SDC

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Running SMB3.x over RDMA on Linux platforms

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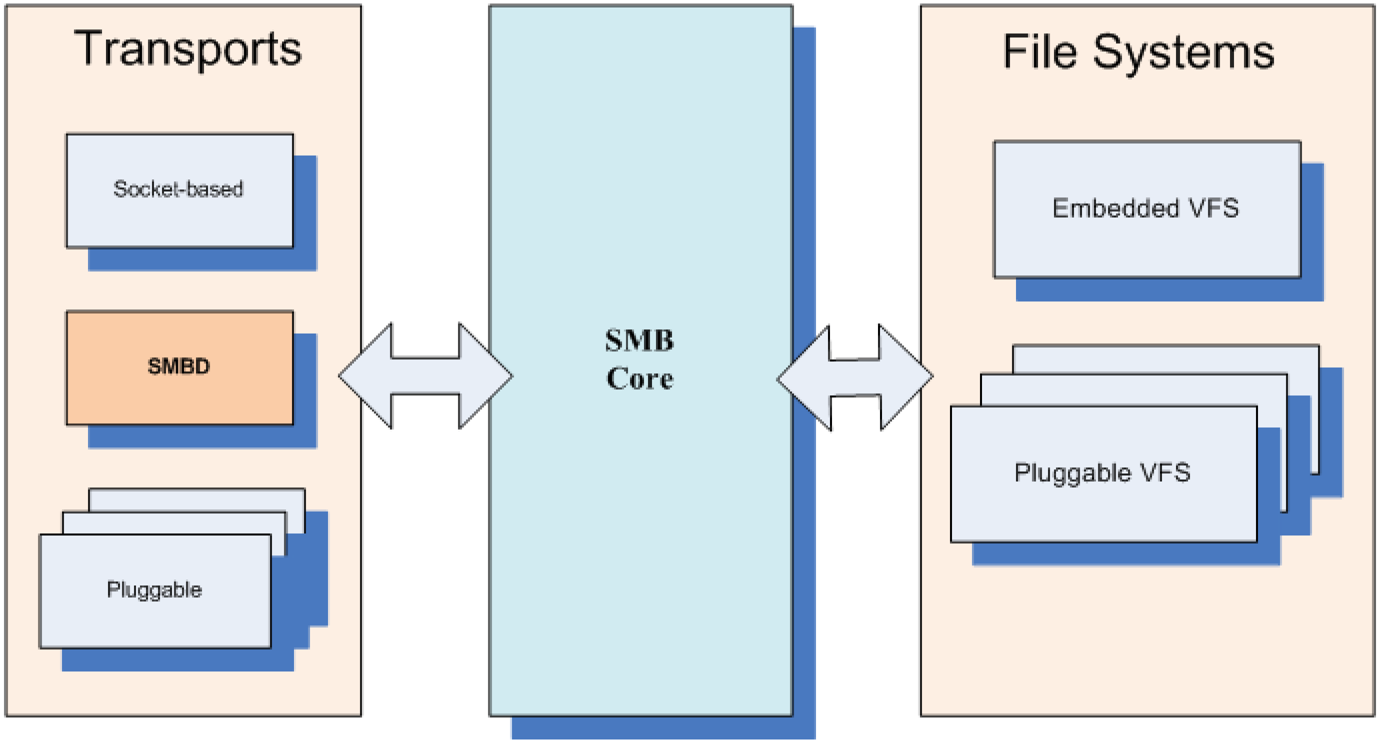
Prehistory

- NQ CIFS is an implementation of SMB client/server for the embedded world:
  - Consumer devices: printers, MFP, routers, STB, etc.
  - Mobile devices: smart phones, tablets
  - Industrial Automation, Medica, Aerospace and Defense
  - Anything else that is neither PC nor MAC nor Samba..
- The last version – NQE – supports basic SMB3.0, mostly towards data encryption.
- SMB over RDMA is only supported on Windows platforms
- Currently we are developing a storage-level version of SMB Server. The presentation is about this venture.

Plans and Goals

- Enterprise-level performance with low latencies
- 10,000 connections at least
- Pluggable transports
- Pluggable VFS

Architecture



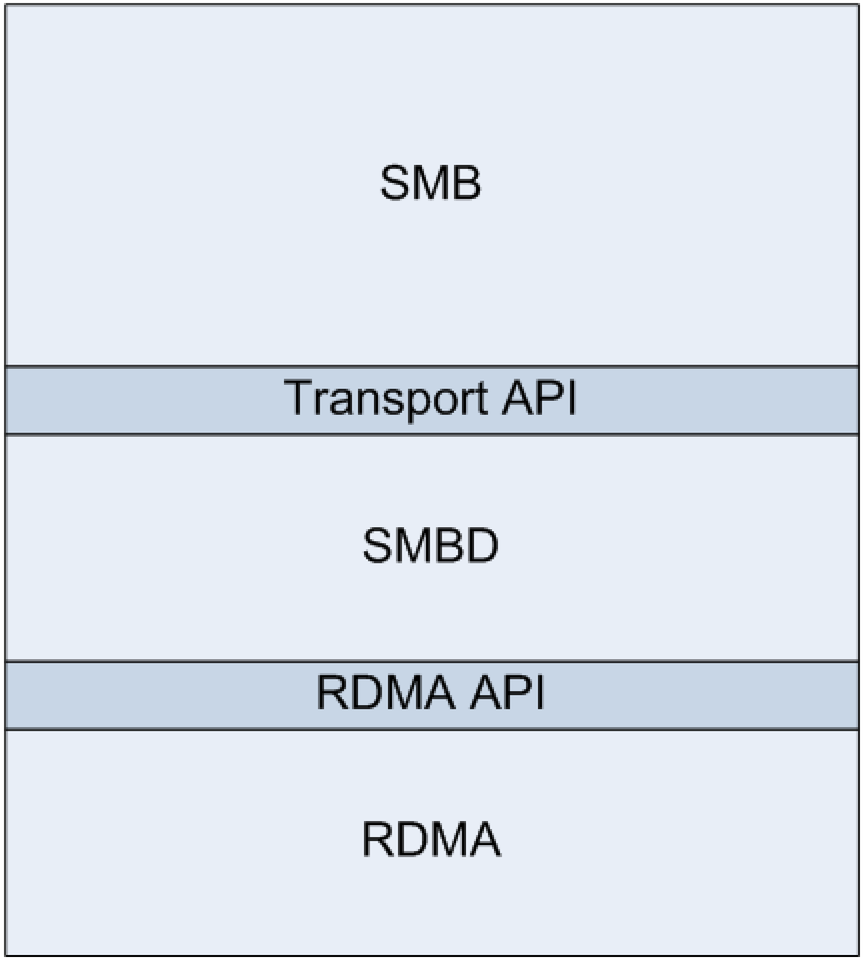
We will mostly talk about the SMBD transport

Architecture remarks

- Socket-based transport uses *epoll()* or alike.
- A pluggable transport may be:
  - Fast, zero-copy sockets
  - Proprietary transport protocol
  - Etc.
- Pluggable transport conforms to Transport API.
- *Core* translates SMBs into NTFS semantics.
- Embedded VFS converts NTFS semantics into POSIX semantics (or whatever the local FS is).
- Pluggable VFS translates NTFS semantics into Storage primitives.
- Pluggable VFS conforms to VFS API.

The SMBD transport is of a particular interest for this session.

Dataflow in layers

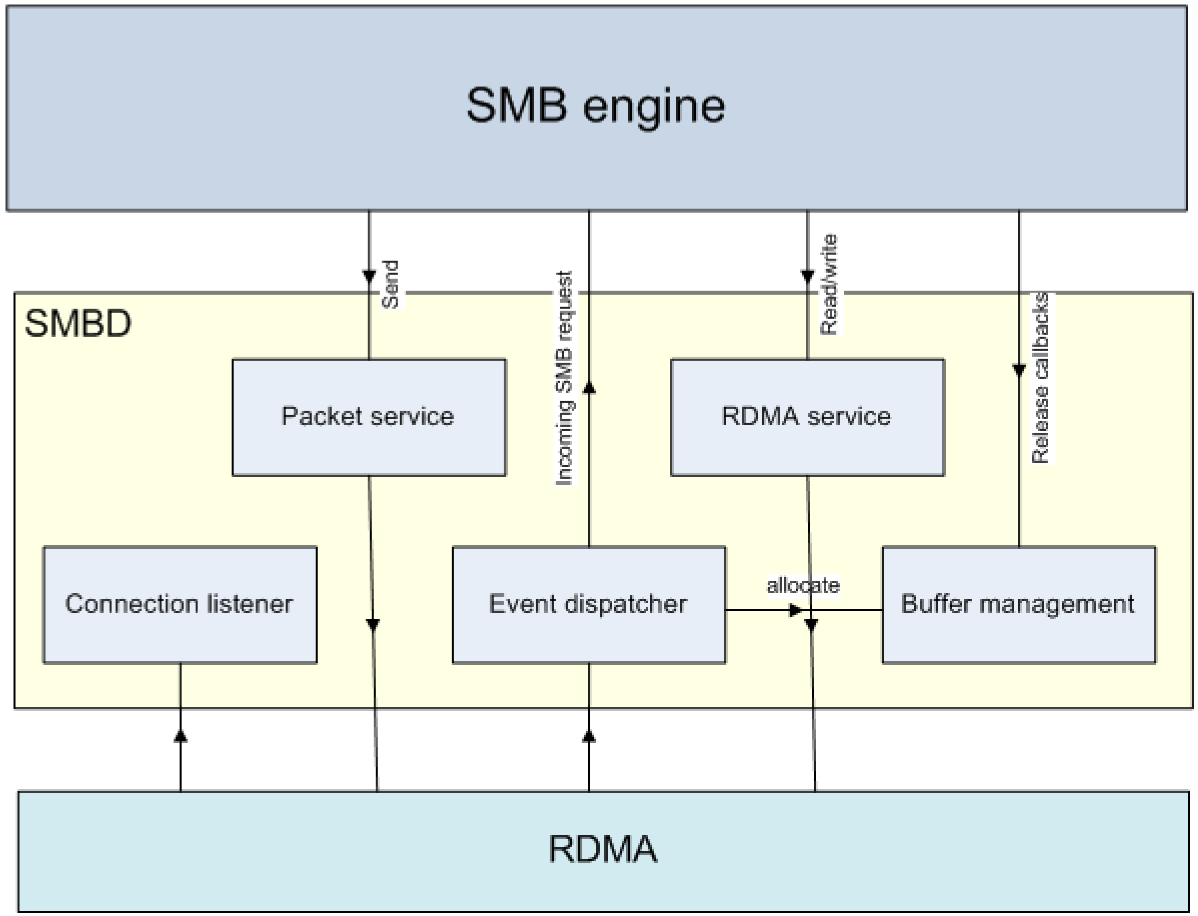


- An example of involved layers as applicable to the subject of this session

Dataflow explained

- Abstract APIs allows replaceable modules
- SMB Direct is one of the possible transports
- "RDMA" actually means two services:
  - Packet delivery
  - Payload delivery, which is applicable to Read(s)/Write(s) and assumes RDMA
- Our RDMA layer is also replaceable

SMBD – a drill-down view



SMBD remarks

- Two thread run:
  - New connection listener registers a callback with RDMA API. On callback:
    - Handles connection request.
    - Handles connection acknowledgement. Submits several request buffers to RDMA receive queue.
    - Handles disconnect
  - Data event listener registers a callback with RDMA API. On callback:
    - On Send complete releases the buffer
    - On Receive complete accepts the incoming packet and delegates it to SMB. Sometimes assembles an SMB.
    - On Read complete and Write complete releases a 1MB buffer.

Buffer sizes

Each protocol negotiates its own buffer sizes

- SMB
  - Max Transaction Size
  - Max Read Size
  - Max Write Size
- SMBD
  - Preferred Send Size
  - Max Read/Write Size
  - Max Receive Size
  - Max Fragmented Size

Buffer sizes (cont.)

		Windows 2012	NQ
SMB	Max Transaction Size	1048576	1048576
	Max Read Size	1048576	1048576
	Max Write Size	1048576	1048576
SMBD	Preferred Send Size	1364	8192
	Max Read/Write Size	1048576	1048576
	Max Receive Size	8192	8192
	Max Fragmented Size	1048576	1048576

Buffer vs. iovec

<u>IOVEC</u>

- Grants zero-copy i/o
- Requires more complicated code and also causes (apparently -minor) performance decrease

<u>Buffer</u>

- Proper buffer management (see below) will not also require data copy
- SMBD over RDMA grants packet delivery in one piece if it fits into the receive buffer
- Most SMBs fit into one buffer and are delivered in one piece

<u>Conclusions</u>

- Majority of SMBs will fit into one receive buffer
- SMBD assembly is rarely needed
- Buffers are sufficient – no need for iovec

Buffer management

- "Small" buffer is 8192 bytes long (Max Receive Size!!)
  - Most SMB requests (except, maybe, for some odd IOCTLs)
  - Most SMB responses (except for Query Directory)
  - Reads and Writes normally small since RDMA is enforced. Some exceptions happen - see below
  - Almost all receive buffers are "small"
- "Medium" buffer is 64K bytes long
  - Query Directory responses
  - Some RPC responses (e.g., NetrEnumShares)
  - Odd requests/response (Query Quota, IOCTL)
- "Big" buffer is 1M bytes long
  - RDMA reads and writes as SMB Read or Write payload
  - Non-RDMA Reads and Writes (rarely happens)

SMBD Fragmentation and Assembly

- Fragmentation may happen on transmitting a long response (e.g., - Query Directory). Fragmentation is achieved by using the same buffer and sending its contexts with shifting offsets.
  - This is available due to the RDMA layer's capability of submitting the same buffer with different offsets.
  - Fragmentation does not cause data copy and applies virtually zero overhead.
- Assembly may happen upon receiving a long request.
  - This almost never happens since the vast majority of requests are small, including RDMA reads and writes.
  - On a (rare) message assembly, data copy happens.
  - A long request is assembled in a "medium" or "big" buffer.

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Buffer pre-allocation

- On a 10Gbs network memory allocation may become a bottleneck.
- NQ uses an abstract API for memory (pre)allocation which counts on the underlying memory management mechanism.
- This is not enough so NQ pre-allocates buffers in:
  - SMB Direct layer
  - SMB layer

SMBD Crediting

- SMBD requests and SMBD responses imply a simple crediting algorithm.
- Credits == number of *receive* buffers per a connection.

RDMA Remarks

- Listens to connection events using *rdma_get_cm_event().*
  - New connection request
  - New connection acknowledge
  - Disconnect
- Listens to data events using *ibv_get_cq_event()* and *ibv_poll_cq().*
  - An incoming message placed into a receive buffer
  - An outgoing packet was sent
  - RDMA transfer completed

Any of the above causes a callback to the SMBD layer.

RDMA Remarks (cont.)

- Queues a buffer for receiving through *rdma_post_recv()*. Receive completion on this buffer will generate an event.
- Queues a buffer for sending through *rdma_post_send()*. Send completion will generate an event.
- Queues a buffer for RDMA read/write through *rdma_post_read()*. A completion on this buffer will generate an event.

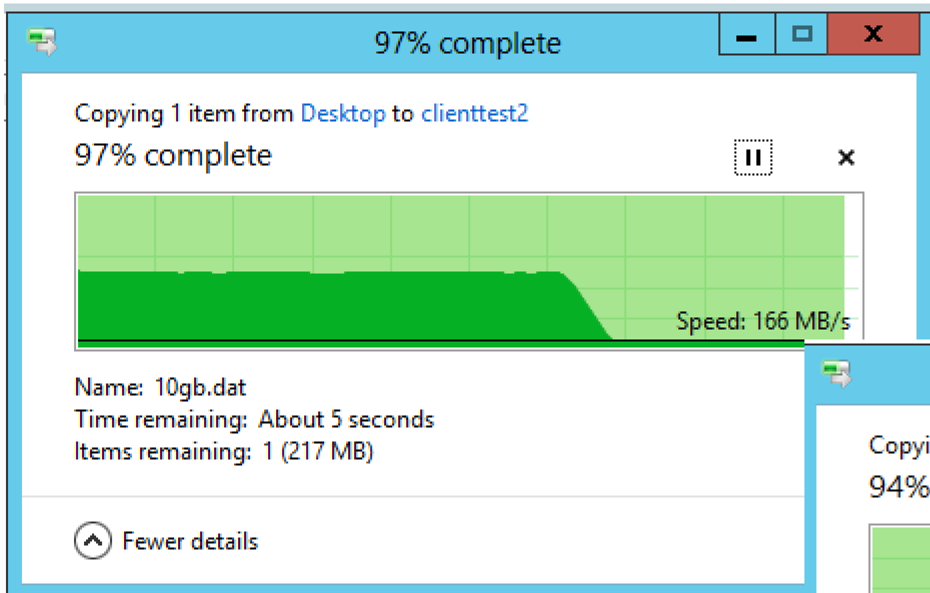
Test Environment

- The Windows client side:
  - HP Proliant ML350P Server
  - Runs Windows 2012
  - Mellanox ConnectX-3 network adapter
- The Linux server side:
  - HP Proliant ML350P Server
  - Runs Redhat 2.6.32
  - Runs NQ CIFS Server 8.0 (prototype)
  - Mellanox ConnectX-3 network adapter
- The Mellanox card was tested in both InfiniBand mode and Ethernet mode.

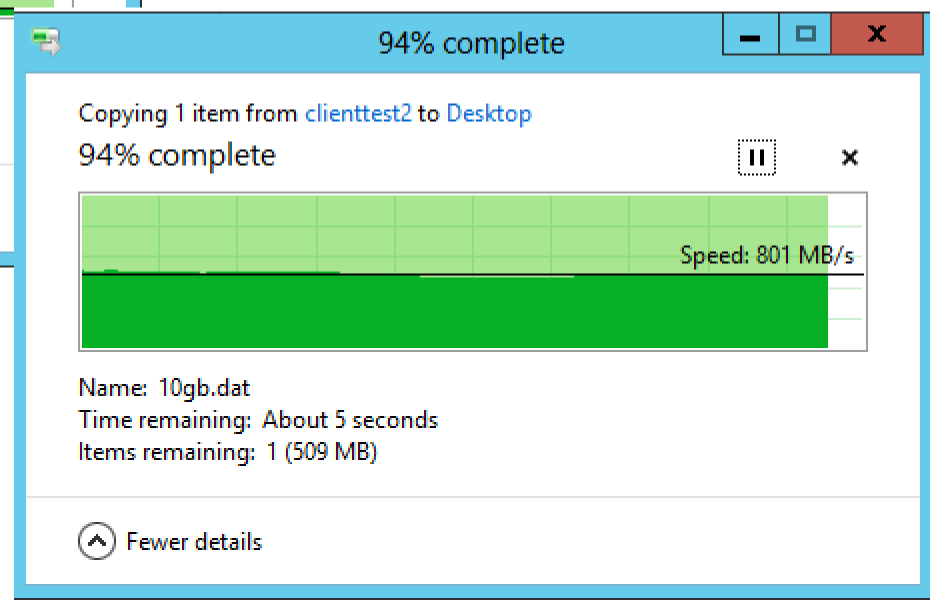
The Testbench

- The aim was to validate SMB over RMDA
- Currently out of scope:
  - Multiple connections
  - Random operations
  - Small chunk operations
- We were only uploading and downloading a 10GBfile.
- We plugged Embedded VFS with POSIX backend. On 10Gbs this is definitely a bottleneck.
- Then we measured with a dummy backend.

Performance



Embedded VFS with POSIX backend.



Embedded VFS with a dummy backend.

Numbers

- We used Embedded VFS with a dummy backend.
- The network is InfiniBand
- Download: 940 MByte/sec
- Upload: 1,400 MByte/sec
- These results are similar to Win-Win numbers

Thank you