Filter Manager

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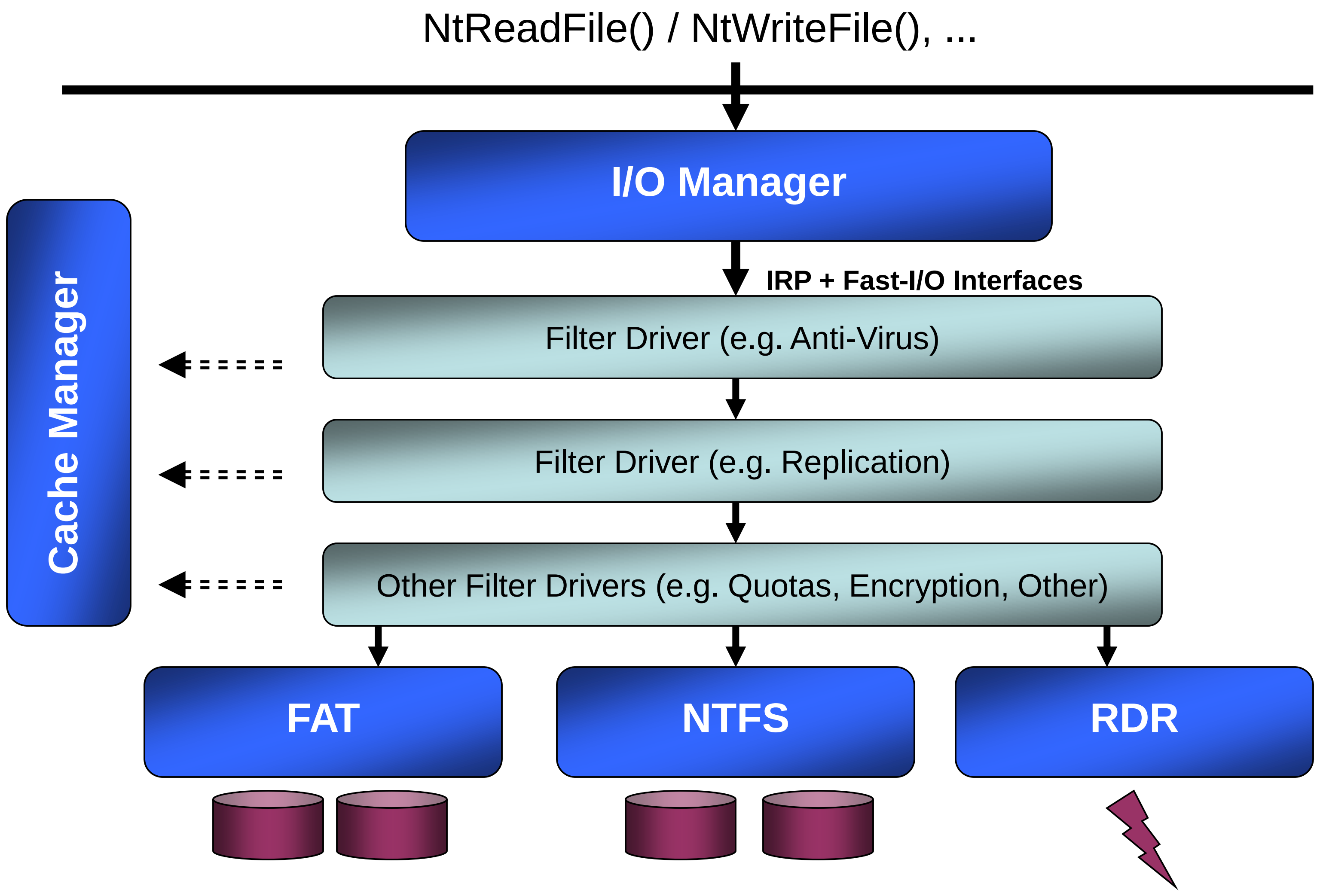
- Filter Manager Overview
  - Legacy Filtering Mechanisms & Issues
  - Filter Manager Benefits
  - Filter Manager Architecture
  - Features / Functionality
  - Project Status & Release Plans
- Question and Answer

- Many products use a ***file system filter***
  - Historically, caused much customer pain
  - Issues include stability, performance, & interoperability
- Examples of products with filter drivers:
  - Antivirus products
    - Filter watches I/O to and from certain file types (.exe, .doc, etc.) looking for virus signatures
  - File replication products
    - File-system-level mirroring
  - System Restore
    - Backs up system files when changes are about to be made so that the user can return to the original state
  - Many more…
    - Quota products, backup agents, undelete, encryption products, etc.
- We've come a long way in addressing issues with filter drivers:
  - Improved documentation
  - Plug-fests
  - AV certification program
  - However, 7% of OCA crashes are still attributed directly to 3rd party filter drivers

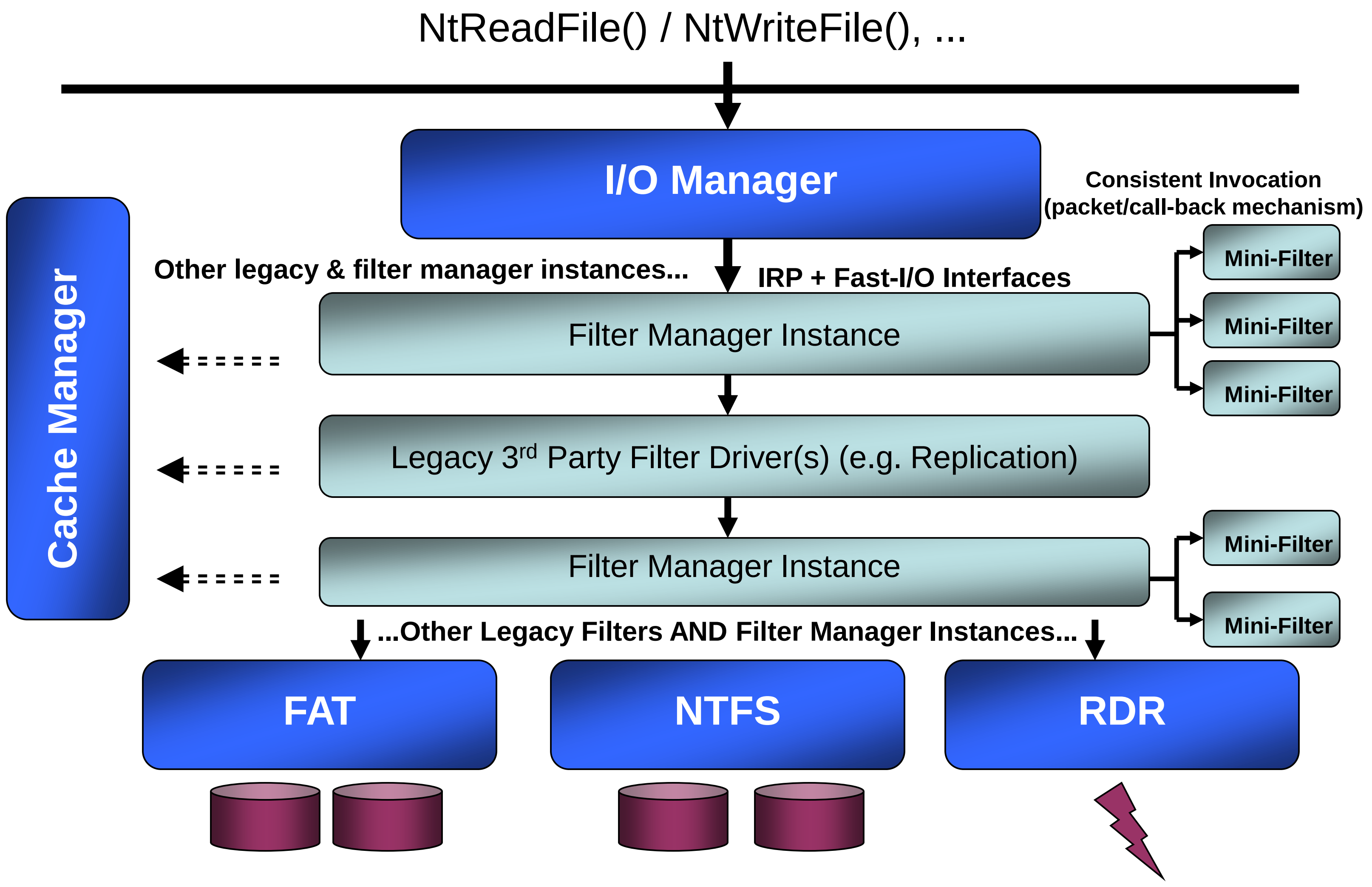

NtReadFile() / NtWriteFile(), ...
I/O Manager
IRP + Fast-I/O Interfaces
Cache Manager
Filter Driver (e.g. Anti-Virus)
Filter Driver (e.g. Replication)
Other Filter Drivers (e.g. Quotas, Encryption, Other)
FAT
NTFS
RDR

- Kernel-mode drivers
- Attach to locally mounted volumes (e.g. C:)and/or to redirectors (e.g. RDR/WebDAV)
  - Attach to file system driver control device objects
  - “Walk” list of mounted volumes in an unsafe manner
  - Intercept mount volume requests
  - Poll for redirector load
- Intercept IRPs and fast-i/o requests issued by I/O Manager to File System Driver (FSD)
- Perform filter-specific processing prior to dispatching request to FSD and/or post-completion of request processing by FSD
  - Often impact control flow
  - Often massage returned data/metadata
- May generate new I/O Request Packets (IRPs) as part of processing

- Reliability
  - A bug in your driver will cause a blue-screen or deadlock
- Performance
  - You’re on the path of all I/O
- Development and maintenance cost
  - Complex code
  - Hard to develop, test, debug, maintain
  - Must revise with each OS version and/or service packs
- Not your core competency
- Not your core value add to the customer

- Many problems with current model (legacy filters)
  - Poor control over stack ordering (load order groups)
  - No unload support
  - Stack limit issues
  - Complex interfaces (“fast-io” and IRPs)
  - Reentrancy issues
  - Inefficiencies due to redundant work in filters
  - Ad-hoc (reinvented) methods for common tasks
    - Attach to mounted volumes and redirectors
    - Generate IRPs
    - Obtain file/path name
    - Maintain filter contexts per object (volume, stream, other)
    - Manage buffers
  - Substantial Performance Degradation
- Expect even more problems with new functionality e.g. TxF (Transactional NTFS) support

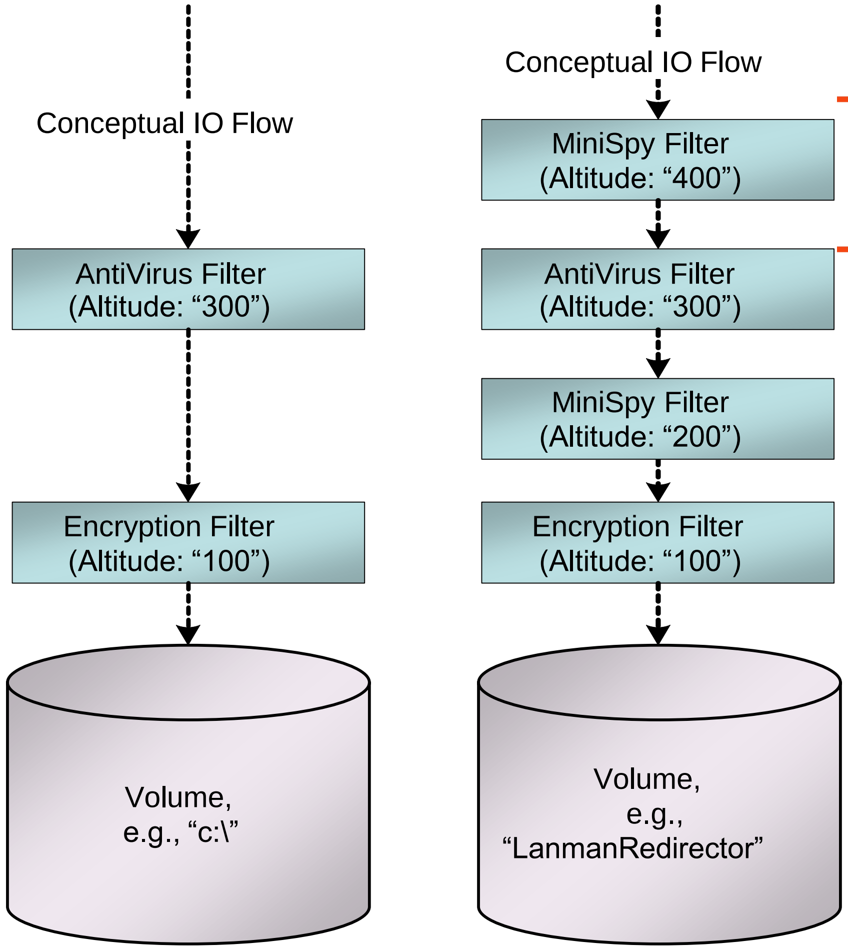
- Callback based rather than chained dispatch routines
  - Helps solve many stack overflow issues
  - Ability for system to add new operation types w/o breaking existing filters
- Uniform interface for all operations
  - Fast I/O, IRP, callbacks are all intercepted in the same manner
- Isolation from gnarly IRP processing rules
  - Filter Manager does this processing on behalf of the filters
- Dynamic load/unload (Ability to unload)
- Non re-entrant filter initiated I/O
- Efficient pass through
- Deterministic Load Order (ease interoperability/testing)
- Efficient context management
- A library of value-add APIs
  - File name management
  - IO cancellation and queuing
  - Buffer Management
- Efficient and secure user/kernel communication
- Support for TxF


NtReadFile() / NtWriteFile(), ...
I/O Manager
Consistent Invocation (packet/call-back mechanism)
Cache Manager
Other legacy & filter manager instances...
IRP + Fast-I/O Interfaces
Filter Manager Instance
Mini-Filter
Mini-Filter
Mini-Filter
Legacy 3rd Party Filter Driver(s) (e.g. Replication)
Filter Manager Instance
Mini-Filter
Mini-Filter
...Other Legacy Filters AND Filter Manager Instances...
FAT
NTFS
RDR

- Legacy file system filter
- Manages the complexity of I/O system through new interfaces and library routines
- Has kernel and user-mode interfaces
- Supports multiple loaded mini-filters and multiple instances per volume
- Coexists with other legacy filter drivers (until they are all phased out)

- Just another kernel mode driver
- Register with filter manager in DriverEntry()
- Leverage filter manager to attach to volumes (local and remote)
- Utilize filter manager to process only I/O operations of interest (specify appropriate callbacks)
- Determine control flow easily and efficiently
- Utilize available library functions for commonly required functionality such as:
  - obtaining file name/path
  - synchronize post-processing of I/O operations
  - queue and manage per-object context
  - other …
- Be able to unload/upgrade driver in field w/o requiring reboot
- Leverage filter manager provided efficient user/kernel communication mechanism
- Interoperate correctly with transactional file system support

- Mini-filter registers only for operations in which it is interested through FLT_REGISTRATION structure
  - Register pre-operation callback and/or post-operation callback
- FLT_CALLBACK_DATA replaces the IRP
  - FLT_CALLBACK_DATA->Iopb contains parameters for this operation, similar to IO_STACK_LOCATION
  - No management of FLT_CALLBACK_DATA needed, i.e., no more IoSkipCurrentIrpStackLocation(), IoSetCompletionRoutine()
  - Common structure for all types of operations:
    Irp, FastIo, and FsFilter



Conceptual IO Flow
AntiVirus Filter (Altitude: “300”)
Encryption Filter (Altitude: “100”)
Volume, e.g., “c:\”
Conceptual IO Flow
MiniSpy Filter (Altitude: “400”)
AntiVirus Filter (Altitude: “300”)
MiniSpy Filter (Altitude: “200”)
Encryption Filter (Altitude: “100”)
Volume, e.g., “LanmanRedirector”

- *Instance*: Instantiation of a filter on a volume at a particular altitude
- Support multiple instances of a mini-filter on a volume
- *Altitude* determines relative stack position

- FltRegisterFilter()
  - Register with Filter Manager
  - All callback information in FLT_REGISTRATION structure

- FltStartFiltering()
  - Begin enumeration of existing volumes in system
  - InstanceSetup() callback is called for mini-filter to see if it wants to attach

- Through FilterUnload() callback, mini-filter is allowed to accept or deny the unload request

- To unload, Filter Manager synchronizes the safe removal of all mini-filter instances through a series of notifications
  - InstanceQueryTeardown() – allows filter to fail the teardown request for given instance
  - InstanceTeardownStart() – Notifies filter that teardown process is beginning for given instance
  - InstanceTeardownComplete() – Notifies filter teardown process has finished for given instance

- Mini-filter communicates control flow choice through callback return value

- In pre-operation, filter can:
  - Pass through the operation –FLT_PREOP_SUCCESS_NO_CALLBACK
  - Ask to see operation completion – FLT_PREOP_SUCCESS_WITH_CALLBACK
  - Pend the operation – FLT_PREOP_PENDING
  - Ask to have completion synchronized to current thread – FLT_PREOP_SYNCHRONIZE
  - Complete the operation – FLT_PREOP_COMPLETE

- In postOperation, mini-filter can:
  - Do its work and continue completion processing – FLT_POSTOP_FINISHED_PROCESSING
  - Pend the completion processing – FLT_POSTOP_MORE_PROCESSING_REQUIRED

- For pended IOs, continue processing with FltCompletePendedPreOperation() or FltCompletePendedPostOperation()

- Queuing Support
- Buffer Manipulation (locking/swapping)
- Context Management
- File Name Management
- I/O Generation

- Provides common functionality for user-mode applications that work with filter drivers
- Application must link with filterlib.dll
- Include header files fltUser.h and fltUserStructures.h
- Load and unload mini-filters
  - FilterLoad(), FilterUnload()
- Open handles to filters or instances to get information
  - FilterCreate(), FilterInstanceCreate()
  - FilterGetInformation(), FilterInstanceGetInformation()

- Enumerate filters, instances, and volumes
  - FilterFindFirst(), FilterFindNext()
  - FilterVolumeFindFirst(), FilterVolumeFindNext()
  - FilterInstanceFindFirst(), FilterInstanceFindNext()
  - FilterVolumeInstanceFindFirst(), FilterVolumeInstanceFindNext()
- Open handle to communication port
  - FilterConnectCommunicationPort()
- Add and remove mini-filter instances
  - FilterAttach(), FilterAttachAtAltitude()
  - FilterDetach()

- Command line utility for common filter management operations
  - Load and unload mini-filters
  - Attach/detach mini-filters to/from volumes
  - Enumerate mini-filters, instances, volumes

- “fltmc help”
  - Displays help information for utility

- Fltkd.dll debugger extension
  - !fltkd.help will list all the available commands
  - For more specific help on a single command, issue that command with no parameters
  - !cbd: Filter Manager equivalent to !irp
  - !volumes, !filters: List all volumes/filters in system
  - !volume, !filter, !instance: Give detail on a specific object
  - Ignore version warning, turn off with “.noversion” command

- Run with debug fltmgr.sys
  - Lots of ASSERT to catch common errors

- Enable through verifying mini-filter via Driver Verifier with “I/O Verification“ option
- Verification starts when a filter registers with the Filter Manager
- Validates all Filter Manager API calls by mini-filter
  - Validates parameters and calling context
- Verifies all the special return values from mini-filter’s pre/post callback routines
- Ensures mini-filter changed the parameters in the callback data in a coherent/consistent manner
- More to come in future

- All existing Microsoft filters converted to minifilter model for Longhorn
- Minifilters and Legacy filters will coexist – however, goal is to strongly encourage all filters to be converted to minifilter model
- Filter Manager to be released in
  - Longhorn
  - Windows Storage Server
  - Windows Server 2003 SP1
  - WinXP SP2
  - Support for Windows 2000 (release plans being finalized)
- IFS Kit update for Windows Server 2003 SP1, Windows XP Service Pack 2 and the Longhorn driver kit will contain filter manager libraries, headers, and samples
- For more information, contact rajeevn@microsoft.com

- **Port your legacy filter to the mini-filter model**
- Send us feedback on the filter manager including any additional support that may benefit your product/mini-filter