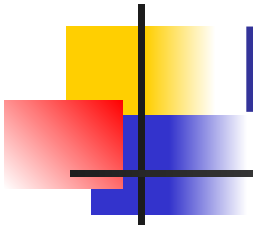
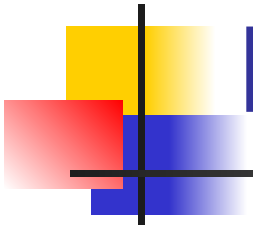
Loading and Unloading Minifilters



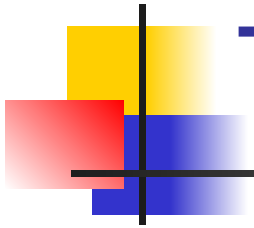
Features

- A minifilter may be loaded at any time
  - A minifilters “altitude” defines its location in the attachment stack
  - Filters have control over what volumes they attach to
  - Filters may support multiple instances (more then one attachment to a given volume)
  - Filters automatically notified about existing volumes



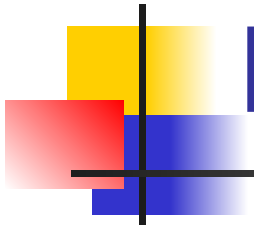
Features

- A minifilter may be unloaded at any time
  - Filters have control over when they unload
  - If reloaded, will be inserted back in the same frame



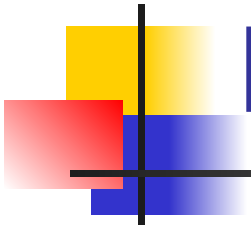
Triggering Minifilter Load

- Driver start type of **BOOT**, **SYSTEM** or **AUTO** when the system boots
  - Must use existing load order group definitions for minifilters
  - This is necessary to support proper interoperation with legacy filters
- Service Start request via:
  - "sc start" or "net start" commands
  - service APIs
- An explicit load request via:
  - "fltmc load" command
  - **`FltLoadFilter()`** API (Kernel mode)
  - **`FilterLoad()`** API (User mode)



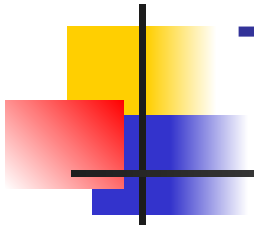
Load Order Groups

- FSFilter Activity Monitor
- FSFilter Undelete
- FSFilter Anti-Virus
- FSFilter Replication
- FSFilter Continuous Backup
- FSFilter Content Screener
- FSFilter Quota Management
- FSFilter System Recovery
- FSFilter Cluster File System
- FSFilter HSM
- FSFilter Compression
- FSFilter Encryption
- FSFilter Physical Quota Management
- FSFilter Open File
- FSFilter Security Enhancer
- FSFilter Copy Protection



Minifilter Startup

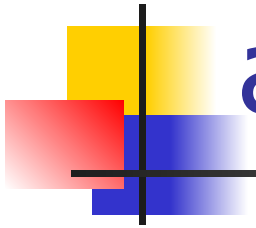
- **`DriverEntry()`** routine called when driver is loaded
  - Do global initialization
  - Call **`FltRegisterFilter()`** API
    - Registers callbacks with Filter Manager
  - Call **`FltStartFiltering()`** API
    - Volume enumeration may start before this call returns



Triggering Instance Creation

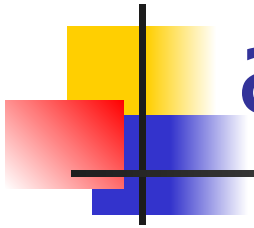
- At minifilter **`FltStartFiltering()`** time
  - Existing volumes enumerated
- Volume mount
- An explicit attachment request via:
  - "**`fltmc attach`**" command
  - **`FltAttachVolume()`** API (kernel mode)
  - **`FilterAttach()`** API (user mode)

What controls which instances are created

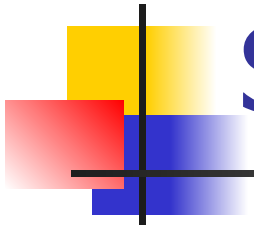


- Instance definitions in INF file
  - Defines: instance name, altitude, flags
    - Altitude values are defined and maintained by Microsoft
    - Flags contains OR-able bit values:
      - 0x01 = when set suppress automatic attachment
      - 0x02 = when set suppress manual attachment
  - Defines: DefaultInstance
    - Must be specified, used to order filters so mount and instance setup callbacks are sent in the correct order
    - Also used with **`FltAttachVolume()`**/ **`FilterAttach()`** APIs when no instance name is specified

What controls which instances are created (cont)



- Instance definitions in INF file (cont)
  - Multiple instances may be defined
  - Definitions apply across all volumes
  - Currently uses AddRegistry section
    - A new "Instance" section type will be added to INF files
- **`InstanceSetup()`** callback in **`FLT_REGISTRATION`** structure

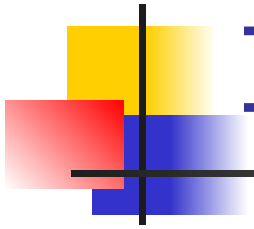


Sample Instance Definitions

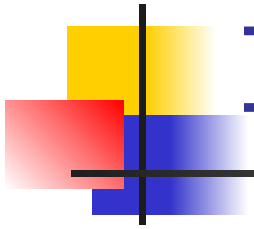
- From MiniSpy.inf:

```
[Minispy.AddRegistry]
HKR,"Instances","DefaultInstance",0x00000000,"Minispy - Top Instance"
HKR,"Instances\Minispy - Bottom Instance","Altitude",0x00000000,"365000"
HKR,"Instances\Minispy - Bottom Instance","Flags",0x00010001,0x1
HKR,"Instances\Minispy - Middle Instance","Altitude",0x00000000,"370000"
HKR,"Instances\Minispy - Middle Instance","Flags",0x00010001,0x1
HKR,"Instances\Minispy - Top Instance","Altitude",0x00000000,"385000"
HKR,"Instances\Minispy - Top Instance","Flags",0x00010001,0x1
```

InstanceSetup callback

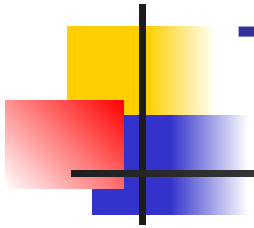


- If NULL, the instance is always created
- If defined:
  - **`FLT_INSTANCE_SETUP_FLAGS`** parameter identifies why this instance is being created
    - Automatic
    - Manual
    - Newly mounted volume
  - **`VolumeDeviceType`** parameter identifies the device type for this volume
    - **`FILE_DEVICE_DISK_FILE_SYSTEM`**
    - **`FILE_DEVICE_NETWORK_FILE_SYSTEM`**
    - **`FILE_DEVICE_CD_ROM_FILE_SYSTEM`**



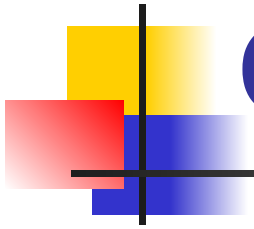
InstanceSetup callback (cont)

- **`VolumeFilesystemType`** parameter identifies the file system type for this volume
  - **`FLT_FSTYPE_NTFS`**
  - **`FLT_FSTYPE_FAT`**
  - **`FLT_FSTYPE_LANMAN`**
  - **`Etc`**
- Instance creation may be failed by returning an error or warning **`NTSTATUS`**



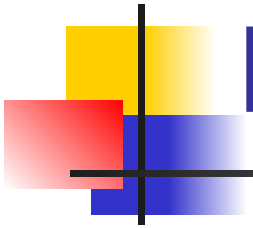
Triggering Minifilter Unload

- Service stop request via:
  - "**`sc stop`**" or "**`net stop`**" commands
  - Service APIs
- An explicit unload request via:
  - "**`fltmc unload`**" command
  - **`FltUnloadFilter()`** API (kernel mode)
  - **`FilterUnload()`** API (user mode)



Controlling Minifilter Unload

- Two mechanisms through **`FLT_REGISTRATION`** structure
  - **`FilterUnload()`** callback
  - **`FLTFL_REGISTRATION_DO_NOT_SUPPORT_SERVICE_STOP`** flag
- FltMgr sets **`DriverUnload()`** routine in filter
  - It calls, at the appropriate time, any **`DriverUnload()`** routine the minifilter may have set in its **`DriverObject`**



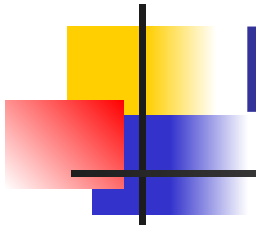
FilterUnload callback

- If NULL, the minifilter **cannot** be unloaded
- If defined:
  - Mandatory unloads (via service stop) cannot be failed
  - Non-mandatory unloads (via **`FltUnloadFilter()`** or **`FilterUnload()`** APIs) may be failed by returning an error or warning **`NTSTATUS`**
  - **`FLT_FILTER_UNLOAD_FLAGS`** parameter identifies reason for unload

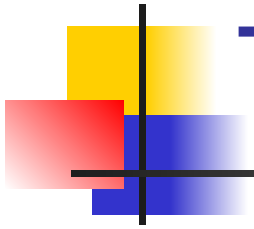
FLTFL_REGISTRATION_DO_NOT_SUPPORT_SERVICE_STOP flag

- If set, a minifilter can not be unloaded via a service stop request
- If a **`FilterUnload()`** callback is defined, the minifilter may be unloaded via the **`FltUnloadFilter()`** or **`FilterUnload()`** APIs
- Use this flag if you always need to have the option of failing an unload request

Minifilter's Responsibilities in FilterUnload callback

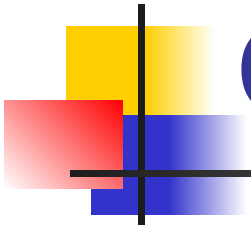


- Call **`FltUnregisterFilter()`**, Filter Manager then:
  - Deletes all instances
  - Deletes volume contexts
  - Waits for outstanding Filter references
    - Entries pending in generic work queue
    - **`FltObjectReference()`**/**`FltObjectDereference()`**
  - When this returns all instances have been deleted
- Do global cleanup:
  - Delete global EResources
  - Free global memory and delete lookaside lists
  - Unregister global callbacks
    - Timer, Process or Thread notification callbacks
- Minifilter will be unloaded if a success NTSTATUS is returned



Triggering Instance teardown

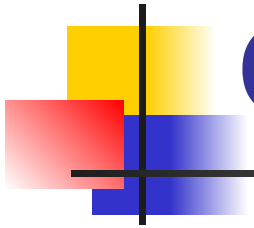
- A minifilter being unloaded
- A volume being dismounted
- An explicit detach request via
  - "**`fltmc detach`**" command
  - **`FltDetachVolume()`** API (kernel mode)
  - **`FilterDetach()`** API (user mode)



Controlling Instance Teardown

- In **`FLT_REGISTRATION`** structure:
  - **`InstanceQueryTeardown()`** callback
  - **`InstanceTeardownStart()`** callback
  - **`InstanceTeardownComplete()`** callback

InstanceQueryTeardown Callback

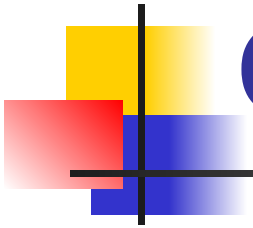


- Only called for explicit detach requests via **`FltDetachVolume()`** or **`FilterDetach()`**
  - **Not** called for **`FilterUnload()`**
  - **Not** called for volume dismount
- If NULL, instance **cannot** be torn down via an explicit detach request
- If defined:
  - May be failed by returning an error or warning NTSTATUS
  - If a success NTSTATUS is returned, teardown starts immediately

InstanceTeardownStart Callback

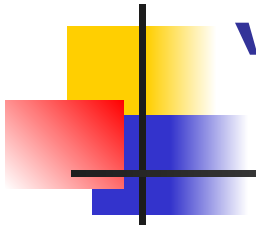
- May be NULL, instance is still torndown
- If defined:
  - Must:
    - Pass on or complete pended preOperation IOs
      - Use **`FltCompletePendedPreOperation()`**
    - Guarantee you won't pend any new IOs (see **`FltCbdqXxx()`** routines)
    - Complete pended postOperation IOs
      - Use **`FltCompletePendedPostOperation()`**
  - May:
    - Close opened files
    - Make worker threads start doing minimal work
    - Cancel filter initiated IOs
    - Stop queuing new work items
  - No **new** operation callbacks are being sent to the minifilter, may see operation callbacks for operations started before teardown was initiated

Outstanding Operation Callbacks



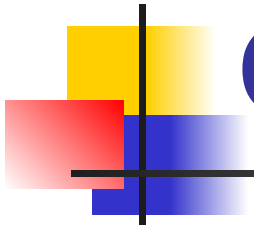
- Any currently executing preOperation callback continues normal processing
- Any currently executing postOperation callback continues normal processing
- Any IO that has completed the preOperation callback and is waiting for a postOperation callback may be "drained" or "canceled"

“Draining” Operation Callbacks

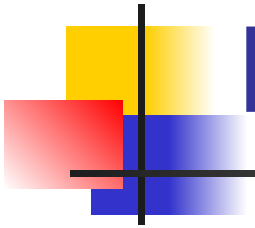


- Is a PostOperation callback that is called asynchronously from the actual operation being completed.
  - Always called at a safe IRQL
- **`FLTFL_POST_OPERATION_DRAINING`** in “Flags” parameter is set
- Receives “fake” CallbackData structure
  - Minimally initialized
  - Contains valid **`FLT_IO_PARAMETER_BLOCK`** (Iopb)
  - **`IoStatus.Status`** contains **`STATUS_FLT_POST_OPERATION_CLEANUP`**
- Receives fully populated FLT_RELATED_OBJECTS structure
- Must:
  - Perform minimal work
  - Cleanup context from preOperation callback
  - Return **`FLT_POSTOP_FINISHED_PROCESSING`**
- Must Not:
  - Restore swapped data buffers
  - Attempt to defer the operation in any way
- If drained, will not receive a normal postOperation callback

“Cancelling” Operation Callbacks



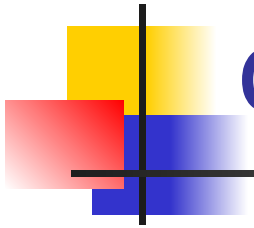
- If buffers have been swapped for a given operation, that operation is not drainable
  - Instead, Filter Manager attempts to cancel the operation
- After canceling, Filter Manager waits for the operation to complete



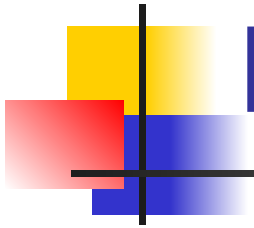
Minifilter Generated IOs

- These IOs will continue normal processing
- Minifilter should cancel any long lived IOs
  - Oplocks, directory change notifications, etc.
- Instance teardown will wait for all filter generated IOs to complete

InstanceTeardownComplete callback

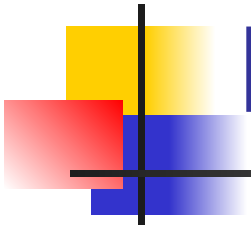


- May be NULL, instance is still torndown
- If defined:
  - When called, all outstanding IO operations have been completed or drained
    - **WARNING:** This routine will not be called if:
      - There are any outstanding pended operations
      - There is any outstanding filter generated IO
      - The unload request will look like it has hung
  - Must
    - Close any files that are still open
  - Referencing an Instance (with FltObjectReference) does **not** prevent this routine from being called



Final Cleanup of Instance

- Waits for outstanding Instance references
  - Waits for deferred IO work items to complete
  - Waits for any other references on the instance
    - `FltObjectReference()/FltObjectDereference()`
- All remaining contexts deleted
- The instance is now gone



Debugging Aids

- In checked builds:
  - Lots of internal asserts
  - When your minifilter unloads, the following is reported on the debugger screen:
    - Contexts you have forgotten to release
    - Files opened by **`FltCreateFile()`** that you have forgotten to close
- Try **`!fltkd.help`** in debugger for Filter Manager debugger extensions