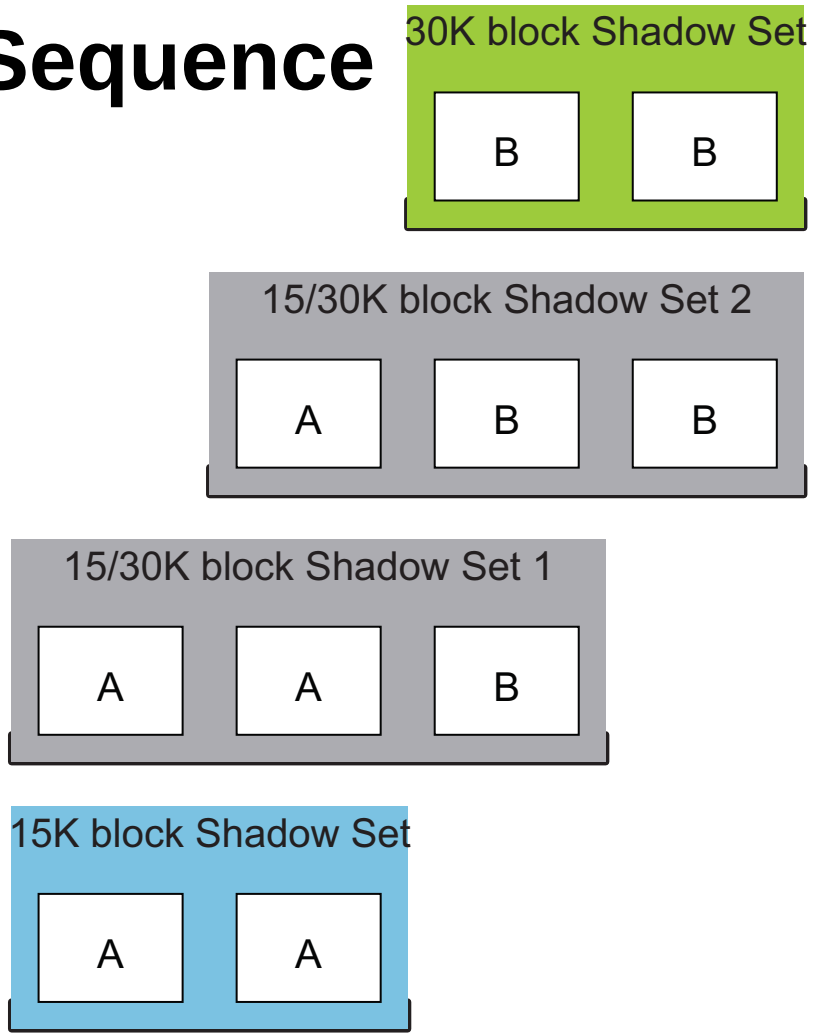
```
$ show device disk$shadowtest

Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
DSA9999:                Mounted              0  SHADOWTEST         6936     1   1
$1$LDA18:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
$1$LDA19:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
```

- The old 15Kblock volumes have been replaced with 30Kblock volumes without interrupting users
- We now need to use Dynamic Volume Expansion to to increase the space available to users

```
$ set volume/size=30000 disk$shadowtest
$ show device disk$shadowtest

Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
DSA9999:                Mounted              0  SHADOWTEST        21936     1   1
$1$LDA18:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
$1$LDA19:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
```

Recap – The "Stradddle" Sequence

- Never less than two members
- No interruption of availability



Time Elapses: Deja vue – We are again out of available space

```
$ ld connect pseudodisk5.dsk/symbol
$ LD-I-UNIT, Allocated device is $1$LDA20:
$ allocate ld20 newmember
%DCL-I-ALLOC, _$1$LDA20: allocated
$ initialize newmember: scratch_disk
$ deallocate newmember
$ mount/system disk$shadowtest/shadow=newmember-
/policy=verify_label shadowtest
%MOUNT-I-MOUNTED, SHADOWTEST mounted on _DSA9999:
%MOUNT-I-SHDWMEMCOPY, _$1$LDA20: (ALFA) added to the shadow set with a copy
operation
%MOUNT-I-ISAMBR, _$1$LDA18: (ALFA) is a member of the shadow set
%MOUNT-I-ISAMBR, _$1$LDA19: (ALFA) is a member of the shadow set
$
%%%%%%%%%%  OPCOM  23-AUG-2005 06:28:25.82  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVINICPY, initiating copy operation on _DSA9999: at LBN:
0, I/O size: 127 blocks, ID number: 05000764.
$
%%%%%%%%%%  OPCOM  23-AUG-2005 06:28:45.85  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVNORMAL, successful completion of copy operation on
device _DSA9999: at LBN: 30000, ID number: 05000764.
$ dismount lda18
%%%%%%%%%%  OPCOM  23-AUG-2005 06:28:59.67  %%%%%%%%%%
$1$LDA18: (ALFA) has been removed from shadow set.
%%%%%%%%%%  OPCOM  23-AUG-2005 06:28:59.84  %%%%%%%%%%
DSA9999: shadow set has been reduced.
```

Complete the second straddle

```
$ ld connect pseudodisk6.dsk/symbol
%LD-I-UNIT, Allocated device is $1$LDA21:
$ allocate ld21 newmember
%DCL-I-ALLOC, _$1$LDA21: allocated
$ initialize newmember: scratch_disk
$ deallocate newmember
$  mount/system disk$shadowtest/shadow=newmember-
/policy=verify_label shadowtest
%MOUNT-I-MOUNTED, SHADOWTEST mounted on _DSA9999:
%MOUNT-I-SHDWMEMCOPY, _$1$LDA21: (ALFA) added to the shadow set
  with a copy operation
%MOUNT-I-ISAMBR, _$1$LDA19: (ALFA) is a member of the shadow set
%MOUNT-I-ISAMBR, _$1$LDA20: (ALFA) is a member of the shadow set
$
%%%%%%%%%%  OPCOM  23-AUG-2005 06:29:26.90  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVINICPY, initiating copy operation on
   _DSA9999: at LBN: 0, I/O size: 127 blocks, ID number: 04000761.
%%%%%%%%%%  OPCOM  23-AUG-2005 06:29:46.92  %%%%%%%%%%
Message from user SYSTEM on ALFA
%SHADOW_SERVER-I-SSRVNORMAL, successful completion of copy
  operation on device _DSA9999: at LBN: 30000, ID number:
  04000761.
$ dismount lda19
%%%%%%%%%%  OPCOM  23-AUG-2005 06:29:56.34  %%%%%%%%%%
$1$LDA19: (ALFA) has been removed from shadow set.
%%%%%%%%%%  OPCOM  23-AUG-2005 06:29:56.90  %%%%%%%%%%
DSA9999: shadow set has been reduced.
```

Complete the process of making space available to users

```
$ set volume/size=30000 disk$shadowtest
$ show device disk$shadowtest

Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
DSA9999:                Mounted              0  SHADOWTEST       21936     1   1
$1$LDA18:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
$1$LDA19:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
```

- The old 15Kblock volumes have been replaced with 30Kblock volumes without interrupting users
- We now need to use Dynamic Volume Expansion to to increase the space available to users

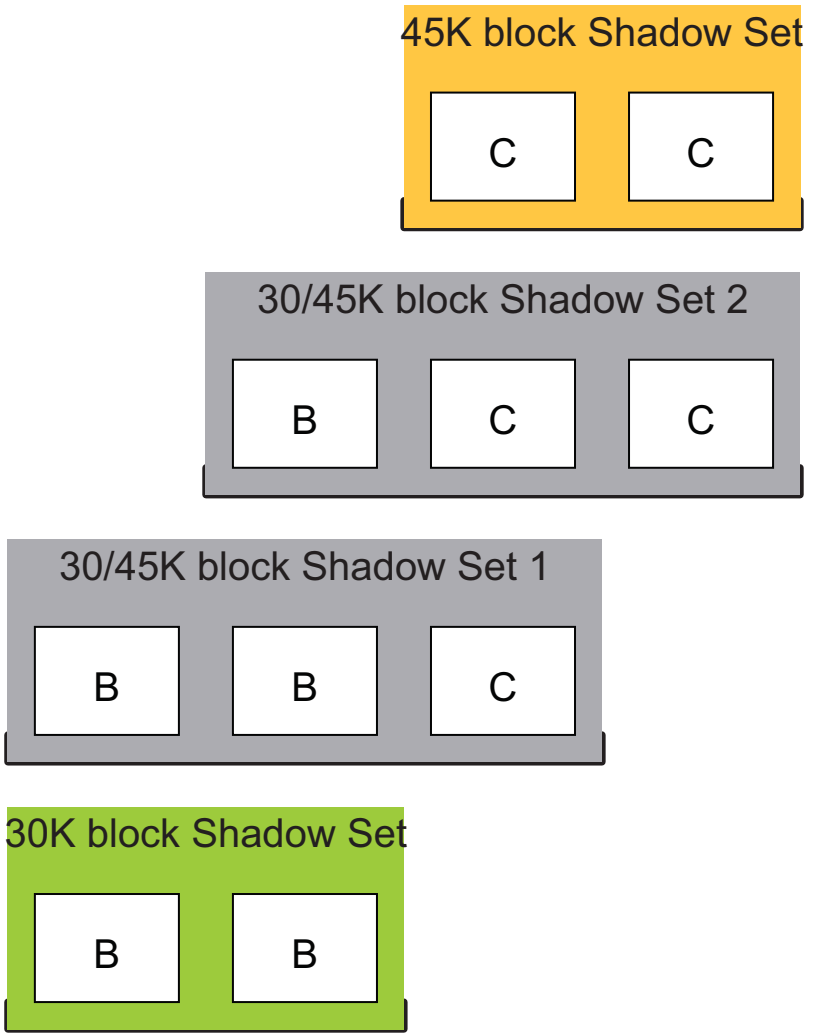
```
$ set volume/size=45000 disk$shadowtest
$ show device disk$shadowtest

Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
DSA9999:                Mounted              0  SHADOWTEST       36936     1   1
$1$LDA20:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
$1$LDA21:     (ALFA)    ShadowSetMember      0  (member of DSA9999:)
```

What about the files we placed on the shadow set?

- Our files are still where we placed them
- There was no interruption of file access or availability at any point in the preceding two generations of storage devices

The Second Interation

- From 30K to 45K blocks without interruption



Summary

- Users have uninterrupted access to data throughout this process. To recap:
  - two sets of storage transitions
  - size of individual volume grew 300% from 15K blocks to 45K blocks
    - two sets of storage transitions
      files fully accessible throughout

Summary (cont'd)

- Test procedures using Logical Disks; experiment without:
  - /LIMIT to force bitmap to allow for future expansion
  - /MAXIMUM_FILES to large value
  - /HEADERS to values commensurate with /MAXIMUM_FILES and /CLUSTER

Besides Increasing Space, How Can This Be Used?

- Changes in striping
- Changes in physical hardware
- Any change that does not affect underlying FILES-11 structures (e.g., cluster factor); everything else is limited only by your imagination

Questions?

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Session Notes & Materials:
http://www.rlgsc.com/openvms-bootcamp/2024/index.html