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Introduction to VSAM

Virtual Storage Access Method (VSAM) is two things. It is a type of disk data set, and an Application Programming Interface (API) for using these data sets. Or in other words, an access method, such as sequential access, or direct access.

- VSAM data sets must be stored on disk. Tape data sets cannot be VSAM.
- VSAM is included free with z/OS, z/VSE, and z/VM, though there can be differences between these operating systems.

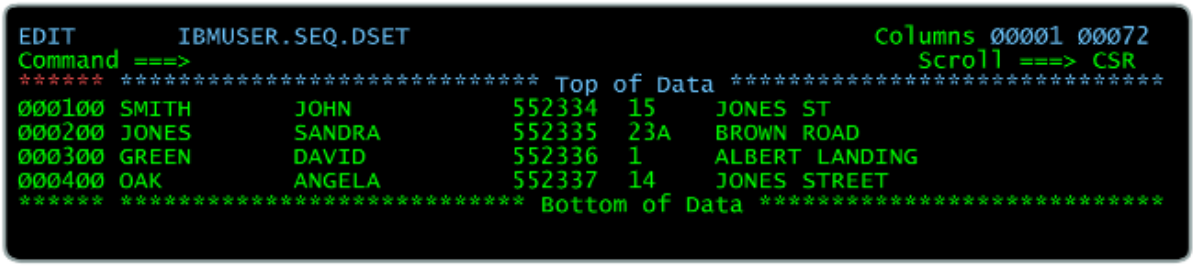
VSAM and Other Access Methods

There are several different data set types on the mainframe, each with advantages and disadvantages.

VSAM data sets are usually used by programs to store and manage data. They cannot be directly browsed or edited from ISPF without special software like IBM File Manager for z/OS or Compuware File-AID.

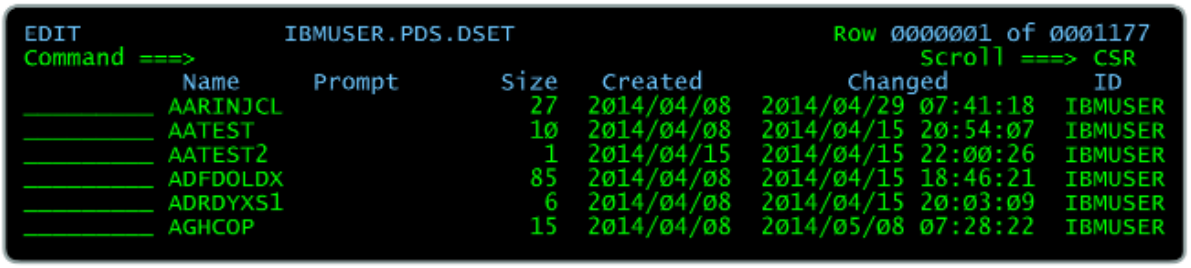
Sequential

- Data sets you can edit or browse in ISPF
- It is ideal for text
- Access method: QSAM or BSAM



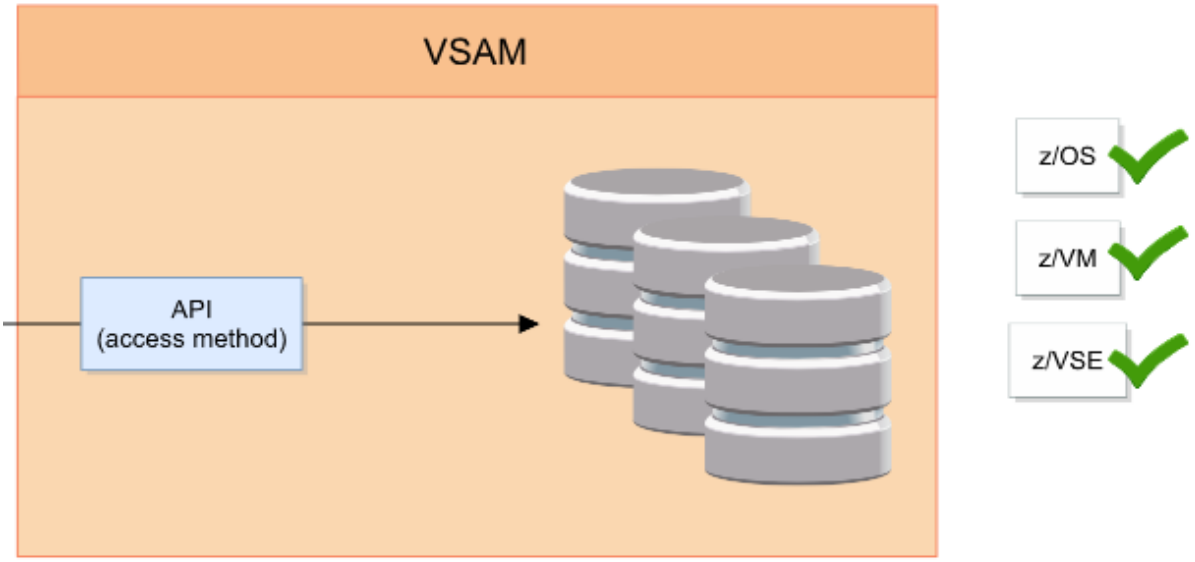
Partitioned

- A data set that has been divided into partitions called members.
- Each member contains sequential information such as data records, JCL statements or program code
- Access method: BPAM



VSAM

- One or more connected data sets
- It is ideal for storing data



VSAM Features

VSAM provides extra features that make it excellent for storing data. These include the following:

- **Speed** - VSAM data sets are the fastest data sets available for most data-related needs. They are excellent for heavy workloads.
- **Size** - VSAM data sets can be quite big; with the introduction of extended addressability, a DB2 VSAM data set, for example, could yield a maximum size of128TB.
- **Extents** - VSAM data sets can have up to 123 extents on each disk, up to a maximum of 255 extents. They can have even more if configured by the systems admin.
- **Access** - VSAM data sets can be accessed in three ways:
    - Sequential access - one record at a time from the beginning of the data set
    - Direct access - using a key or location to directly access a record
    - Skip-sequential access - locating on record directly and then processing later records sequentially from this record

VSAM Extended

VSAM data sets have been used since the 1970s. More recently, IBM introduced a newer format of VSAM data set; VSAM extended (Extended Format VSAM).

Extended Format VSAM is a VSAM data set with extended features that must be managed by DFSMS. Application programs see no difference between VSAM and Extended Format VSAM. However Extended Format VSAM provides some advanced features for the storage administrator.

- **Sharing** - Extended format VSAM data set records can be shared by many different users at the same time, even from different systems. This is called record level sharing (RLS).
- **Size** - Prior to DFSMS 1.6, a 4 gigabyte architectural limit for data set size was imposed. With the introduction of extended addressability and extended format VSAM data sets, this maximum size was increased to 128 terabytes.
- **Compression** - Extended format VSAM data sets can be stored in a compressed format on disk.
- **Speed** - Extended format VSAM provides features to improve VSAM performance, including intelligent buffering and data set striping.

VSAM Users

VSAM is used by many different software products, and even z/OS itself. Listed below are a few examples of this:

- **IMS** - Stores some IMS databases as VSAM data sets.
- **DB2** - Uses VSAM to store Db2 objects.
- **z/OS** - Many system data sets including catalogs and SMF data sets are VSAM.
- **CA ACF2 and RACF** - User information and security rules are stored in VSAM data sets.
- **Other z/OS File Types** - z/OS uses VSAM to implement other file types such as HFS, zFS and PDSE.

VSAM Data Sets

ESDS

There are five basic types of VSAM data set. The simplest is called the Entry Sequenced Data Set (ESDS). ESDS data sets are similar to normal QSAM data sets, and can hold fixed or variable length records in any order.

ESDS data sets can be accessed sequentially or directly. They cannot be accessed skip-sequentially.

ESDS data sets are excellent for applications such as logs where sequential access is needed.

How ESDS Data Sets Work

- **Structure** - ESDS data sets hold fixed or variable length records in any order.
- **Sequential access** - An ESDS record can be located sequentially by checking each record, starting from the beginning of the data set.
- **Direct access** - An ESDS record can be located directly if the location, known as the relative byte address (RBA) is known. The location could have been determined from a previous sequential search, or by remembering the location when the record was first inserted.
- **New Records** - They must be added at the end of the data set
- **Removing Records** - Records cannot be physically deleted from an ESDS. Records that are no longer needed can be marked as deleted, but will remain in the data set until the ESDS is completely rebuilt.
- **Updating Records** - Records can be updated where they are, providing the length remains the same. If the length changes, the record must be marked as deleted, and a new record added at the end.

Control Intervals

A VSAM control interval (CI) is the basic building block of a VSAM data set. It holds one or more VSAM records.

When a record in a VSAM data set is read, it must be moved into memory from a DASD device. Similarly, when a record is written, it is moved from memory to a DASD device.

- When a record is read from a VSAM data set on disk, the entire control interval is moved.

For VSAM data sets, the entire CI is moved, not just one record. This can speed up VSAM processing. The CI is similar to the block for sequential and partitioned data sets. The size of the control interval is defined by the user when creating the VSAM data set.

CIs and ESDS

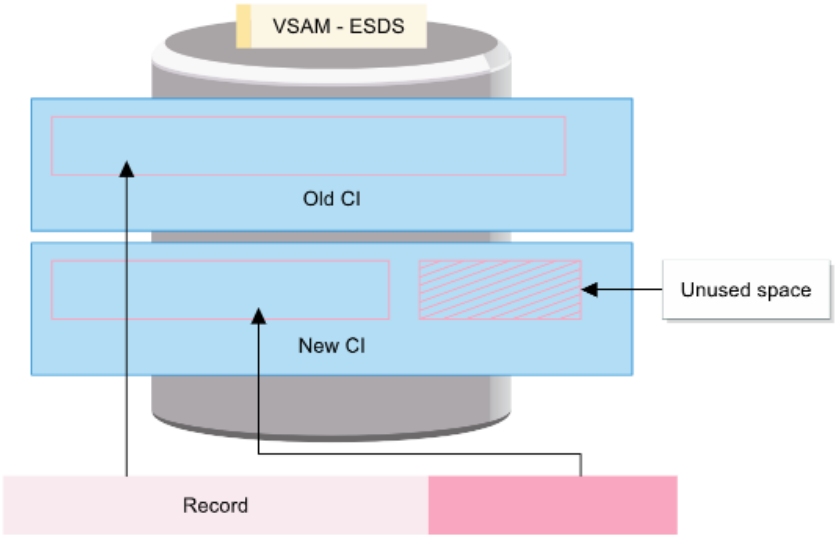
For ESDS data sets, each record is inserted at the end of the data set, at the end of the most recent CI. If there is not enough room at the end of the CI, a new one is started.

If a record is larger than the CI size, it can use more than one CI, providing the VSAM data set is defined as spanned.

Spanned records
If the record is bigger than the CI size, it cannot be stored.

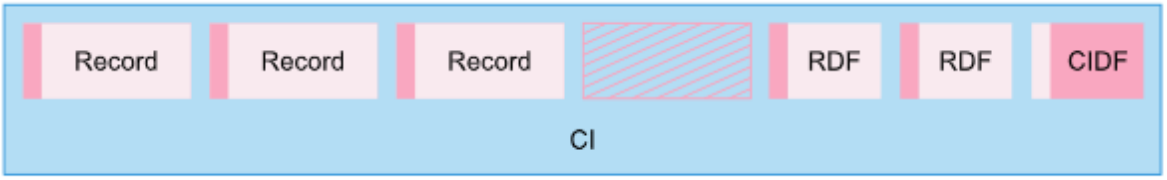
However if the VSAM data set is defined as spanned, the record can span across more than one CI. This is called a spanned record.

Spanned records occupy entire CIs. Any unused space in the CI cannot be used.



CI Structure

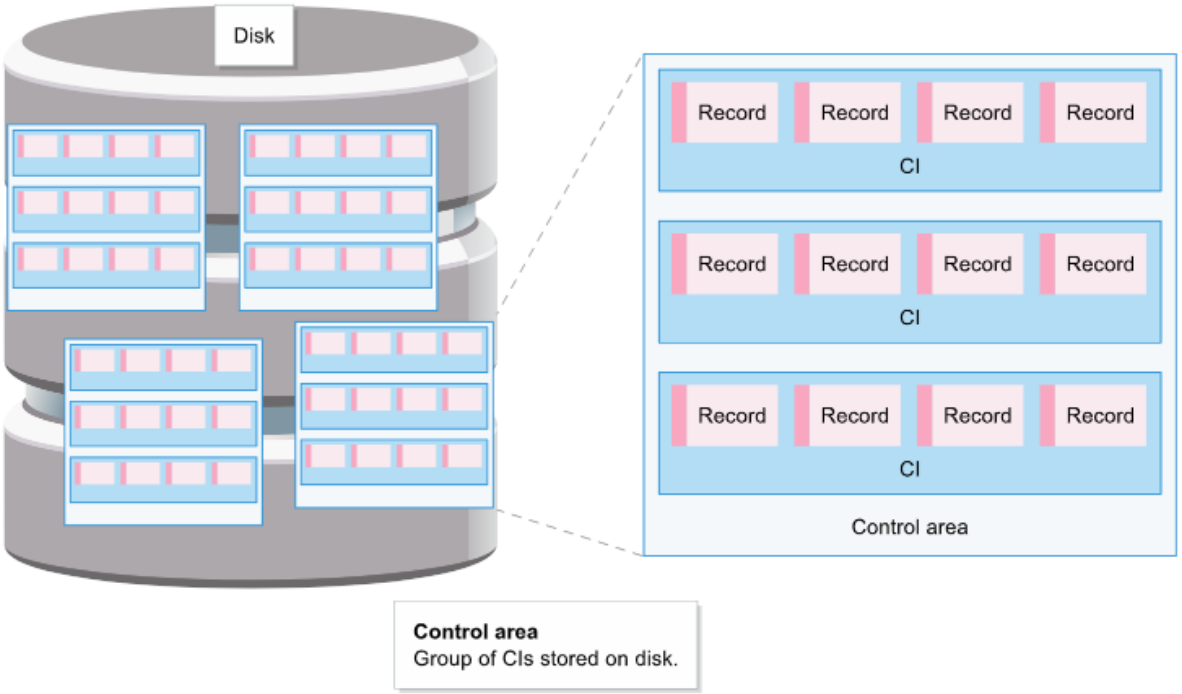
VSAM not only stores records in the CI. It also stores other information needed to manage the CI. This information includes the following



- **Records** - Data records are stored in each interval.
- **Unused Space** - For ESDS data sets, this cannot be used unless it is after the final record in the data set.
- **Record Definition Field (RDF)** - The RDF stores the length of each record. There is one per record for VSAM data sets with variable length records. VSAM data sets with fixed length records only need two; one for the record length and one recording the number of records.
- **Control Interval Definition Field (CIDF**) - This is one 4-byte field holding the size and location of unused space in the CI.

Control Areas

VSAM CIs are stored on disk in groups. These groups are called control areas (CAs). One VSAM data set can have one or more CAs.



The size of the CA is determined by the system when the data set is defined.

RRDS

The relative record data set (RRDS) is another type of VSAM data set.

How RRDS Data Sets Work

- **Structure:**
  - RRDS data sets consist of fixed length areas called slots. Slots are pre-formatted when the data set is created, or whenever a new CA is created.
  - Records are inserted and deleted into these slots.
  - They also have the same CI structure as ESDA data sets, including RDFs and CIDFs. Any unused space created as a result of CI fragmentation cannot be used to store data.
  - There is one RDF for every slot; each RDF is used to indicate whether the corresponding slot is being used or is empty.
- **Limitations:**
  - All records must be the same length.
  - No spanned records; records cannot span slots or CIs.

RRDS Access

RRDS data sets have some advantages over ESDS data sets:

- Records can be added and deleted within the data set.
- Records can be directly accessed by specifying the slot number. This is called a Relative Record Number, or RRN. The first slot has an RRN of 1.
- Skip-sequential processing can be used.

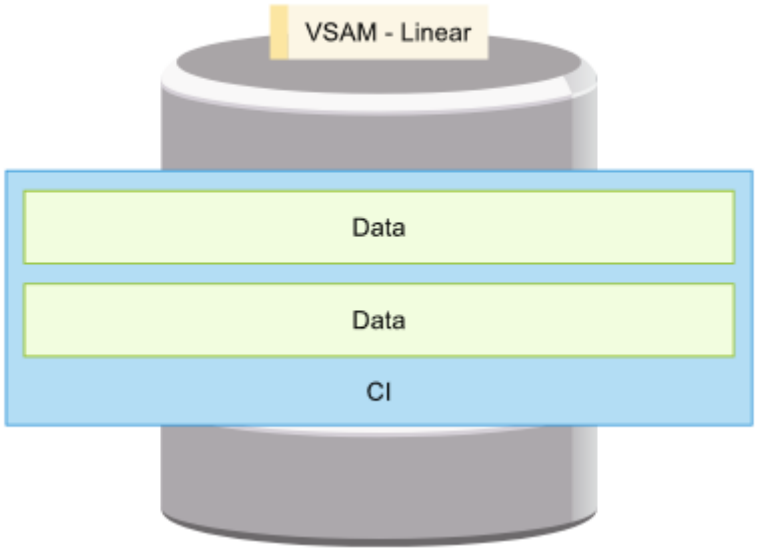
RRDS data sets are excellent for applications with fixed length records where direct access by relative record numbers is needed. In reality, RRDS data sets are rarely used today.

How to access:

- **Sequential access** - Like ESDS data sets, records can be located sequentially by checking each record, starting from the beginning of the data set.
- **Direct access** - A RRDS record can be located by specifying the RRN; for example to access the 8th record the RRN would be 8.
- **Skip-sequential access** - A RRDS record can be located directly by specifying the RRN, and subsequent records accessed sequentially.
- **New Records** - These can be inserted into any free slot. The application program can specify the destination slot; this is known as direct insertion. Or the application program can request the record be inserted in the next slot; this is known as sequential insertion.
- **Removing Records** - Any record can be deleted, and the slot reused.

Linear Data Sets

Linear data sets are different from other VSAM data sets. They do not hold records, but simply strings of data.



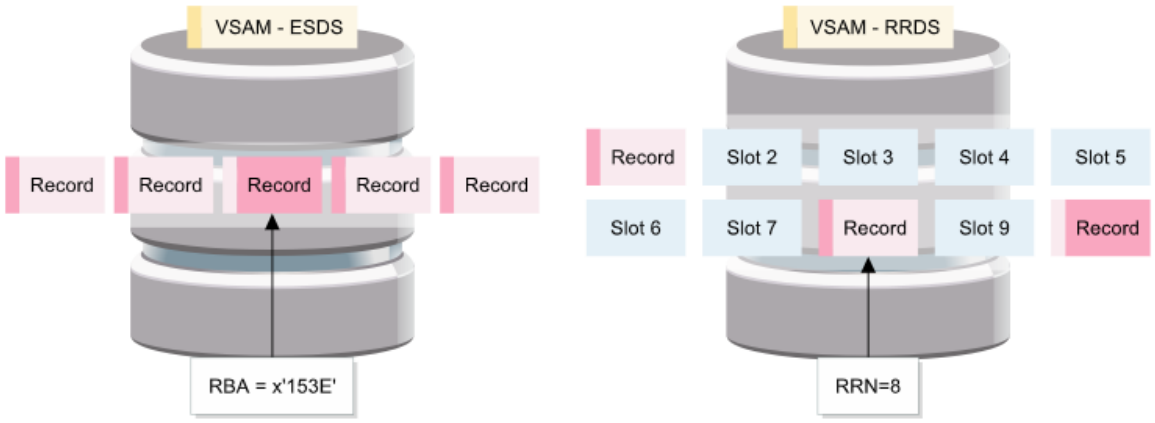
Linear data sets are usually used by programs and applications that want to specify their own internal record structure. Db2 uses linear data sets to store Db2 objects.

How Linear Data Sets Work

- **Structure** - Linear data sets hold only data. There are no records, and no RDFs or CIDFs. Programs accessing the data set must internally determine their own record structure.
- **Access** - Programs use z/OS data-in-virtual (DIV) or similar services to insert, update, read and delete data as if it was memory.

VSAM Indexes

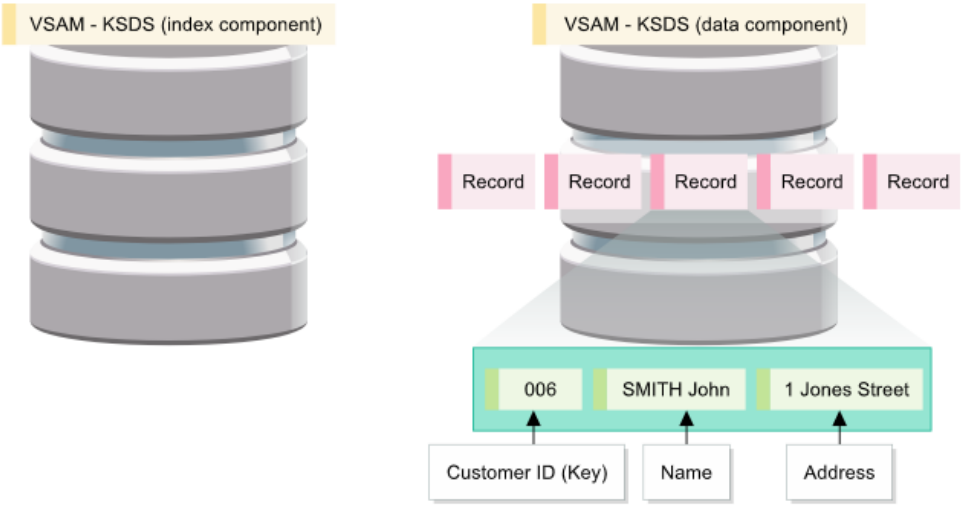
ESDS and RRDS VSAM data sets are excellent for sequential access. However, to directly locate a record inside these data sets a program must know either the RBA for ESDS, or the RRN for RRDS.



Although there are ways to obtain the RBA or RRN, it can be difficult. VSAM solves this problem with another VSAM data set type; the key sequenced data set (KSDS).

KSDS

A KSDS is actually two VSAM data sets that are used together. Each data set is called a component.



The data component holds the data in the same way as an ESDS; fixed or variable length. A part of each record is the record's key.

- This key can be any 1-255 contiguous bytes in the record that are unique.
- There cannot be two records with the same key.
- This key must also be the same length and position for all records.
- This key can be used to locate the record.

Record Insert into KSDS

Records in the data component of a KSDS are stored in key order.

They can be stored sequentially or directly.

Once a record has been inserted, its key cannot be altered. To change a record's key, the record must be deleted and re-inserted.

- **Free Space** - When defining VSAM data sets (other than RRDS), the amount of space to leave free in every CI is specified: the free space. RRDS data sets do not have free space.
- **Sequential insert** - KSDS records can be inserted sequentially. This often happens when the data set is first created and the data is loaded in. Records are inserted in key order until the free space limit is reached or the CI is full. Records are then inserted in the next CI.
- **Direct insert** - Records can also be inserted directly. This is the normal processing when using a VSAM data set that has already been loaded with data. A record is inserted in a space so that it is in key order. If there is not enough room to insert a record, other records are moved into the free space to make room for the new record.

Record Update in KSDS

Records in a KSDS data component can be updated and their length changed.

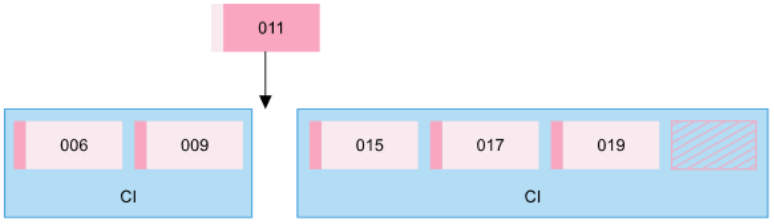
- **Same Length** - If a record is updated and the length is the same, the processing is the same as for an ESDS or KSDS.
- **Reduced Length** - If the length of the record being updated is reduced, then the remaining space is now free space. It can be reused as necessary for record inserts or updates.
- **Increased Length** - If the length of the record being updated is increased, then the records are moved into the free space to make room for the extra length.

CI Split

If there is not enough free space in a CI for a new record or increased length of an existing record, the CI is split into two. This is called a CI split.

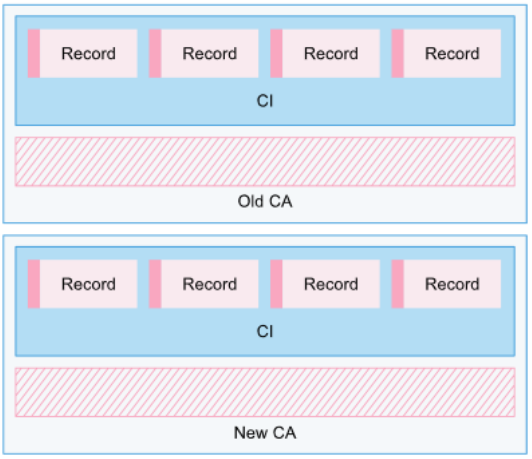
Suppose a new record is ready to be inserted, or an existing record will be updated and its length increased. However, there is not enough free space in the CI for the new data to fit.

- The CI is split into two.
- The second half is moved to a free CI in the CA
- There is now enough free space to insert the new record, or to expand an existing one.



CA Split

In a CI split, half of the CI is moved to a spare CI in the CA. Like CI, the amount of space to leave free in every CA can be specified when defining the VSAM data set - the free space.



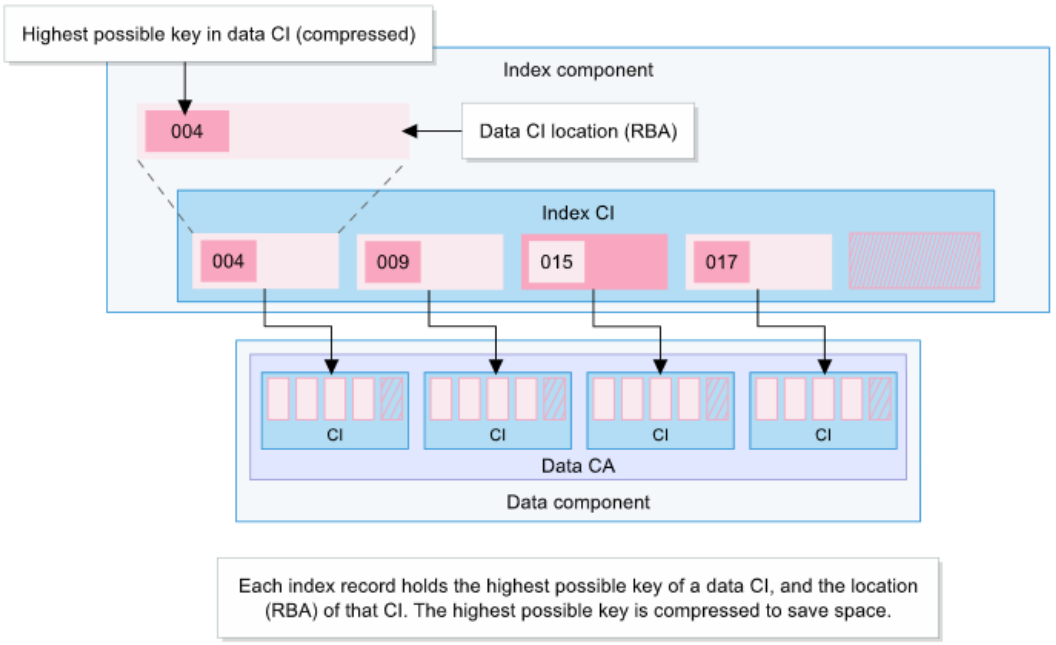
During sequential inserts, this free space is not used. If there is a CI split, one half of the CI is moved into a new CI in the CA free space.

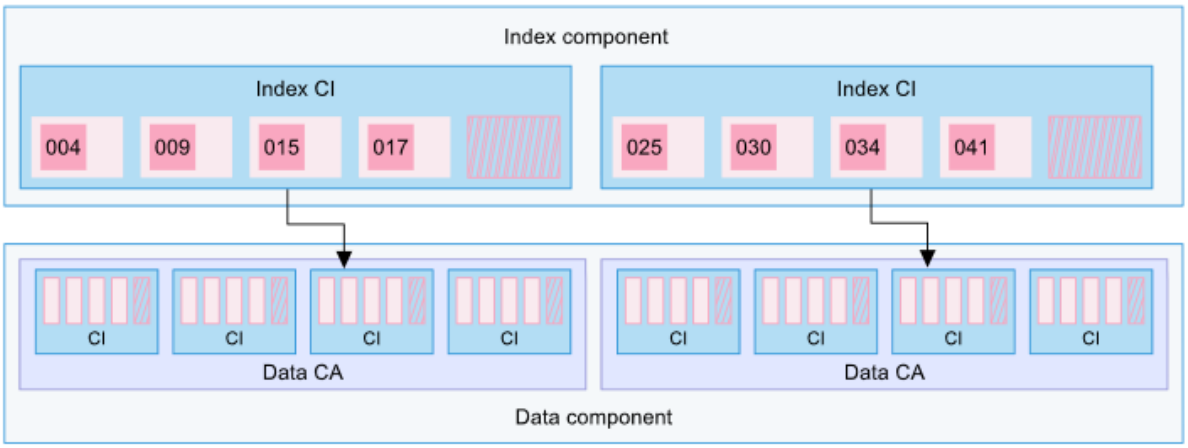
- If there is not enough space in the CA for another CI, then the CA is split into two.
- This is when one half of the cold CA is moved to a new CA at the end of the VSAM data set.
- The CI split can now be processed.

KSDS Index

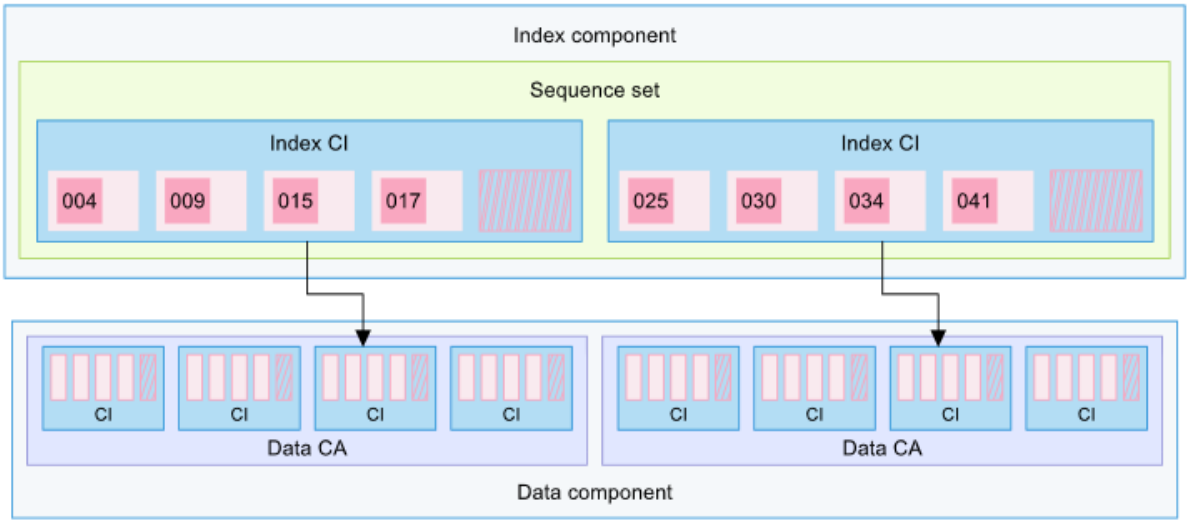
The index component of a KSDS holds exactly that, an index into the data component. This is sometimes called the prime index. It is built automatically as records are inserted, updated, or deleted. It is also updated automatically for any CA or CI splits.

This index allows VSAM to locate any data record given its key value.

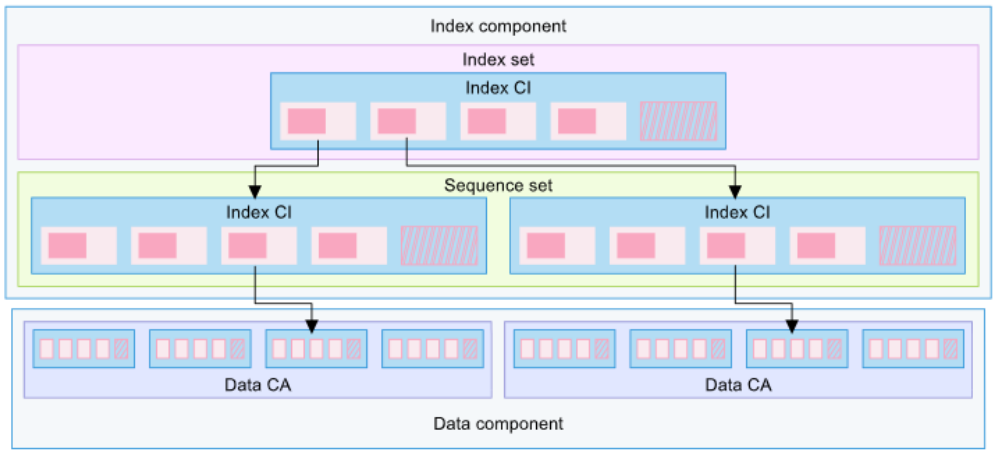




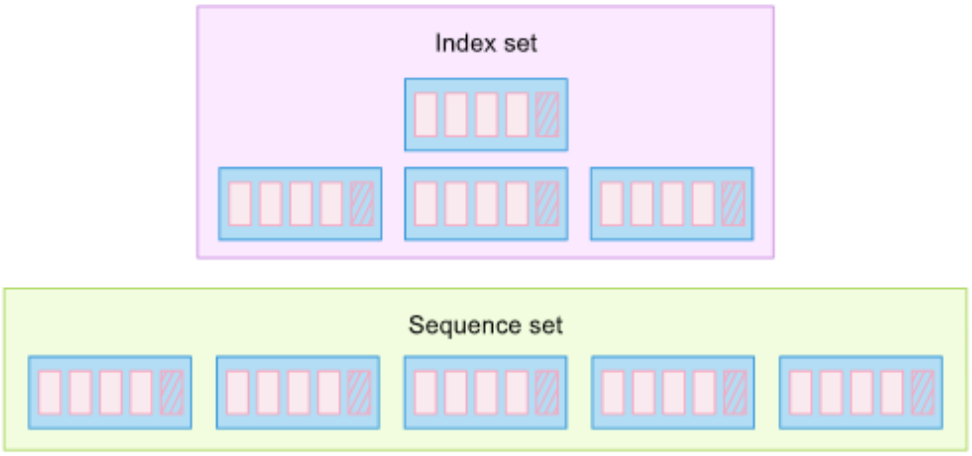
Every index CI holds all the indexes for one data CA.



This index is called the sequence set.



Larger VSAM data sets will have a second index level, where each record points to a sequence set CI. When accessing a VSAM data set, this second level is accessed first to find the sequence set index record. The sequence set record is then accessed to locate the data record.



VSAM data sets can have many index levels. However, there will always be only one sequence set.

Index Component Structure

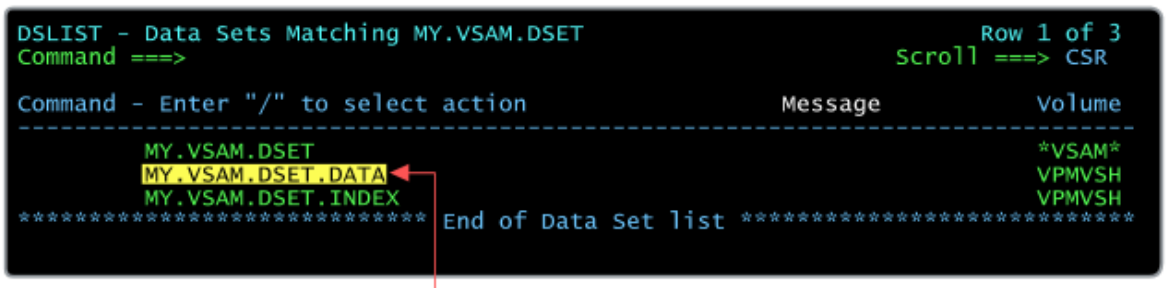
The KSDS index component is very similar in structure to the data component.

- **CIs and Free Space** - The index component is broken into CIs. The size of this CI can be determined when creating the VSAm data set. The free space of each index CI can also be specified when creating the VSAM data set.
- **CAs and Free Space** - Like the data component, the index CIs are grouped into CAs. Like all CAs, the size is determined by the system. The free space of each index CA can be specified when creating the VSAM data set.
- **CI Split** - Index CIs will split if there is not enough space in the CI for another index record.
- **CA Split** - If the index CA does not have enough space for a new index CI, a CA split will occur.

KSDS Data Set Names

This screen shows the ISPF DSLIST (option 3.4) listing of a VSAM KSDS. All these components together are called a VSAM cluster.

The name of each component is specified when the VSAM data set is created, and can be any valid data set name. However, most users use the cluster name for the data and index components, ending each with something like DATA or INDEX respectively.



The Components:

- **Cluster Component** - A component that relates the data and index components together. The cluster component is not a data set, only a catalog entry. All VSAM data sets have a cluster component, and any program or utility accessing a VSAM data set refers to the cluster component.
- **Data Component** - Every VSAM data set has a data component
- **Index Component** - Only KSDS and VRRDS data sets have an index component

KSDS Processing

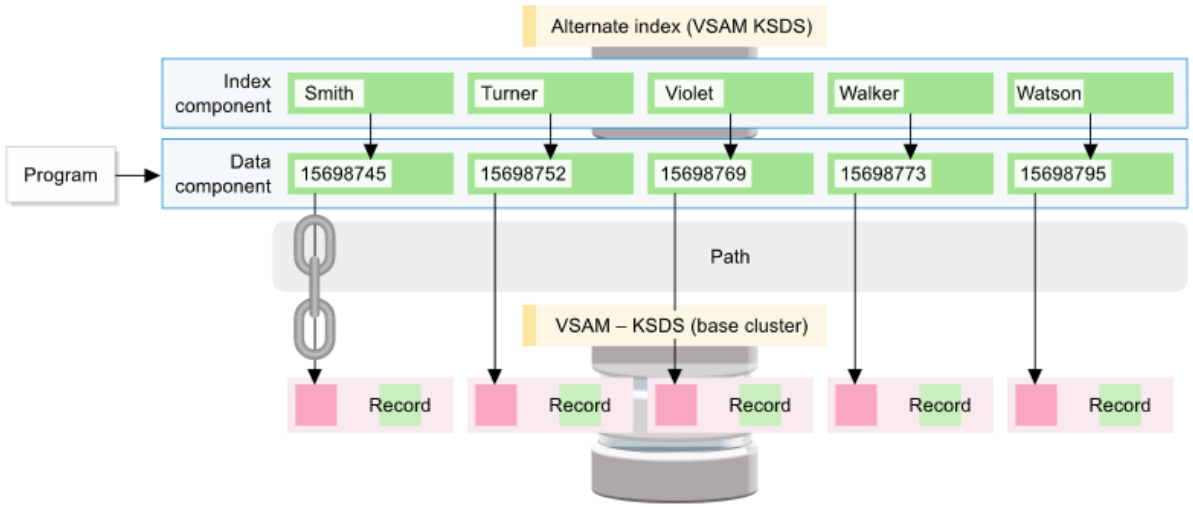
KSDS data sets can be accessed sequentially, directly, or skip-sequentially.

- **Sequential access** - Like ESDS and RRDS data sets, records can be located or processed sequentially by accessing each record. Records are accessed from the lowest key to the highest key. Records in a KSDS are not necessarily next to each other, particularly if a CI or CA split has occurred. So sequential processing locates each record using the sequence set in the index component.
- **Direct access** - Records in a KSDS can be located directly by specifying the record key. The KSDS index is accessed to locate the record with this corresponding key.
- **Skip-sequential access** - A record in a KSDS can be located directly by specifying the record key. Records after this record are processed sequentially.

Alternate Indexes

Suppose a VSAM record can be accessed by two different keys. For example, a telephone directory may have a unique customer number and telephone number.

VSAM allows this using an alternate index. An alternate index is the way of accessing a VSAM data set using a key that is different from the defined key. So in the example, the VSAM key could be the telephone number and the alternate index is the customer number.



Alternate indexes can also be used to add an index to an existing ESDS data set.

- An alternate index is a group of pointers into a VSAM KSDS or ESDS data set using a different key. The VSAM data set holding the data is called the base cluster.
- For example, a KSDS may use an eight byte customer ID at the beginning of the record as the primary key. An alternate index could be defined to use the 20 byte customer name beginning at position 8 in the record.

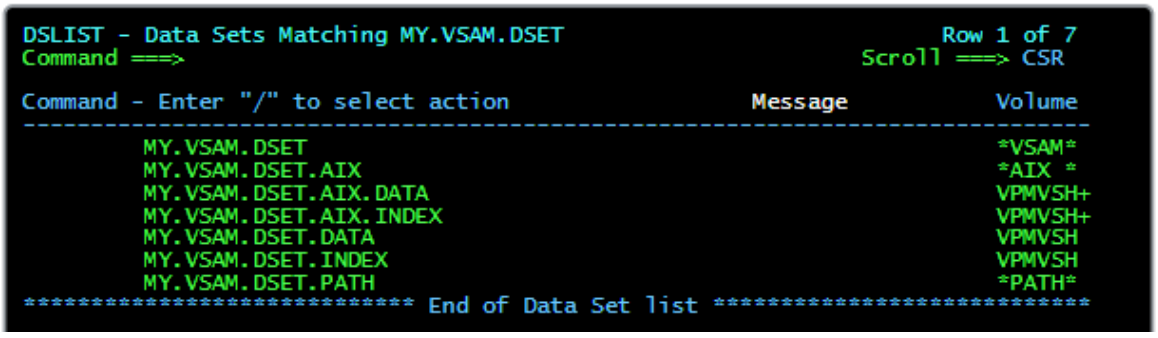
- One base cluster can have any number of alternate indexes.
- There is one alternate index object for every alternate key in a base cluster. Like the primary key of the base cluster, alternate keys can be any 1-255 contiguous bytes in a VSAM record. However, unlike the primary key, alternate keys do not have to be unique. There can be more than one base cluster record with the same alternate key.
- The alternate index object is itself a VSAM KSDS that is created after the base cluster.
    - The data component of the alternate index holds pointers to the base cluster, either an RBA address (if the base cluster is an ESDS) or the prime key (if the data component is a KSDS).
    - The index component works the same as the index component of a VSAM KSDS.
- Once the alternate index has been built, an object called a path is created to link the alternate index to the base cluster.
- Programs access the path as if it was the base cluster, using the alternate key. The alternate index can be automatically updated by VSAM whenever the base cluster changes.

VSAM Sphere

This screen shows the ISPF DSLIST (option 3.4) listing of a VSAM KSDS together with its alternate indexes and paths. There is a base cluster component KSDS (MY.VSAM.DSET), alternate index (MY.VSAM.DSET.AIX), and path (MY.VSAM.DSET.PATH). All these components together are called a VSAM sphere.

Like the cluster components of the KSDS and alternate index, the path does not exist on disk; it is only a catalog entry that relates the base cluster and alternate index together.

All these objects can have any name specified when creating the base component, alternate index, or path.

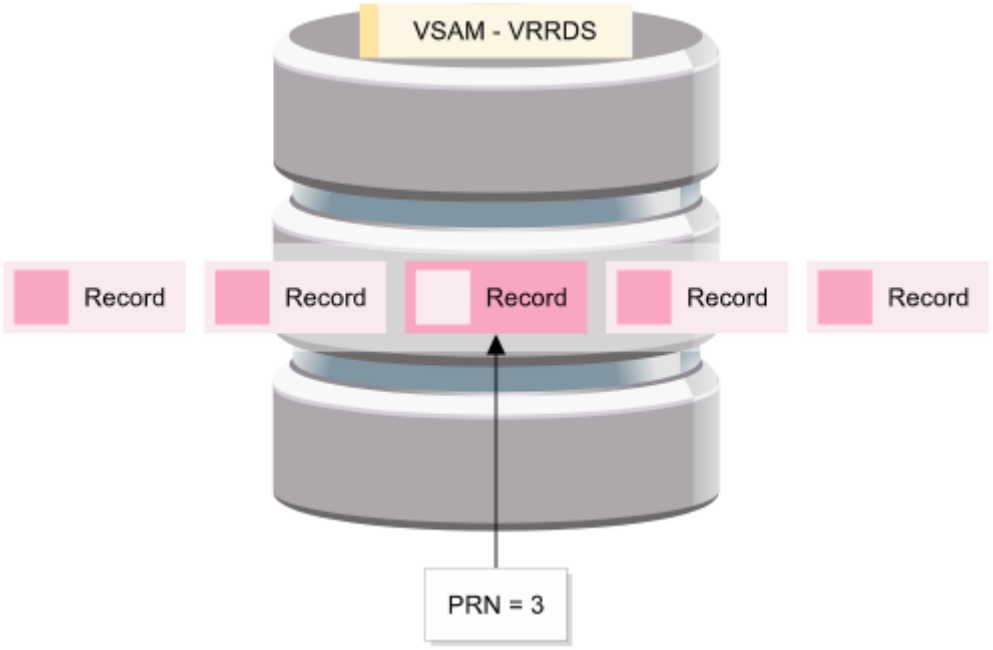


VRRDS

The previous section introduced VSAM RRDS data sets, and how they must have fixed-length records.

VSAM has another data set: Variable-length Relative Record Data Set (VRRDS). Like an RRDS, the VRRDS can be accessed sequentially or directly using the RRN. However, they can hold variable length records.

Unlike RRDSs, VRRDSs do not have slots. They are in effect VSAM KSDS data sets that are accessed using an RRN instead of a key. Like KSDS data sets, they have both a data component and an index component.



Creating VSAM Data Sets

Introduction

There are several different ways to allocate a VSAM data set; from ISPF panels and TSO/E commands to batch jobs.

Some of these include:

- **IDCAMS** - VSAM data sets can be created using the access method services utility IDCAMS from a batch job.
- **TSO/E Define** - VSAM data sets can be created using this command.
- **TSO/E Allocate** - VSAM data sets can be created using this command.
- **DD Statement** - A DD statement can be used to allocate a VSAM data set.
- ISPF Panels - The ISPF VSAM Utilities panel (ISPF option 3.2.V) can be used to create a VSAM data set.
- **Dynamic Allocate** - A VSAM can be allocated within a program using z/OS dynamic allocation services.
- **Utilities** - Utility products such as IBM File Manager for z/OS provide panels and functions to create VSAM data sets.

Using IDCAMS

The z/OS component used to create and manage VSAM data sets is called Access Method Services (AMS).

The primary AMS utility used with VSAM data sets is a batch utility called IDCAMS. IDCAMS is used frequently when dealing with VSAM data sets.

Some data set tasks:

- Create - This can create VSAM data sets, alternate indexes, and paths.

```
//JOB001 JOB (ACCT),IDCAMS,MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
  DEFINE CLUSTER -
     (NAME(DAVIDS.VSAM1) -
     INDEXED -
     FREESPACE(20 20) -
     VOLUMES(*) -
     STORCLAS(SC1)) -
  DATA -
    (CYLINDERS(5 1) -
     KEYS(5 0) -
     RECORDSIZE(80 80)) -
  INDEX -
    (CYLINDERS(1 1))
/*
```

- Delete - This can delete any VSAM data set or object, or any non-VSAM data sets.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   DELETE DAVIDS.VSAM1
```

- Modify - This can change VSAM data set characteristics; however, there are restrictions on what type of data set attributes can be modified.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   ALTER DAVIDS.VSAM1 NEWNAME(DAVIDS.VSAM2)
```

- Copy and Move - Can copy and move data between VSAM and non-VSAM data sets.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTDATASET(DAVIDS.QSAM1)
```

- List - Can be used to list data set information and print data stored in a data set.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   LISTCAT ENT(DAVIDS.VSAM1) ALL
```

IDCAMS Return Codes

IDCAMS returns messages describing what has happened, and a return code that indicates the success or failure of the command. Every command also returns a return code for example:

- 0 - command successful
- 4 - command with warnings
- 8 - command completed with errors
- 12 - an error prevented the command from completing
- 16 - a serious error occurred in SYSIN

Coding IDCAMS

The IDCAMS batch utility requires a SYSIN and SYSPRINT DD statement, while other DD statements may be added depending on the task being performed.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
   /* Copy DAVIDS.VSAM1 to QSAM1 DD */
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTFILE(QSAM1)
```

Details on each statement:

- Statement 1 - The program name is IDCAMS.
- Statement 2 - IDCAMS messages and information are sent to the SYSPRINT DD; This is a required DD statement.
- Statement 3 - Other DD statements may be used by IDCAMS commands.
- Statement 4 - IDCAMS commands are read from SYSIN DD. This is a required DD statement. In this case, we are copying records from the VSAM data set: DAVIDS.VSAM1 to the sequential data set specified in the QSAM1 DD statement.
- Statement 5 - SYSIN DD statement in-stream data can contain comments by enclosing it between /* and */ strings.
- Statement 6 - SYSIN statements must be in columns 2 to 72; these margins can be changed using the MARGINS parameter on the EXEC statement.

IDCAMS Modal Commands

The IDCAMS utility is documented in the IBM z/OS DFSMS Access Method Services Command manual.

IDCAMS messages all begin with the three characters IDC, and are documented in the z/OS messages manuals or can be found by searching via the IBM Knowledge Center search facility.

Modal Commands:

- Conditional execution based on the success of the previous function:
    - In this example, the IF statement uses the LASTCC parameter to obtain the condition code from the last functional command performed (REPRO). It then compares this to a value, which if true, will invoke another command (DELETE).

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTFILE(QSAM1)
   IF LASTCC = 0 THEN -
      DELETE DAVIDS.VSAM1
```

- Conditional execution based on the maximum condition code:
    - In this example, the IF statement uses the MAXCC parameter to obtain the highest condition code from any previous functional command performed within the step. It then compares this to a value, which if true, will invoke another command (DELETE).

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTFILE(QSAM1)
   IF MAXCC <= 4 THEN -
      DELETE DAVIDS.VSAM1
```

- Action taken if a comparison is true or false:
    - In this example, the IF THEN and ELSE command sequence identifies the action to be taken based on the condition code from the last functional command performed (REPRO). If this is true, then the DAVIDS.VSAM1 data set will be deleted. If this is false, then the DAVIDS.VSAM2 data set will be deleted.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTFILE(QSAM1)
   IF LASTCC = 0 THEN -
      DELETE DAVIDS.VSAM1
   ELSE -
      DELETE DAVIDS.VSAM2
```

- Invoking several actions based on a condition:
    - In this example, the IF statement uses DO and END to specify a group of commands (DELETE and ALTER) to be invoked if the condition code from the REPRO functional command is 0.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTFILE(QSAM1)
   IF LASTCC = 0 THEN DO
      DELETE DAVIDS.VSAM1
      ALTER DAVIDS.VSAM2 NEWNAME(DAVIDS.VSAM2.COPY)
   END
```

- End processing of the current job step:
    - In this example, the IF statement uses the CANCEL command to end the current job step immediately. This means that the ALTER command will not be invoked if the condition code from the REPRO command is greater than 4.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
   REPRO INDATASET(DAVIDS.VSAM1) -
         OUTFILE(QSAM1)
   IF LASTCC > 4 THEN -
      DELETE DAVIDS.VSAM1
   ELSE -
    CANCEL
   ALTER DAVIDS.VSAM2 NEW NEWNAME(DAVIDS.VSAM2.OLD)
```

- Reset a condition code:
    - In this example, the SET command is used to change the value of the LASTCC and MAXCC parameters to 0. This means that regardless of the result for the DELETE command, the condition code for the step will always be displayed as 0.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//QSAM1    DD DISP=OLD,DSN=DAVIDS.QSAM1
//SYSIN    DD *
 DELETE DAVIDS.VSAM1
 SET LASTCC = 0
    SET MAXCC = 0
```

IDCAMS Documentation

The IDCAMS utility is documented in the IBM z/OS DFSMS Access Method Services for Catalogs manual.

IDCAMS messages all begin with the three characters IDC, and are documented in the z/OS messages manuals.

TSO/E and IDCAMS

IDCAMS commands can also be used from TSO/E. The syntax of each IDCAMS command is the same as if it was submitted from a batch. Messages are returned to the TSO/E user.

The TSO/E HELP command can also be used to find out information about IDCAMS commands, for example, HELP DEFINE.

```
 READY
DEFINE CLUSTER(NAME('DAVIDS.VSAM4') INDEXED FREESPACE(20 20) VOLUMES(*)
STORCLAS(SC1)) DATA(CYLINDERS(5 1) KEYS(5 0) RECORDS(80 80))
INDEX(CYLINDERS(1 1))
 DATA ALLOCATION STATUS FOR VOLUME VPSMSB IS 0
 INDEX ALLOCATION STATUS FOR VOLUME VPSMSB IS 0
 NAME GENERATED-(D) DAVIDS.VSAM1.DATA
 NAME GENERATED-(I) DAVIDS.VSAM1.INDEX
 STORAGECLASS USED IS SC1
 READY
```

BATCH DD

The standard JCL DD statement can be used to define and delete only DFSMS managed VSAM data sets. However, the DD statement only has a subset of the VSAM options provided by IDCAMS. For example, VRRDS data sets cannot be defined from a DD statement.

VSAM related DD statement parameters are documented in the standard z/OS JCL manuals.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IEFBR14
//DD1      DD DISP=(,CATLG),DSN=DAVIDS.VSAM3,STORCLAS=SC1,
//         LRECL=80,KEYLEN=5,KEYOFF=0,RECORG=KS,
//         SPACE=(CYL,(5,5))
```

TSO/E Allocate

The TSO/E ALLOCATE command is the standard command for allocating data sets from TSO/E. It can also be used to allocate and delete VSAM data sets.

The ALLOCATE command has the same limitations as the JCL DD statement for VSAM data sets.

VSAM related options can be found using the TSO/E HELP command HELP ALLOCATE.

```
 READY
ALLOCATE DA('DAVIDS.VSAM1') NEW SPACE(5,5) CYLINDERS STORCLAS(SC1)
RECORG(KS) KEYOFF(0) KEYLEN(5) LRECL(80)
 READY
```

Dynamic Allocation

Dynamic allocation allows programs to allocate data sets. It can also be used to allocate and delete VSAM data sets.

Dynamic allocation has the same limitations as the JCL DD statement and TSO/E ALLOCATE command for VSAM data sets.

Dynamic allocation is documented in the z/OS Assembler Services Guide.

```
FILE-CONTROL.
   SELECT VSAM-DSET   ASSIGN S-PRINT  STATUS IS PRINT-STAT.

 01 ENV-VARS.
    05 ENV-NAME       PIC X(8).
    05 ENV-VALUE      PIC X(100).
    05 ENV-OVERWRITE  PIC S9(8) COMP.

  01 PRINT-STAT        PIC 99.

 PROCEDURE DIVISION.
 SETUP.
     MOVE z'PRINT' TO ENV-NAME.
     MOVE z'DSN(DAVIDS.VSAM3),NEW,CYL,SPACE(5,5),STORCLAS(SC),CATALOG
-          'LRECL(80),RECORG(KS),KEYLEN(5),KEYOFF(0)'
           TO ENV-VALUE.
     MOVE 1 TO ENV-OVERWRITE.
     CALL "setenv" USING ENV-NAME, ENV-VALUE, ENV-OVERWRITE.
     OPEN OUTPUT VSAM-DSET.
```

Focusing on IDCAMS

Define Cluster

The IDCAMS function to create a VSAM data set is the DEFINE CLUSTER command. This function can be used to specify all VSAM options.

Details:

- The DEFINE CLUSTER command is used to define the attributes of the VSAM data set and its components.
- The NAME parameter is used to specify the name of the cluster. This can be any valid data set name.
- The CYLINDERS parameter specifies the space allocation for the entire cluster, both data and index components, in cylinders. In this example, the primary space allocation is 5 cylinders, and the secondary space allocation is 1 cylinder.
    - If a secondary allocation is not required, then this parameter can be coded like this - CYLINDERS(5).
    - TRACKS, KILOBYTES, MEGABYTES and RECORDS can also be used instead of CYLINDERS to specify primary and secondary in different units.
    - A space allocation must be specified, unless it is automatically defined by DFSMS for a DFSMS managed data set.
- The VOLUMES parameter lists candidate volumes for the data set. Up to 59 volume serial numbers can be specified. In this example the VSAM data set can be multi-volume on VOL001 or VOL002. VOL001 will be attempted first, and VOL002 used if there is not enough space on VOL001.
- To allow DFSMS to choose a volume, an asterisk (*) can be used as the volume serial number - VOLUMES (*).
    - Using two or more asterisks like VOLUMES (* *) would allow the data set to be a multi-volume.
    - Volumes must be specified , unless it is automatically defined by DFSMS for a DFSMS managed data set.
- All DEFINE CLUSTER parameters must be enclosed by a set of brackets.
- When this job is submitted, the VSAM data set is created. By default VSAM uses the cluster name for the data component, adding the string '.DATA' to the end. VSAM also uses the cluster name for the index component, adding '.INDEX' to the end.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   DEFINE CLUSTER -
      (NAME(DAVIDS.VSAM1) -
      CYLINDERS(5 1) -
      VOLUMES(VOL001 VOL002) -
   )
```

Specifying Parameters

In the previous screen a VSAM data set was created, specifying the VSAM cluster name, space, and location. This will create a data set with default VSAM options.

In most cases, specific VSAM options that are different to the defaults are needed. This can be done in different ways.

Defaults:

If VSAM parameters are not specified in the DEFINE CLUSTER command, default values will be used.

Default VSAM Options
Type: KSDS
Record Length: fixed length of 4089 bytes
Spanned: no
Key Length: 64 bytes
Key Offset: 0 (starts at beginning of record)
Control Interval Size: system determined for direct access
Data component name: cluster name with '.DATA' at the end
Index component name: cluster name with '.INDEX' at the end

DFSMS Data Class:

These can optionally specify default VSAM options to be used by all VSAM data sets created with that Data Class. Storage administrators can automatically assign a Data Class to a data set, or it can be specified using the DATACLASS or DATACLAS parameter.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
  DEFINE CLUSTER -
     (NAME(DAVIDS.VSAM1) -
     CYLINDERS(5 1) -
     VOLUMES(VOL001 VOL002) -
     DATACLAS(DC1) -
     )
```

DFSMS Data Class and Extended Format VSAM:

DFSMS Data Class options are the only way to create Extended Format VSAM data sets, and use EFVSAM functionality such as compression, data set striping, and system managed buffering. There are no DEFINE CLUSTER parameters to enable this functionality.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
  DEFINE CLUSTER -
     (NAME(DAVIDS.VSAM1) -
     CYLINDERS(5 1) -
     VOLUMES(VOL001 VOL002) -
     DATACLAS(DC1) -
     )
```

DFSMS Management Class and Storage Class:

The DFSMS management class and storage class can also be specified using the STORAGECLASS or STORCLAS and MANAGEMENTCLASS or MGMTCLAS parameters.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
  DEFINE CLUSTER -
     (NAME(DAVIDS.VSAM1) -
     CYLINDERS(5 1) -
     VOLUMES(VOL001 VOL002) -
     DATACLAS(DC1) -
     MGMTCLAS(MC1) -
     STORCLAS(SC1) -
     )
```

Model:

An existing VSAM data set can also be used as a template using the MODEL parameter. All VSAM options (except DATACLAS, MANAGEMENTCLASS and STORAGECLASS) not specified in the DEFINE CLUSTER command will be taken from the template, or model, data set. In the example below, all options except RECORDSIZE, CYLINDERS and VOLUMES will be taken from the data set DAVIDS.MODEL.VSAM.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD  SYSOUT=*
//SYSIN    DD  *
  DEFINE CLUSTER -
     (NAME(DAVIDS.VSAM1) -
     CYLINDERS(5 1) -
     VOLUMES(VOL001 VOL002) -
     MODEL (DAVIDS.MODEL.VSAM) -
     RECORDSIZE(80 80) -
     )
```

Data Set Structural Parameters

A number of other DEFINE CLUSTER parameters specify the structure of the VSAM data set. These include the following:

Record Size:
The RECORDSIZE parameter is used to specify the average and maximum size of records to be stored in the VSAM data set. In this example, variable length records with an average record size of 80 bytes and a maximum record size of 200 bytes will be accommodated in the data set's data component.

Keys:
The KEYS parameter identifies the prime key length and its location within the KSDS. In this example, the prime key is 5 bytes in length and begins at byte 0, which is the beginning of the data record. The KEYS parameter is not used for other types of VSAM data sets.

Data Organization:
This parameter is used to define the type of data organization for the VSAM data set.

- INDEXED - KSDS (the default)
- NUMBERED - RRDS (if fixed length records) or VRRDS (if variable length)
- NONINDEXED - ESDS
- ZFS - A linear data set used for a UNIX System Services zFS file system

Control Interval Size:
The CONTROLINTERVALSIZE or CISZ parameter specifies the control interval size for all components (data and index) in bytes. If not specified, the system chooses the CI size that is best for direct access.

Free Space:
This parameter is used to define the percentage of space to leave free for every Control Interval and Control Area when a VSAM dataset is initially loaded or a mass (or sequential) insert is performed. In this example, 20% of every CI and 30% of every CA will be left free.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   DEFINE CLUSTER -
      (NAME(DAVIDS.VSAM1) -
      CYLINDERS(5 1) -
      VOLUMES(VOL001 VOL002) -
      RECORDSIZE(80 80) -
      KEYS(5 0) -
      INDEXED -
      CISZ(23400) -
      FREESPACE(20 30) -
   )
```

Other Parameters

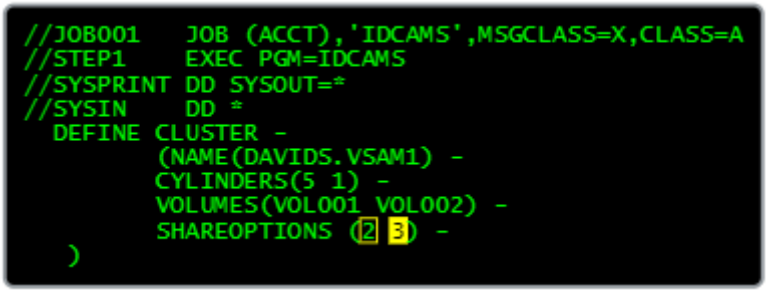
There are several other optional parameters that can be specified for a VSAM data set. The IBM DFSMS Access Method Services Commands manual documents them all.

USS	Commands
BUFFERSPACE	Minimum buffer space to use.
ERASE	If the catalog entry for the VSAM data set is deleted, the ERASE parameter will overwrite each VSAM data set component with binary zeros.
OWNER	Userid of the dataset owner.
REUSE	Clears the VSAM dataset every time it is opened. This is good for temporary files.
SPANNED	Allows records larger than one CI to span multiple CIs.

Sharing

VSAM data sets can be shared by different jobs and tasks, both on the same z/OS system, and other systems. The SHAREOPTIONS parameter specifies how the VSAM data set will be shared. This parameter contains two values:

- The first specifies sharing capabilities related to the same z/OS system, or another z/OS system sharing data sets using global resource serialisation.
    - 1 - Many tasks can read the data set at the same time. Only one can update it, and no users can read the data set while it is being updated. VSAM maintains data set integrity.
    - 2 - This is the same as specifying 1 except that many users can read the data set while it is being updated. VSAM maintains data set integrity, but the tasks accessing it must manage read integrity.
    - 3 - Many tasks read from and write to the data set at the same time. The tasks accessing the data set must maintain all integrity.
    - 4 - This is the same as specifying 3 except that buffers are refreshed after every update.
- The second describes how the data set will be shared across multiple systems.
    - 3 - Many tasks across the systems can be read from and written to the data set at the same time. The tasks accessing the data set are responsible for maintaining its integrity.
    - 4 - This is the same as specifying 3 except that buffers are refreshed after every update.



Data and Index Components

All DEFINE CLUSTER parameters mentioned so far have been for the entire cluster. Sometimes parameters may need to be specified only for a single component of the VSAM file.

Parameters for the data and index component can be specified after the Cluster components using the DATA and INDEX statements.

- Just like CLUSTER parameters, the DATA and INDEX parameters are enclosed in parentheses.
- It is common to have different parameters for the data and index component. For example, space, name, and CI size parameters are often different for each component.
- The syntax for parameters is the same in all sections of DEFINE CLUSTER. However, some parameters may not be applicable in the data or index component.
- Some parameters can be specified in either the cluster or data sections for example RECORDSIZE or KEYS.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IDCAMS
//SYSPRINT DD SYSOUT=*
//SYSIN    DD *
   DEFINE CLUSTER -
      (NAME(DAVIDS.VSAM1) -
      VOLUMES(VOL001 VOL002) -
      SHAREOPTIONS (1 3)) -
   DATA -
     (NAME(DAVIDS.VSAM1.DATA) -
      CYLINDERS(50 10) -
      CISZ(23000)) -
   INDEX -
     (NAME(DAVIDS.VSAM1.INDEX) -
      CYLINDERS(2 1) -
      CISZ(4096))
```

IDCAMS and JCL

IDCAMS has been the face of VSAM for a long time. More recently, z/OS has been enhanced to allow VSAM data sets to be created from JCL DD statements.

JCL DD statements have some advantages and disadvantages to using IDCAMS. These same advantages and disadvantages also apply to the TSO/E ALLOCATE command and z/OS dynamic allocation.

Advantages:

- Using a DD statement is the only way to create a temporary VSAM data set. Like other data sets, this is done by specifying a data set name beginning with the characters & or && or omitting the data set name.
- As the VSAM data set is created from a DD, there is no need for an extra jobstep to execute IDCAMS.
- All the VSAM definitions are in the JCL. There is no need to look in SYSIN or the IDCAMS output to see the VSAM options specified.
- Subsequent JCL steps can refer back to the DD statement creating the VSAM data set. They do not need to know the VSAM data set name.

Disadvantages:

- Not all IDCAMS parameters can be specified using a JCL DD statement; these include:
    - CONTROLINTERVALSIZE
    - ERASE
    - FREESPACE
    - REUSE
    - SHAREOPTIONS
    - SPANNED
    - WRITECHECK
    - Separate Data and Index component parameters

DATACLAS

Like IDCAMS, many VSAM options can be specified using a DFSMS data class. In particular, Extended Format VSAM options must be defined using a data class.

JCL DD statements are the same. The data class can be automatically assigned by the storage administrator, or specified on the DD statement.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=MYPROG
//DD1      DD DISP=(,CATLG),DSN=DAVIDS.VSAM3,DATACLAS=DC1,
//         SPACE=(CYL,(5,5))
```

LIKE

In the previous section, you saw that the IDCAMS MODEL parameter allowed an existing data set to be used as a template or model. Unless otherwise specified, VSAM options for the model data set would be used for the new data set.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=MYPROG
//DD1      DD DISP=(,CATLG),DSN=DAVIDS.VSAM3,
//         LIKE=DAVIDS.VSAM.TEMPLATE,
//         SPACE=(CYL,(5,5))
```

In JCL, this can also be done using the LIKE parameter.

REFDD

In JCL, the REFDD parameter can be used to help model a data set for a new DFSMS managed data set by taking values from a data set defined on a previous DD statement.

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=MYPROG
//DD1      DD DISP=(,CATLG),DSN=DAVIDS.VSAM3,STORCLAS=SC1,
//         LRECL=80,KEYLEN=5,KEYOFF=0,RECORG=KS,
//         SPACE=(CYL,(5,5))
//DD2      DD DISP=(,CATLG),DSN=DAVIDS.VSAM4,
//         REFDD=*.DD1
```

The syntax of the REFDD parameter is one of the following:

- *.ddname - values are obtained from a specified DD statement within the same job step.
- *.stepname.ddname - values are obtained from a specified DD statement from a previous step within the job.
- *.stepname.procstep.ddname - values are obtained from a specified DD statement that exists in a procedure of a previous step within the job.

VSAM Options

There are JCL DD parameters that can be used to define the VSAM options of a new VSAM data set. These include the following:

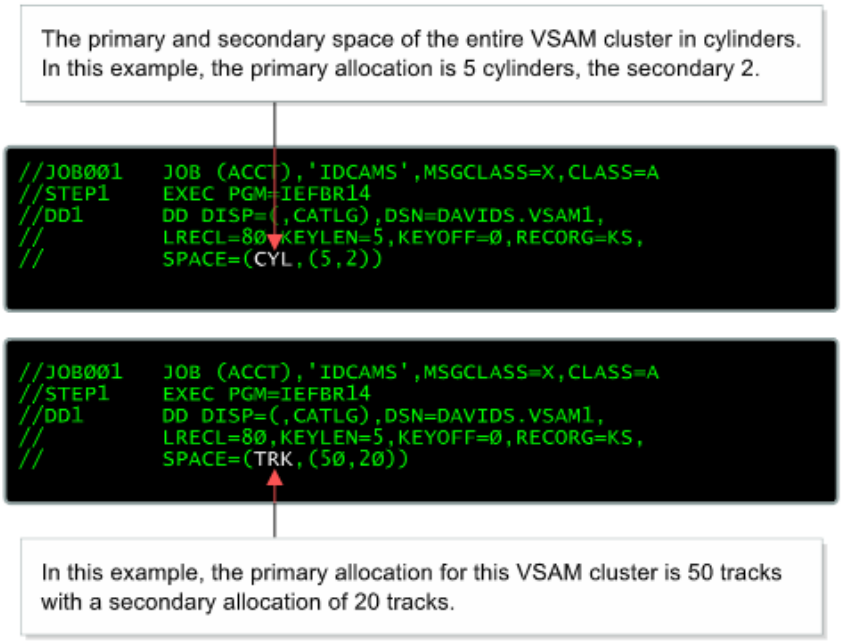
```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IEFBR14
//DD1      DD DISP=(,CATLG),DSN=DAVIDS.VSAM1,
//         LRECL=80,KEYLEN=5,KEYOFF=0,RECORG=KS,
//         SPACE=(CYL,(5,5))
```

- LRECL - The parameter is used to specify the maximum length of records (in bytes) to be stored in the VSAM data set.
- RECORG - The parameter is used to specify the record organisation for the VSAM data set. It can be one of the following:
    - ES - ESDS
    - LS - Linear Data Set
    - KS - KSDS
    - RR - RRDS
- KEYLEN - The parameter is used to define the length of the KSDS key (in bytes)
- KEYOFF - The parameter is used to specify the location of the key within each KSDS record. In the example here, 0 indicates the first byte.

Space

Like IDCAMS, JCL DD statements can be used to specify VSAM data set space characteristics in the following units:

- Cylinders
- Tracks
- Kilobytes
- Megabytes
- Records



AVGREC

The AVGREC parameter can be used in conjunction with the SPACE parameter to describe the space values specified. It specifies that the first number in the space parameter is the average record length of the data set. The primary and secondary numbers are multipliers of this averager record length.

Possible values for AVGREC are as follows:

```
//JOB001   JOB (ACCT),'IDCAMS',MSGCLASS=X,CLASS=A
//STEP1    EXEC PGM=IEFBR14
//DD1      DD DISP=(,CATLG),DSN=DAVIDS.VSAM1,
//          LRECL=80,KEYLEN=5,KEYOFF=0,RECORG=KS,
//          SPACE=(60,(500,200)),AVGREC=K
```

- U - The primary and secondary space numbers are the number of records.
- K - The primary and secondary space numbers are the number of records in thousands (multiplied by 1024).
- M - The primary and secondary space numbers are the number of records in millions (multiplied by 1024*1024, or 1048576).