

multichannel / io_uring

Status Update within Samba

Stefan Metzmacher <metze@samba.org>

Samba Team / SerNet

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<https://samba.org/~metze/presentations/2021/SDC/>

- ▶ Check for an updated version of this presentation here:
- ▶ <https://samba.org/~metze/presentations/2021/SDC/>

- ▶ What is SMB3 Multichannel?
- ▶ Updates in Samba 4.15
- ▶ What is io-uring?
- ▶ io-uring for Samba
- ▶ Performance research, prototyping and ideas
- ▶ Questions? Feedback!

What is SMB3 Multichannel?

- ▶ Multiple transport connections are bound to one logical connection
 - ▶ This allows using more than one network link
 - ▶ Good for performance
 - ▶ Good for availability reasons
 - ▶ Non TCP transports like RDMA (InfiniBand, RoCE, iWarp)
- ▶ All transport connections (channels) share the same ClientGUID
 - ▶ This is important for Samba
- ▶ An authenticated binding is done at the user session layer
 - ▶ SessionID, TreeID and FileID values are valid on all channels
- ▶ Available network interfaces are auto-negotiated
 - ▶ FSCTL_QUERY_NETWORK_INTERFACE_INFO interface list
 - ▶ IP (v4 or v6) addresses are returned together with:
 - ▶ Interface Index (which addresses belong to the same hardware)
 - ▶ Link speed
 - ▶ RSS and RDMA capabilities

Last Status Updates (SDC 2020 / SambaXP 2021)

- ▶ I gave a similar talk at the storage developer conference 2020:
 - ▶ See <https://samba.org/~metze/presentations/2020/SDC/>
 - ▶ It explains the milestones and design up to Samba 4.13 (in detail)
- ▶ I gave a similar talk at the SambaXP 2021:
 - ▶ See <https://samba.org/~metze/presentations/2021/SambaXP/>
 - ▶ It explains the milestones and updates up to Samba 4.15 (in detail)

Updates in Samba 4.15

- ▶ Automated regression tests are in place:
 - ▶ socket_wrapper got basic fd-passing support (Bug #11899)
 - ▶ We added a lot more multichannel related regression tests
- ▶ The last missing features/bugs are fixed (Bug #14524)
 - ▶ The connection passing is fire and forget (Bug #14433)
 - ▶ Pending async operations are canceled (Bug #14449)
- ▶ 4.15 finally has "server multi channel support = yes"
 - ▶ We require support for TIOCOUTQ (Linux) or FIONWRITE (FreeBSD)
 - ▶ We disable multichannel feature if the platform doesn't support this
 - ▶ See: Retries of Lease/Oplock Break Notifications (Bug #11898)

What is io-uring? (Part 1)

- ▶ Linux 5.1 introduced a new scalable AIO infrastructure
 - ▶ It's designed to avoid syscalls as much as possible
 - ▶ kernel and userspace share mmap'ed rings:
 - ▶ submission queue (SQ) ring buffer
 - ▶ completion queue (CQ) ring buffer
 - ▶ See "[Ringing in a new asynchronous I/O API](#)" on LWN.NET
- ▶ This can be nicely integrated with our async tevent model
 - ▶ It may delegate work to kernel threads
 - ▶ It seems to perform better compared to our userspace threadpool
 - ▶ It can also inline non-blocking operations

io-uring for Samba (Part 1)

- ▶ Between userspace and filesystem (available from 5.1):
 - ▶ IORING_OP_READV, IORING_OP_WRITEV and IORING_OP_FSYNC
 - ▶ Supports buffered and direct io
- ▶ Between userspace and socket (and also filesystem) (from 5.8)
 - ▶ IORING_OP_SENDMSG, IORING_OP_RECVMSG
 - ▶ Improved MSG_WAITALL support (5.12, backported to 5.11, 5.10)
 - ▶ IORING_OP_SPLICE, IORING_OP_TEE
 - ▶ Maybe using IORING_SETUP_SQPOLL or IOSQE_ASYNC
- ▶ Path based syscalls with async impersonation (from 5.6)
 - ▶ IORING_OP_OPENAT2, IORING_OP_STATX
 - ▶ Using IORING_REGISTER_PERSONALITY for impersonation
 - ▶ IORING_OP_UNLINKAT, IORING_OP_RENAMEAT (from 5.10)
 - ▶ IORING_OP_MKDIRAT, IORING_OP_SYMLINKAT, IORING_OP_LINKAT (from 5.15)

IORING_FEAT_NATIVE_WORKERS (from 5.12)

- ▶ In the kernel...
 - ▶ The io-uring kernel threads are clone()'ed from the userspace thread
 - ▶ They just appear to be blocked in a syscall and never return
 - ▶ This makes the accounting in the kernel much saner
 - ▶ Allows a lot of restrictions to be relaxed in the kernel
- ▶ For admins and userspace developers...
 - ▶ They are no longer 'io_wqe_work' kernel threads
 - ▶ 'top' shows them as part of the userspace process ('H' shows them)
 - ▶ They are now visible in containers
 - ▶ 'pstree -a -t -p' is very useful to see them
 - ▶ They are shown as iou-wrk-1234, for a task with pid/tid 1234

- ▶ With Samba 4.12 we added "io_uring" vfs module
 - ▶ For now it only implements SMB_VFS_PREAD,PWRITE,FSYNC_SEND/RECV
 - ▶ It has less overhead than our pthreadpool default implementations
 - ▶ I was able to speed up a smbclient 'get largefile /dev/null'
 - ▶ Using against smbd on loopback
 - ▶ The speed changes from 2.2GBytes/s to 2.7GBytes/s
- ▶ The improvement only happens by avoiding context switches
 - ▶ But the data copying still happens:
 - ▶ From/to a userspace buffer to/from the filesystem/page cache
 - ▶ The data path between userspace and socket is completely unchanged
 - ▶ For both cases the cpu is mostly busy with memcpy

Performance research (SMB2 Read)

- ▶ In October 2020 I was able to do some performance research
 - ▶ With 100Gbit/s interfaces and two NUMA nodes per server.
- ▶ At that time I focussed on the SMB2 Read performance only
 - ▶ We had limited time on the given hardware
 - ▶ We mainly tested with fio.exe on a Windows client
 - ▶ Linux kernel 5.8.12 on the server
- ▶ More verbose details can be found here:
 - ▶ <https://lists.samba.org/archive/samba-technical/2020-October/135856.html>

Performance with MultiChannel, sendmsg()

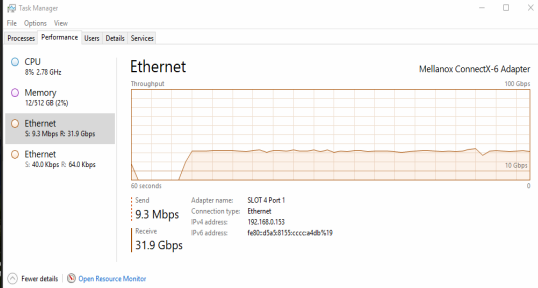
4 connections, ~3.8 GBytes/s, bound by >500% cpu in total, sendmsg() takes up to 0.5 msec

```
top - 05:43:16 up 2 days, 44 min, 2 users, load average: 5.42, 3.22, 1.52
Threads: 823 total, 33 running, 790 sleeping, 0 stopped, 0 zombie
%Cpu(s): 0.0 us, 6.3 sy, 0.0 ni, 93.4 id, 0.0 wa, 0.1 hi, 0.2 si, 0.0 st
MiB Mem : 191624.1 total, 182280 free, 2617.5 used, 6726.1 buff/cache
MiB Swap: 1024.0 total, 1024.0 free, 0.0 used, 185648.1 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	TIME+	COMMAND	
307312	root	20	0	2426196	63088	19104	R	06.8	0.0	0:52.29	send
307486	root	20	0	2426196	63408	19104	R	14.3	0.0	0:06.96	send
307412	root	20	0	2426196	65256	19104	R	14.8	0.0	0:06.92	send
307405	root	20	0	2426196	63144	19104	R	13.6	0.0	0:06.82	send
307410	root	20	0	2426196	64464	19104	R	13.6	0.0	0:06.77	send
307414	root	20	0	2426196	65520	19104	R	13.6	0.0	0:06.80	send
307422	root	20	0	2426196	68952	19104	R	13.6	0.0	0:06.78	send
307432	root	20	0	2426196	71592	19104	R	13.6	0.0	0:06.66	send
307400	root	20	0	2426196	63936	19104	R	13.3	0.0	0:06.50	send
307411	root	20	0	2426196	64992	19104	R	13.3	0.0	0:06.77	send
307413	root	20	0	2426196	65256	19104	R	13.3	0.0	0:06.68	send
307415	root	20	0	2426196	65256	19104	R	13.3	0.0	0:06.63	send
307410	root	20	0	2426196	66040	19104	R	13.3	0.0	0:06.69	send
307419	root	20	0	2426196	67104	19104	R	13.3	0.0	0:06.84	send
307420	root	20	0	2426196	67632	19104	R	13.3	0.0	0:06.76	send
307421	root	20	0	2426196	68160	19104	R	13.3	0.0	0:06.71	send
307423	root	20	0	2426196	69400	19104	R	13.3	0.0	0:06.68	send
307425	root	20	0	2426196	69400	19104	R	13.3	0.0	0:06.59	send
307420	root	20	0	2426196	70000	19104	R	13.3	0.0	0:06.59	send
307430	root	20	0	2426196	70000	19104	R	13.3	0.0	0:06.84	send
307433	root	20	0	2426196	72304	19104	R	13.3	0.0	0:06.61	send
307436	root	20	0	2426196	70000	19104	R	13.3	0.0	0:06.62	send
307429	root	20	0	2426196	70000	19104	R	13.0	0.0	0:06.07	send
307434	root	20	0	2426196	72304	19104	R	13.8	0.0	0:06.70	send
307435	root	20	0	2426196	72640	19104	R	13.0	0.0	0:06.71	send
307407	root	20	0	2426196	63672	19104	R	12.6	0.0	0:06.58	send
307416	root	20	0	2426196	66040	19104	R	12.6	0.0	0:06.68	send
307417	root	20	0	2426196	66312	19104	R	12.6	0.0	0:06.53	send
307427	root	20	0	2426196	70000	19104	R	12.6	0.0	0:06.87	send
307431	root	20	0	2426196	71064	19104	R	12.6	0.0	0:06.50	send
307424	root	20	0	2426196	69400	19104	R	12.3	0.0	0:06.65	send
307409	root	20	0	2426196	67200	19104	R	12.0	0.0	0:06.60	send
307404	root	20	0	2426196	62616	19104	D	11.3	0.0	0:06.61	send
307183	root	20	0	0	0	0	I	0.3	0.0	0:00.41	kworker/u166:2-u1
307302	root	20	0	0	0	0	I	0.3	0.0	0:00.03	kworker/23:1-even
307452	root	20	0	62928	5536	3936	R	0.3	0.0	0:00.00	top
1	root	20	0	242512	10952	8176	S	0.0	0.0	0:02.84	system
2	root	20	0	0	0	0	S	0.0	0.0	0:00.13	khthread
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_gp
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_par_gp
6	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	kworker/0:00-kblockd
10	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	mm_percpu_wq
11	root	20	0	0	0	0	S	0.0	0.0	0:00.32	ksoftirqd/0
12	root	20	0	0	0	0	I	0.0	0.0	0:03.17	rcu_sched
13	root	rt	0	0	0	0	S	0.0	0.0	0:00.03	migration/0
14	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/0
15	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/1
16	root	rt	0	0	0	0	S	0.0	0.0	0:01.38	migration/1

```
Administrator: Windows PowerShell
complete : 0=0.0%, 4=09.78, 0=0.3%, 16=0.1%, 32=0.0%, 64=0.0%, >=64=0.0%
issued puts: total=4003,0,0,0 short=0,0,0,0 dropped=0,0,0,0
latency : target=0, window=0, percentile=100.00%, depth=16

Run status group 0 (all jobs):
  READ: bw=3266MiB/s (3425Mb/s), 3266MiB/s-3266MiB/s (3425Mb/s-3425Mb/s), io=8000MiB (8395Msec), run=2451-2451msec
PS C:\Users\Administrator> . "Program Files\Fio\Fio.exe" --group_reporting=1 --name=fio_test --ioengine=windowsaio --iodepth=16 --direct
--io-read --rw-rw-rw --size=100M --bw=0 --numjobs=1 --time_based --runtime=60 --directory=C:\110
Fio test: (p=0) rw+read, bs=(R) 4096KiB-4096KiB, (W) 4096KiB-4096KiB, (T) 4096KiB-4096KiB, ioengine=windowsaio, iodepth=16
...
Fio 3.22
Starting 2 threads
Jobs: 2 (F2): [R][T][117.3%][r=3812MiB/s][r=952.10PS][eta 04m:08s]
```



IOURING_OP_SENDMSG (Part1)

4 connections, ~6.8 GBytes/s, smbdc only uses ~11% cpu, (io_wqe_work ~50% cpu) per connection, we still use >300% cpu in total

```
top - 05:45:38 up 2 days, 46 min, 2 users, load average: 3.03, 2.04, 1.61
Threads: 823 total, 3 running, 820 sleeping, 0 stopped, 0 zombie
%cpu(s): 0.1 us, 4.7 sy, 0.0 ni, 94.6 id, 0.0 wa, 0.1 hi, 0.5 si, 0.0 st
Mem Mem : 191624.1 total, 182194.6 free, 2702.6 used, 6726.9 buff/cache
Mem Swap: 1024.0 total, 1024.0 free, 0.0 used, 185554.7 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
307577	root	20	0	0	0	0	R	49.0	0.0	0:05.00	io_wqe_worker-0
307549	root	20	0	0	0	0	S	46.0	0.0	0:21.39	io_wqe_worker-0
307555	root	20	0	0	0	0	R	44.0	0.0	0:21.45	io_wqe_worker-0
307567	root	20	0	0	0	0	S	29.8	0.0	0:09.92	io_wqe_worker-1
307558	root	20	0	663100	144024	18804	S	23.2	0.1	0:09.10	smbd
307556	root	20	0	663100	144024	18804	S	19.9	0.1	0:08.95	smbd
307559	root	20	0	663100	144024	18804	S	19.5	0.1	0:08.92	smbd
307563	root	20	0	663100	144024	18804	S	19.5	0.1	0:08.06	smbd
307557	root	20	0	663100	144024	18804	S	19.2	0.1	0:09.11	smbd
307560	root	20	0	663100	144024	18804	S	19.2	0.1	0:09.38	smbd
307561	root	20	0	663100	144024	18804	S	19.2	0.1	0:09.07	smbd
307534	root	20	0	663100	144024	18804	S	18.9	0.1	0:09.00	smbd
307576	root	20	0	663100	144024	18804	S	18.9	0.1	0:05.61	smbd
307562	root	20	0	663100	144024	18804	S	18.5	0.1	0:08.93	smbd
307530	root	20	0	663100	144024	18804	D	11.3	0.1	0:05.16	smbd
307552	root	20	0	0	0	0	S	9.3	0.0	0:12.25	io_wqe_worker-0
417	root	20	0	0	0	0	I	0.3	0.0	0:03.50	kworker/0:2-event
307183	root	20	0	0	0	0	I	0.3	0.0	0:00.61	kworker/u160:2-ml
307568	root	20	0	0	0	0	I	0.3	0.0	0:00.02	kworker/29:0-event
307588	root	20	0	62964	5532	3904	R	0.3	0.0	0:00.12	top
1	root	20	0	242512	10952	8176	S	0.0	0.0	0:02.04	systemd
2	root	20	0	0	0	0	S	0.0	0.0	0:00.13	kthreadd
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_gp
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_par_gp
6	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	kworker/0:0H-kblou
10	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	mm_percpu_wq
11	root	20	0	0	0	0	S	0.0	0.0	0:00.32	ksoftirqd/0
12	root	20	0	0	0	0	I	0.0	0.0	0:03.17	rcu_sched
13	root	rt	0	0	0	0	S	0.0	0.0	0:00.03	migration/0
14	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/0
15	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/1
16	root	rt	0	0	0	0	S	0.0	0.0	0:01.38	migration/1
17	root	20	0	0	0	0	S	0.0	0.0	0:00.07	ksoftirqd/1
19	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	kworker/1:0H-kblou
21	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/2
22	root	rt	0	0	0	0	S	0.0	0.0	0:01.37	migration/2
23	root	20	0	0	0	0	S	0.0	0.0	0:00.01	ksoftirqd/2
25	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	kworker/2:0H-kblou
26	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/3
27	root	rt	0	0	0	0	S	0.0	0.0	0:01.39	migration/3

The screenshot shows a Windows Task Manager window with the 'Performance' tab selected. The system is running on a Windows 10 desktop. The Performance tab displays the following metrics:

- CPU:** 16% 2.78 GHz
- Memory:** 12/512 GB (2%)
- Ethernet:** S: 17.4 Mbps R: 57.5 Gbps
- Ethernet:** S: 32.0 Mbps R: 96.0 Kbps

The 'Ethernet' section is expanded, showing a throughput graph for the last 60 seconds. The graph shows a significant spike in receive throughput, reaching approximately 57.5 Gbps. Below the graph, the following details are provided:

- Adapter name:** SLOT 4 Port 1
- Connection type:** Ethernet
- IPv4 address:** 192.168.0.153
- IPv6 address:** fe80:d5a5b155:cccc4db%19

The 'Send' and 'Receive' rates are displayed as 17.4 Mbps and 57.5 Gbps, respectively. The Task Manager window also shows the 'Processes' tab, with the 'Administrator: Windows PowerShell' window open, displaying system statistics and command execution output.

IOURING_OP_SENDMSG (Part2)

The results vary havily depending on the NUMA bouncing, between 5.0 GBytes/s and 7.6 GBytes/s

Monitoring 783 processes and 825 threads (interval: 5.0s)

PID	PPID	RMA(K)	LMA(K)	RMA/LMA	CPI	%CPU
387530	smad	25.2	267516.6	0.0	3.40	2.0
387552	io_wq_work	12012.0	37401.2	0.3	3.97	0.7
387549	io_wq_work	10153.3	46117.4	0.2	5.28	0.7
387555	io_wq_work	5.8	50352.7	0.0	5.63	0.6
387533	io_wq_work	19868.2	21523.9	0.9	4.70	0.4
387578	io_wq_work	29.0	14415.0	0.0	3.73	0.2
387563	kworker/1	3.0	50.3	0.1	2.65	0.0
384171	kworker/77	0.3	19.3	0.0	2.23	0.0
387567	io_wq_work	0.3	775.3	0.0	5.95	0.0
387569	numatop	11.1	28.2	0.4	0.69	0.0
387102	kworker/u16	0.0	11.3	0.1	2.28	0.0
387510	kworker/47	0.2	20.8	0.0	1.72	0.0
387183	kworker/u16	0.1	1.6	0.1	1.90	0.0
387342	kworker/71	0.0	10.0	0.0	3.00	0.0
386985	kworker/71	0.0	20.0	0.0	2.23	0.0
387359	kworker/57	0.0	10.0	0.0	3.57	0.0
1	system	0.0	0.0	0.0	0.00	0.0
2	ktthread	0.0	0.0	0.0	0.00	0.0
3	rcu_gp	0.0	0.0	0.0	0.00	0.0
4	rcu_par_gp	0.0	0.0	0.0	0.00	0.0
6	kworker/0:0	0.0	0.0	0.0	0.00	0.0
10	mm_percpu_w	0.0	0.0	0.0	0.00	0.0
11	ksftirq/0	0.0	0.0	0.0	0.00	0.0
12	rcu_sched	0.0	0.0	0.0	0.00	0.0
13	migration/0	0.0	0.0	0.0	0.00	0.0
14	cpulp/0	0.0	0.0	0.0	0.00	0.0
15	cpulp/1	0.0	0.0	0.0	0.00	0.0
16	migration/1	0.0	0.0	0.0	0.00	0.0
17	ksftirq/1	0.0	0.0	0.0	0.00	0.0
18	kworker/1:0	0.0	0.0	0.0	0.00	0.0
21	cpulp/2	0.0	0.0	0.0	0.00	0.0
22	migration/2	0.0	0.0	0.0	0.00	0.0
23	ksftirq/2	0.0	0.0	0.0	0.00	0.0
25	kworker/2:0	0.0	0.0	0.0	0.00	0.0
26	cpulp/3	0.0	0.0	0.0	0.00	0.0
27	migration/3	0.0	0.0	0.0	0.00	0.0
28	ksftirq/3	0.0	0.0	0.0	0.00	0.0
30	kworker/3:0	0.0	0.0	0.0	0.00	0.0
31	cpulp/4	0.0	0.0	0.0	0.00	0.0
32	migration/4	0.0	0.0	0.0	0.00	0.0
33	ksftirq/4	0.0	0.0	0.0	0.00	0.0
35	kworker/4:0	0.0	0.0	0.0	0.00	0.0
36	cpulp/5	0.0	0.0	0.0	0.00	0.0
37	migration/5	0.0	0.0	0.0	0.00	0.0
38	ksftirq/5	0.0	0.0	0.0	0.00	0.0

<- Hotkey for sorting: 1(RMA), 2(LMA), 3(RMA/LMA), 4(CPI), 5(CPU%) ->
CPU% = system CPU utilization

Q: Quit; H: Home; R: Refresh; I: IR Normalize; N: Mode

Administrator: Windows PowerShell

```
complete : 0=0.0%, 4=100.0%, 8=0.1%, 16=0.1%, 32=0.0%, 64=0.0%, >=64=0.0%
Issued rwts: total=64728,0,0,0 short=0,0,0,0 dropped=0,0,0,0
latency : target=0, window=0, percentile=100.00%, depth=10

Run status group 0 (all jobs):
R00: bw=53961B/s (56580B/s), 4096KIB/s-53961B/s (42950B/s-56580B/s), io=25361B (2710B), run=47960-47960msec
PS C:\Users\Administrator> & { .\Program Files\IOUring\io_uring_group_reportings1 -name=fio_test -ioengine=winioctl
s1 --thread -rwread -size=100M -ps=4M -numjobs=2 --time_based=1 --runtime=5m --directory=C:\1190
fio_test1 (g=0): rw=read, bs=(R) 4096KIB-4096KIB, (W) 4096KIB-4096KIB, (T) 4096KIB-4096KIB, ioengine=windowsa, io
...
fio=3.22
Starting 2 threads
Jobs: 2 (f=2) | [R(2)][T(7)][r=608310/s][r=1700 IOPS][eta 04m:37s]
```

Task Manager

Processes Performance Users Details Services

- CPU 16% 2.78 GHz
- Memory 12/512 GB (2%)
- Ethernet S: 16.8 Mbps R: 56.7 Gbps
- Ethernet S: 32.0 Kbps R: 64.0 Kbps

Ethernet Mellanx

Throughput

60 seconds

16.8 Mbps

56.7 Gbps

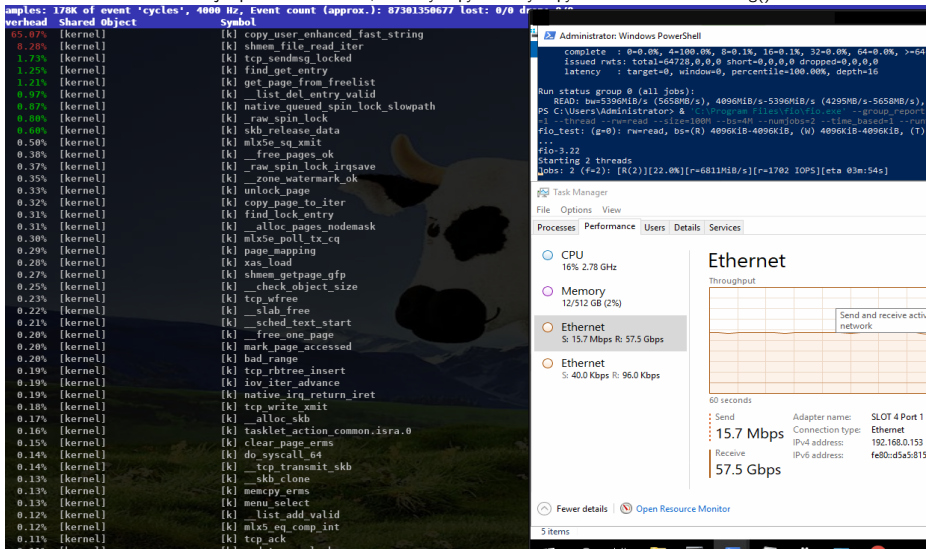
Adapter name: SLOT 4 Port 1
Connection type: Ethernet
IPv4 address: 192.168.0.153
IPv6 address: fe80:d5a5:8155:ccccca4db%19

Fewer details | Open Resource Monitor

5 items

IOURING_OP_SENDMSG (Part3)

The major problem still exists, memory copy done by `copy_user_enhanced_fast_string()`



```
amples: 178K of event 'cycles', 4000 Hz, Event count (approx.): 87301350677 Lost: 0/0 d...
verhead Shared Object Symbol
65.07% [kernel] [k] copy_user_enhanced_fast_string
8.20% [kernel] [k] shmem_file_read_iter
1.73% [kernel] [k] tcp_sendmsg_locked
1.25% [kernel] [k] find_get_entry
1.21% [kernel] [k] get_page_from_freelist
0.97% [kernel] [k] __list_del_entry_valid
0.87% [kernel] [k] native_queued_spin_lock_slowpath
0.80% [kernel] [k] __raw_spin_lock
0.60% [kernel] [k] skb_release_data
0.50% [kernel] [k] mlx5e_sq_xmit
0.38% [kernel] [k] __free_pages_ok
0.37% [kernel] [k] __raw_spin_lock_irqsave
0.35% [kernel] [k] __zone_watermark_ok
0.33% [kernel] [k] unlock_page
0.32% [kernel] [k] copy_page_to_iter
0.31% [kernel] [k] find_lock_entry
0.31% [kernel] [k] __alloc_pages_nodemask
0.30% [kernel] [k] mlx5e_poll_tx_cq
0.29% [kernel] [k] page_mapping
0.28% [kernel] [k] xas_load
0.27% [kernel] [k] shmem_getpage_gfp
0.25% [kernel] [k] __check_object_size
0.23% [kernel] [k] tcp_wfree
0.22% [kernel] [k] __slab_free
0.21% [kernel] [k] __sched_text_start
0.20% [kernel] [k] __free_one_page
0.20% [kernel] [k] mark_page_accessed
0.20% [kernel] [k] bad_range
0.19% [kernel] [k] tcp_rbtrees_insert
0.19% [kernel] [k] iov_iter_advance
0.19% [kernel] [k] native_irq_return_iret
0.18% [kernel] [k] tcp_write_xmit
0.17% [kernel] [k] __alloc_skb
0.16% [kernel] [k] tasklet_action_common.isra.0
0.15% [kernel] [k] clear_page_erms
0.14% [kernel] [k] do_syscall_64
0.14% [kernel] [k] __tcp_transmit_skb
0.13% [kernel] [k] __skb_clone
0.13% [kernel] [k] memcpy_erms
0.13% [kernel] [k] menu_select
0.12% [kernel] [k] __list_add_valid
0.12% [kernel] [k] mlx5_eq_comp_int
0.11% [kernel] [k] tcp_ack
```

```
Administrator: Windows PowerShell
Complete : 0=0.0%, 4=100.0%, 8=0.1%, 16=0.1%, 32=0.0%, 64=0.0%, >=64
Issued rwts: total=64728,0,0,0 short=0,0,0,0 dropped=0,0,0,0
latency : target=0, window=0, percentile=100.00%, depth=16

Run status group 0 (all jobs):
READ: bw=5396MiB/s (5658MB/s), 4096MiB/s-5396MiB/s (4295MB/s-5658MB/s),
PS C:\Users\Administrator> & 'C:\Program Files\io\io.exe' --group_report
r1 --thread --rnrread --size=100M --bs=4M --numjobs=2 --time_based=1 --run
io_test: (g=0) rw=read, bs=(R) 4096KiB-4096KiB, (W) 4096KiB-4096KiB, (T)
...
File-3.22
Starting 2 threads
Jobs: 2 (F=2): [R(2)][22.0%][r=6811MiB/s][r=1702 IOPS][eta 03m:54s]
```

Task Manager Performance

- CPU: 16% 2.78 GHz
- Memory: 12/512 GB (2%)
- Ethernet: S: 15.7 Mbps R: 57.5 Gbps
- Ethernet: S: 40.0 Kbps R: 96.0 Kbps

Ethernet Throughput

60 seconds

- Send: 15.7 Mbps
- Receive: 57.5 Gbps

Adapter name: SLOT 4 Port 1
Connection type: Ethernet
IPv4 address: 192.168.0.153
IPv6 address: fe80::d5a5b15

Fewer details | Open Resource Monitor

5 items

IOURING_OP_SENDMSG + IOURING_OP_SPLICE (Part1)

16 connections, ~8.9 GBytes/s, smbdc ~5% cpu, (io_wqework 3%-12% cpu filesystem->pipe->socket), only ~100% cpu in total.

The Windows client was still the bottleneck with "Set-SmbClientConfiguration -ConnectionCountPerRssNetworkInterface 16"

```
top - 04:59:15 up 3 days, 0 min, 4 users, load average: 0.63, 0.54, 0.28
tasks: 854 total, 1 running, 853 sleeping, 0 stopped, 0 zombie
Cpu(s): 0.1 us, 1.2 sy, 0.0 ni, 97.1 id, 0.0 wa, 0.2 hi, 1.4 si, 0.0 st
MiB Mem : 191624.4 total, 177404.7 free, 2931.6 used, 11287.7 buff/cache
MiB Swap: 1824.0 total, 1824.0 free, 0.0 used, 188883.9 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	CPU	MEM	TIME	COMMAND
312117	root	20	0	0	0	0	0	5	12.3	0.0	0:01.26 io_wqeworker-0
311999	root	20	0	0	0	0	0	5	11.0	0.0	0:00.98 io_wqeworker-0
312125	root	20	0	0	0	0	0	5	8.6	0.0	0:01.19 io_wqeworker-0
312826	root	20	0	0	0	0	0	5	6.6	0.0	0:00.97 io_wqeworker-0
312836	root	20	0	0	0	0	0	5	6.6	0.0	0:00.94 io_wqeworker-0
312132	root	20	0	0	0	0	0	5	6.0	0.0	0:00.59 io_wqeworker-1
312135	root	20	0	0	0	0	0	5	6.0	0.0	0:01.04 io_wqeworker-0
312122	root	20	0	0	0	0	0	5	5.6	0.0	0:00.58 io_wqeworker-1
311994	root	20	0	457860	24880	18424	5	3.0	0.0	0:00.07 smbdc	
312879	root	20	0	0	0	0	0	5	3.0	0.0	0:00.40 io_wqeworker-0
312892	root	20	0	0	0	0	0	5	3.0	0.0	0:00.44 io_wqeworker-0
312100	root	20	0	0	0	0	0	5	3.0	0.0	0:00.40 io_wqeworker-0
312106	root	20	0	0	0	0	0	5	3.0	0.0	0:00.41 io_wqeworker-0
312109	root	20	0	0	0	0	0	5	3.0	0.0	0:00.44 io_wqeworker-0
312112	root	20	0	0	0	0	0	5	3.0	0.0	0:00.41 io_wqeworker-0
308304	root	20	0	2986356	108452	54660	5	2.7	0.1	1:38.13 perf	
312895	root	20	0	0	0	0	0	5	2.7	0.0	0:00.46 io_wqeworker-0
312115	root	20	0	0	0	0	0	5	2.7	0.0	0:00.37 io_wqeworker-0
312145	root	20	0	0	0	0	0	5	2.7	0.0	0:00.18 io_wqeworker-1
312062	root	20	0	0	0	0	0	5	2.3	0.0	0:00.37 io_wqeworker-0
312869	root	20	0	0	0	0	0	5	2.3	0.0	0:00.35 io_wqeworker-0
312103	root	20	0	0	0	0	0	5	2.3	0.0	0:00.15 io_wqeworker-0
312151	root	20	0	62904	5532	3804	R	0.7	0.0	0:00.03 top	
308276	root	20	0	62812	5404	3844	5	0.3	0.0	3:57.64 top	
310569	root	20	0	0	0	0	I	0.3	0.0	0:00.02 kworker/61:2-event	
311821	root	20	0	0	0	0	I	0.3	0.0	0:00.10 kworker/u16:2-nl	
311830	root	20	0	0	0	0	I	0.3	0.0	0:00.30 kworker/u16:0-nl	
311894	root	20	0	0	0	0	I	0.3	0.0	0:00.42 kworker/u16:3-nl	
1	root	20	0	242512	18952	8176	5	0.0	0.0	0:03.35 systemd	
2	root	20	0	0	0	0	0	5	0.0	0.0	0:00.20 kthreadd
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00 rcu_gp	
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00 rcu_par_gp	
6	root	0	-20	0	0	0	I	0.0	0.0	0:00.00 kworker/0:0H-kblockd	
10	root	0	-20	0	0	0	I	0.0	0.0	0:00.00 mm_percpu_wq	
11	root	20	0	0	0	0	0	5	0.0	0.0	0:00.39 ksoftirqd/0
12	root	20	0	0	0	0	0	1	0.0	0.0	0:07.04 rcu_sched
13	root	rt	0	0	0	0	0	5	0.0	0.0	0:00.05 migration/0
14	root	20	0	0	0	0	0	5	0.0	0.0	0:00.00 cpupk/0
15	root	20	0	0	0	0	0	5	0.0	0.0	0:00.00 cpupk/1
16	root	rt	0	0	0	0	0	5	0.0	0.0	0:01.40 migration/1
17	root	20	0	0	0	0	0	5	0.0	0.0	0:00.00 ksoftirqd/1
19	root	0	-20	0	0	0	I	0.0	0.0	0:00.00 kworker/1:0H-kblockd	
21	root	20	0	0	0	0	0	5	0.0	0.0	0:00.00 cpupk/2
22	root	rt	0	0	0	0	0	5	0.0	0.0	0:01.40 migration/2
23	root	20	0	0	0	0	0	5	0.0	0.0	0:00.01 ksoftirqd/2
25	root	0	-20	0	0	0	I	0.0	0.0	0:00.00 kworker/2:0H-kblockd	

Administrator: Windows PowerShell

```
PS C:\Users\Administrator> Run status group 0 (all jobs):
READ: bw=7910MiB/s (8204MB/s), 4096MiB/s-7910MiB/s (4295MB/s-8204MB/s), io=1893GiB (2033GB), run=245120-245120sec
PS C:\Users\Administrator> & {Programme /?io /?io /?io -name=FileTest --ioengine=windowsaio --iodepth=16 --direct
g-1 --thread --read --size=100 --bs=0 --iojobs=20 --time=used --runtime=5m --directory=\\192.168.0.151
FileTest: (g=0) rw=read, bs=(R) 8192KiB-8192KiB, (W) 8192KiB-8192KiB, (T) 8192KiB-8192KiB, ioengine=windowsaio, iodepth=16
1/1/...
3/1/20:3.22
Starting 20 threads
Jobs: 20 (fx20): [R(20)][5.7%][r=8833MiB/s][r=1104 IOPS][eta 0m:43s]
```

Task Manager Performance

- CPU: 25% 2.78 GHz
- Memory: 15% 512 GB (3%)
- Ethernet: S: 73.7 Mbps R: 75.1 Gbps
- Ethernet: S: 32.0 Kbps R: 48.0 Kbps

Ethernet Mellanox ConnectX-6 Adapter

Throughput

- Send: 73.7 Mbps
- Receive: 75.1 Gbps

Adapter name: SLOT 4 Port 1
Connection type: Ethernet
IPv4 address: 192.168.0.151
IPv6 address: fe80::da5a5155cccca4db%19

smbclient IORING_OP_SENDMSG/SPLICE (network)

4 connections, ~11 GBytes/s, smbld 8.6% cpu, with 4 io_wqework threads (pipe to socket) at ~20% cpu each.

smbclient is the bottleneck here too

```
getting file S96.dat of size 2097152000 as /dev/null [2771312.2 KiBytes/sec] (average 2746784.9 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3195609.5 KiBytes/sec] (average 3223967.9 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3180123.7 KiBytes/sec] (average 3174986.8 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [2824027.2 KiBytes/sec] (average 2828665.4 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3255961.3 KiBytes/sec] (average 324002.5 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [2782688.3 KiBytes/sec] (average 2746838.3 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3238233.4 KiBytes/sec] (average 3178965.8 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3215878.2 KiBytes/sec] (average 3223992.8 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [2790190.4 KiBytes/sec] (average 2820636.8 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3185609.5 KiBytes/sec] (average 3178974.8 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [2797813.8 KiBytes/sec] (average 2748894.5 KiBytes/sec)
getting file S96.dat of size 2097152000 as /dev/null [3250783.1 KiBytes/sec] (average 3224021.1 KiBytes/sec)
```

```
top - 02:41:58 up 17 days, 17:34, 1 user, load average: 3.97, 4.22, 3.55
Tasks: 977 total, 5 running, 972 sleeping, 0 stopped, 0 zombie
Cpu(s): 0.1 us, 4.0 sy, 0.0 ni, 93.5 id, 0.0 wa, 0.0 hi, 1.7 si, 0.0 st
Mem Mem : 131824.1 total, 127133.7 free, 3813.5 used, 60991.4 buff/cache
Mem Swap: 1824.0 total, 737.0 free, 287.0 used, 131646.0 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
740188	root	20	0	375608	35968	16852	R	99.3	0.0	0:35.55	smbclient
740185	root	20	0	375664	36180	17016	R	99.0	0.0	0:30.87	smbclient
740187	root	20	0	375692	35888	16896	R	88.1	0.0	0:44.08	smbclient
740186	root	20	0	375652	35896	16748	R	86.4	0.0	0:49.28	smbclient
180189	root	20	0	31548	7872	3412	S	2.0	0.0	180:08.15	top
238	root	20	0	0	0	0	S	1.3	0.0	5:56.38	ksftirqd/45
740176	root	20	0	249536	8076	5136	S	1.3	0.0	0:11.20	iftop

```
top - 02:41:57 up 3 days, 21:43, 5 users, load average: 1.11, 0.89, 0.62
Tasks: 977 total, 1 running, 876 sleeping, 0 stopped, 0 zombie
Cpu(s): 0.1 us, 1.4 sy, 0.0 ni, 97.6 id, 0.0 wa, 0.1 hi, 0.9 si, 0.0 st
Mem Mem : 131824.1 total, 117240.5 free, 3955.5 used, 11338.1 buff/cache
Mem Swap: 1824.0 total, 1824.0 free, 0.0 used, 180675.2 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
316136	root	20	0	0	0	0	S	21.3	0.0	0:52.01	io_wqeworker-0
316133	root	20	0	0	0	0	S	20.3	0.0	0:53.37	io_wqeworker-0
316139	root	20	0	0	0	0	S	17.9	0.0	0:46.39	io_wqeworker-0
316121	root	20	0	0	0	0	S	17.3	0.0	0:34.40	io_wqeworker-0
316116	root	20	0	458880	21264	17852	S	4.6	0.0	0:40.53	smbd

Samples: 786 of event 'cycles', 4800 Hz, Event count (approx.): 35349326236 last: 0/0 drop: 0/32990

Overhead	Shared object	Symbol
7.85%	[kernel]	[k] do_tcp_sendpages
5.37%	[kernel]	[k] raw_spin_lock_bh
4.00%	[kernel]	[k] copy_page_to_iter
3.75%	[kernel]	[k] page_cache_pipe_buf_release
3.09%	[kernel]	[k] s6c_retpoline_rax
3.09%	[kernel]	[k] page_cache_pipe_buf_confirm
2.87%	[kernel]	[k] native_queued_spin_lock_slowpath
2.04%	[kernel]	[k] shmem_file_read_iter
2.04%	[kernel]	[k] inet_sendpage
2.01%	[kernel]	[k] tcp_sendpage

	1546038464gb	3892866928cb	4638801264cb	6184121056cb7738152448gb
192.168.10.191	==>	192.168.10.190		91.7Gb 91.5Gb 89.7Gb
192.168.10.191	==>	192.168.0.153		18.3Mb 18.7Mb 19.6Mb
				0b 0b 210b
TX:	cur: 3146b	peak: 0b	rates:	91.7Gb 91.5Gb 89.7Gb
RX:	68.7Mb	22.1Mb		18.3Mb 18.7Mb 19.6Mb
TOTAL:	3146b	0b		91.8Gb 91.5Gb 89.7Gb

smbclient (R_G_OP_READMSG/SPICE (loopback))

8 connections, ~22 GBytes/s, smbdc 22% cpu, with 4 io_wqe_work threads (pipe to socket) at ~22% cpu each.

smbclient is the bottleneck here too, it triggers the memory copy done by copy_user_enhanced_fast_string()

getting file %SMB.dat of size 2097152000 as /dev/null	3075974.0 KiloBytes/sec	average 268808.0 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12945258.3 KiloBytes/sec	average 2843676.6 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12771877.3 KiloBytes/sec	average 2841617.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12951800.2 KiloBytes/sec	average 2879437.6 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12831641.2 KiloBytes/sec	average 2733178.9 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13187778.5 KiloBytes/sec	average 2958866.5 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12694736.5 KiloBytes/sec	average 2714142.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13068334.0 KiloBytes/sec	average 2733560.0 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13117188.0 KiloBytes/sec	average 2898622.1 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13047818.6 KiloBytes/sec	average 2944356.1 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13088355.4 KiloBytes/sec	average 2741473.6 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12741632.0 KiloBytes/sec	average 2849412.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13002322.1 KiloBytes/sec	average 2888256.5 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13126712.1 KiloBytes/sec	average 2951913.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13080880.9 KiloBytes/sec	average 2891556.4 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12515970.2 KiloBytes/sec	average 2731748.0 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12173791.0 KiloBytes/sec	average 2709284.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12923548.2 KiloBytes/sec	average 2844283.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13093655.7 KiloBytes/sec	average 2743728.7 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13093655.7 KiloBytes/sec	average 2842526.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13007341.7 KiloBytes/sec	average 2841881.0 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13187778.5 KiloBytes/sec	average 2968878.4 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13136293.6 KiloBytes/sec	average 2891072.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12752887.8 KiloBytes/sec	average 2731809.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13064336.0 KiloBytes/sec	average 2945895.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12745338.0 KiloBytes/sec	average 2789462.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13117188.0 KiloBytes/sec	average 2748788.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13117188.0 KiloBytes/sec	average 2844253.7 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12963318.4 KiloBytes/sec	average 2863638.2 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12518064.0 KiloBytes/sec	average 2854685.1 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13093655.1 KiloBytes/sec	average 2894348.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12828728.0 KiloBytes/sec	average 2732566.5 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12771312.2 KiloBytes/sec	average 2789897.3 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13134488.0 KiloBytes/sec	average 2884841.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13134488.0 KiloBytes/sec	average 2748478.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12596898.4 KiloBytes/sec	average 2842472.7 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13003875.2 KiloBytes/sec	average 2957376.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12976743.8 KiloBytes/sec	average 2878388.8 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	13083575.2 KiloBytes/sec	average 2895262.7 KiloBytes/sec
getting file %SMB.dat of size 2097152000 as /dev/null	12824822.2 KiloBytes/sec	average 2783196.6 KiloBytes/sec

```
top - 04:00:58 up 4 days, 23:02, 6 users, load average: 9.15, 3.56, 1.44
Tasks: 937 total, 14 running, 903 sleeping, 0 stopped, 0 zombie
Cpu(s): 0.3 us, 11.2 sy, 0.0 ni, 06.1 id, 0.0 wa, 0.2 hi, 2.1 si, 0.0 st
MiB Mem: 191824.1 total, 170095.4 free, 3316.7 used, 11382.0 buff/cache
MiB Swap: 1824.0 total, 1824.0 free, 0.0 used, 188693.7 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	CPU	MEM	TIME+	COMMAND
322763	root	20	0	376228	36628	13764	R	02.5	0.0	1:26.20	smbclient
322764	root	20	0	368036	28192	17128	R	01.5	0.0	1:26.18	smbclient
322765	root	20	0	368040	28216	17164	R	01.1	0.0	1:25.83	smbclient
322768	root	20	0	376244	36740	17468	R	79.8	0.0	1:25.73	smbclient
322769	root	20	0	376236	36608	17228	R	79.8	0.0	1:24.42	smbclient
322781	root	20	0	376248	36808	17282	R	79.5	0.0	1:24.74	smbclient
322786	root	20	0	368040	28248	17464	R	79.5	0.0	1:25.83	smbclient
322759	root	20	0	378140	36494	17312	R	79.1	0.0	1:24.31	smbclient
322782	root	20	0	368040	0	0	S	23.8	0.0	0:14.84	io_wqe_worker-0
322827	root	20	0	0	0	0	S	23.5	0.0	0:12.77	io_wqe_worker-0
322882	root	20	0	0	0	0	S	22.8	0.0	0:14.36	io_wqe_worker-0
322838	root	20	0	0	0	0	S	22.8	0.0	0:12.96	io_wqe_worker-0
322772	root	20	0	458268	21488	17596	R	22.5	0.0	0:22.45	smbd
322796	root	20	0	0	0	0	S	22.2	0.0	0:11.80	io_wqe_worker-0
322880	root	20	0	0	0	0	S	21.5	0.0	0:14.13	io_wqe_worker-0
322822	root	20	0	0	0	0	R	21.5	0.0	0:12.86	io_wqe_worker-0
322818	root	20	0	0	0	0	S	19.2	0.0	0:12.71	io_wqe_worker-0
318818	root	20	0	248476	6976	4988	S	9.3	0.0	1:31.29	iffop
322833	root	20	0	0	0	0	S	5.3	0.0	0:02.61	io_wqe_worker-0
322854	root	20	0	0	0	0	S	5.0	0.0	0:02.58	io_wqe_worker-0
322842	root	20	0	0	0	0	S	4.6	0.0	0:02.70	io_wqe_worker-0
322861	root	20	0	0	0	0	S	4.6	0.0	0:02.66	io_wqe_worker-0
322888	root	20	0	0	0	0	S	4.6	0.0	0:02.54	io_wqe_worker-0
322862	root	20	0	0	0	0	S	4.6	0.0	0:02.78	io_wqe_worker-0
318738	root	20	0	3837184	172756	54344	S	4.3	0.1	1:49.89	perf
322836	root	20	0	0	0	0	S	4.3	0.0	0:02.61	io_wqe_worker-0
322839	root	20	0	0	0	0	S	4.3	0.0	0:02.77	io_wqe_worker-0
322848	root	20	0	0	0	0	R	4.0	0.0	0:02.52	io_wqe_worker-0
322865	root	20	0	0	0	0	S	4.0	0.0	0:02.68	io_wqe_worker-0
322868	root	20	0	0	0	0	S	4.0	0.0	0:02.66	io_wqe_worker-0
322887	root	20	0	0	0	0	S	4.0	0.0	0:02.57	io_wqe_worker-0
322845	root	20	0	0	0	0	S	3.6	0.0	0:02.58	io_wqe_worker-0
322856	root	20	0	0	0	0	S	3.6	0.0	0:02.33	io_wqe_worker-0
322858	root	20	0	0	0	0	S	3.6	0.0	0:02.52	io_wqe_worker-0

```
Samples: 30k of event 'cycles', 1000 Hz, Event count (approx.): 52678559529 last: 0/0 drop: 0/0
Overhead Shared object Symbol
6.01% [kernel] [k] copy_user_enhanced_fast_string
6.00% [kernel] [k] native_queued_spin_lock_slowpath
5.90% [kernel] [k] tcpack_rev
3.79% [kernel] [k] do_tcp_sendpages
3.20% [kernel] [k] raw_spin_lock_bh
3.21% [kernel] [k] prb_fill_curr_block.isra.0
3.18% [kernel] [k] raw_spin_lock
0.92% [kernel] [k] copy_page_to_iter
0.89% [kernel] [k] sbk_release_data
0.89% [kernel] [k] __check_object_size
For a higher level overview, try: perf top --sort comm,dsu
```

```
157537928cb 3151875408cb 4726614816cb 6382151688cb877689344cb
127.0.0.1 <= 127.0.0.1 181cb 181cb 180cb
cb cb cb
Tx: cum: 226476B peak: 6.59cb rates: 181cb 181cb 180cb
Rx: cb cb cb
TOTAL: 226476B 6.59cb 181cb 181cb 180cb
```

More loopback testing on brand new hardware

- ▶ Recently I re-did the loopback read tests IORING_OP_SENDMSG/SPLICE (from /dev/shm/)
 - ▶ 1 connection, ~10-13 GBytes/s, smbd 7% cpu, with 4 iou-wrk threads at 7%-50% cpu.
 - ▶ 4 connections, 24-30 GBytes/s, smbd 18% cpu, with 16 iou-wrk threads at 3%-35% cpu.
- ▶ I also implemented SMB2 writes with IORING_OP_RECVMSG/SPLICE (tested to /dev/null)
 - ▶ 1 connection, ~7-8 GBytes/s, smbd 5% cpu, with 3 io-wrk threads at 1%-20% cpu.
 - ▶ 4 connections, ~10 GBytes/s, smbd 15% cpu, with 12 io-wrk threads at 1%-20% cpu.
- ▶ I tested with a Linux Kernel 5.13
 - ▶ In both cases the bottleneck is clearly on the smbclient side
 - ▶ We could apply similar changes to smbclient and add true multichannel support
 - ▶ It seems that the filesystem->pipe->socket path is much better optimized

Improvements for transfers with SMB3 signing

- ▶ Samba 4.15 has support for AES-128-GMAC signing:
 - ▶ This is also available in recent Windows versions
 - ▶ It's based on AES-128-GCM (but only with authentication data)
 - ▶ The gnutls library is able to provide:
 - ▶ ~6 GBytes/s for AES-128-GCM
 - ▶ ~10 GBytes/s for AES-128-GMAC
- ▶ For SMB3 signing/encryption we use:
 - ▶ IORING_OP_SPLICE from a file into a (splice)pipe
 - ▶ IORING_OP_TEE from the (splice)pipe to a 2nd (tee)pipe
 - ▶ IORING_OP_READ from the (tee)pipe into a userspace buffer
 - ▶ (vmsplice might work even better)
 - ▶ The userspace buffer is only used to calculate the signing signature
 - ▶ IORING_OP_SENDMSG and IORING_OP_SPLICE are used in order to avoid a copy back to the kernel
- ▶ For a SMB2 read test I removed the signing check in smbclient:
 - ▶ The performance changed from ~3 GBytes/s before
 - ▶ To ~5 GBytes/s using the IORING_OP_TEE trick
 - ▶ With smbclient still being the bottleneck at 100% cpu

Future Improvements

- ▶ `recvmsg` and `splice` deliver partial SMB packets to userspace
 - ▶ I tested with `AF_KCM` (Kernel Connection Multiplexor) and an eBPF helper
 - ▶ But `MSG_WAITALL` is the much simpler and faster solution
 - ▶ I also prototyped a `SPLICE_F_WAITALL`
 - ▶ eBPF support in `io-uring` would also be great for optimizations
- ▶ It also seems that `socket->pipe->filesystem`:
 - ▶ Does not implement zero copy for all cases
 - ▶ Maybe it's possible to optimize this in future
- ▶ In the end SMB-Direct will also be able to reduce overhead
 - ▶ My `smbdirect` driver is still work in progress...
 - ▶ With the `IORING_FEAT_NATIVE_WORKERS` feature it will be possible glue it to `IORING_OP_SENDMSG`

Questions? Feedback!

- ▶ Feedback regarding real world testing would be great!
- ▶ Stefan Metzmacher, metze@samba.org
- ▶ <https://www.sernet.com>
- ▶ <https://samba.plus>

Slides: <https://samba.org/~metze/presentations/2021/SDC/>