IP Parcels Implementation Report

IETF115 Intarea Working Group Session (November 9, 2022)

Fred L. Templin (The Boeing Company)

fred.l.templin@boeing.com

Implementation Elements

- Parcel framing in ION-DTN LTP convergence layer (ion-open-source-4.1.0)
- Parcel extensions for (UDP_SEGMENT; UDP_GRO) socket API (linux-5.10.67)
- Linux kernel UDP/IPv4 parcel support, with "IPv4 Jumbo Payload" option
- IPv6 fragmentation in ip6_tunnel.c $\rightarrow$ RFC2473 surrogate OMNI interface
- SO_NO_CHECK for LTP/kernel parcel segment checksum selection (Rx/Tx)
- New skb_checksum_parcel() for kernel parcel segment checksums

Modules Updated

Linux kernel:
./net/core/dev.c
./net/core/skbuff.c
./net/core/sock.c
./net/ipv4/ip_input.c
./net/ipv4/ip_options.c
./net/ipv4/ip_output.c
./net/ipv4/udp.c
./net/ipv6/ip6_tunnel.c
./net/ipv6/udp.c
./include/linux/udp.h
./include/linux/skbuff.h
./include/net/udp.h
./include/net/ipv6.h
./include/net/inet_sock.h
./include/net/ip.h
./include/uapi/linux/ip.h

ION-DTN:
./ltp/udp/libudplsa.c
./ltp/udp/udplsa.h
./ltp/udp/udplsi.c
./ltp/udp/udplso.c
./ltp/library/ltpP.h

OMNI Interface

- RFC2473 IPv6 encapsulation/fragmentation (Adaptation Layer)
- Configured over 10Gbps P2P Ethernet (1500 MTU)

IPv4 in IPv6
Encapsulation

Large data received for small
# of packets (58KB/pkt average)

Large Maximum Transmission Unit
(MTU = ((64KB-1) - 128))

```
fltemplin@harrier:~/DTN-OMNI/configs/25-ipn-ltp$ ifconfig omni0
omni0: flags=209<UP,POINTOPOINT,RUNNING,NOARP>  mtu 65407
        inet 192.168.0.2  netmask 255.255.255.0  destination 192.168.0.2
        inet6 fe80::28e9:6eff:fe27:73c3  prefixlen 64  scopeid 0x20<link>
        unspec FE-80-00-00-00-00-00-00-00-00-00-00-00-00-00-00  txqueuelen 1000  (UNSPEC)
        RX packets 14562   bytes 853236422 (853.2 MB)
        RX errors 0   dropped 0   overruns 0   frame 0
        TX packets 83   bytes 21335 (21.3 KB)
        TX errors 6   dropped 6 overruns 0   carrier 0   collisions 0
```
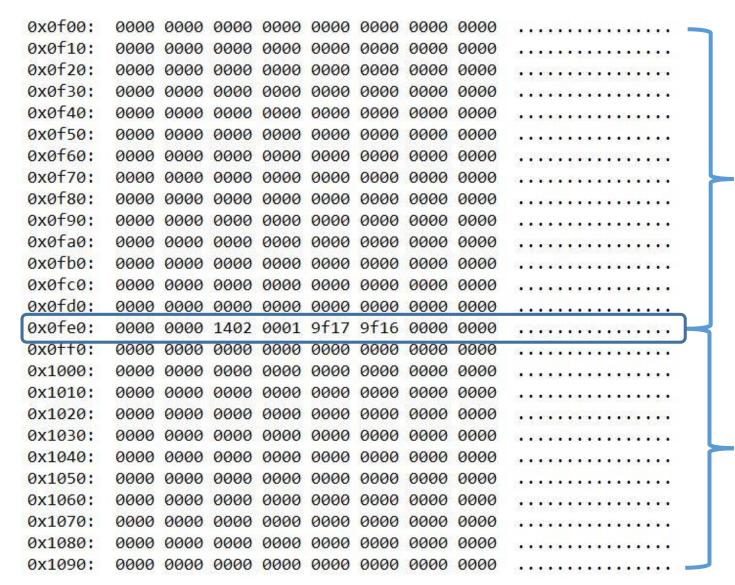
UDP/IPv4 Parcel

- Produced by LTP/UDP source; captured at destination OMNI interface
- Transparent IPv6 fragmentation over underlying 10Gbps Ethernet
- 64052-octet UDP/IPv4 parcel with 16 (3999-octet) segments:

IP version 4 with 28 octet header

IPv4 Length = first segment length only

IPv4 Jumbo Payload option:
Type = 0x0b (RFC1063); Len = 0x06; NSegs = 0x10;
Jumbo Payload Len = 0x00fa34; padding = 0x0000

UDP checksum (header only)

UDP Length = 0

Integrity block w/16 2-octet checksums (one per segment)

```
15:16:29.027313 IP 192.168.0.1.45080 > harrier.25113: truncated-udplength 0
    0x0000:  4700 0f9f acbc 0000 4011 2603 c0a8 0001   G.......@.&....
    0x0010:  c0a8 0002 0b06 1000 fa34 0000 b018 6219   .........4....b.
    0x0020:  0000 c33f 1957 cead b88e a26f 8c50 c1e5   ...?.W......o.P..
    0x0030:  a250 833b 6426 c510 a5fb 86e6 6751 c83b   .P.;d&......gQ.;
    0x0040:  a926 81cd 0014 0200 0100 9f17 0681 1011   .&..............
    0x0050:  1901 1401 1401 0000 82d7 8ce7 4001 822c   ............@..,
    0x0060:  0005 1009 6970 6e00 3230 2e30 0014 0101   ....ipn.20.0....
    0x0070:  0001 09bd 8440 7465 7374 2e2e 2e00 0000   .....@test......
```

Parcel (continued)

```
0x0000:    4700 0f9f acbc 0000 4011 2603 c0a8 0001    G........@.&.....
0x0010:    c0a8 0002 0b06 1000 fa34 0000 b018 6219    .........4....b.
0x0020:    0000 c33f 1957 cead b88e a26f 8c50 c1e5    ...?.W.....o.P..
0x0030:    a250 833b 6426 c510 a5fb 86e6 6751 c83b    .P.;d&......gQ.;
0x0040:    a926 81cd 0014 0200 0100 9f17 0681 1011    .&..............
0x0050:    1901 1401 1401 0000 82d7 8ce7 4001 822c    ............@..,
0x0060:    0005 1009 6970 6e00 3230 2e30 0014 0101    ....ipn.20.0....
0x0070:    0001 09bd 8440 7465 7374 2e2e 2e00 0000    .....@test......
0x0080:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0090:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x00a0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x00b0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x00c0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x00d0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x00e0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x00f0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0100:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0110:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0120:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0130:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0140:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0150:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0160:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0170:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0180:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x0190:    0000 0000 0000 0000 0000 0000 0000 0000    ................
```

Parcel Headers

Start first segment

Parcel (continued)

```
0x0f00:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f10:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f20:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f30:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f40:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f50:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f60:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f70:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f80:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0f90:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0fa0:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0fb0:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0fc0:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0fd0:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x0fe0:   0000 0000 1402 0001 9f17 9f16 0000 0000   .................
0x0ff0:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1000:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1010:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1020:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1030:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1040:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1050:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1060:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1070:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1080:   0000 0000 0000 0000 0000 0000 0000 0000   .................
0x1090:   0000 0000 0000 0000 0000 0000 0000 0000   .................
```

End first segment

Start second segment

Parcel (continued)

```
0x5d00:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d10:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d20:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d30:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d40:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d50:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d60:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d70:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d80:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5d90:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5da0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5db0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5dc0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5dd0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5de0:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5df0:    0000 0000 0000 0000 0000 0000 0000 0014    ................
0x5e00:    0200 0181 bb04 9f15 0000 0000 0000 0000    ................
0x5e10:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e20:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e30:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e40:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e50:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e60:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e70:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e80:    0000 0000 0000 0000 0000 0000 0000 0000    ................
0x5e90:    0000 0000 0000 0000 0000 0000 0000 0000    ................
```

← Later segment break

Parcel (continued)

```
0xf900:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf910:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf920:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf930:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf940:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf950:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf960:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf970:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf980:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf990:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf9a0:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf9b0:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf9c0:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf9d0:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf9e0:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xf9f0:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xfa00:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xfa10:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xfa20:   0000 0000 0000 0000 0000 0000 0000 0000   ................
0xfa30:   0000 0000                                  ....
```

end of parcel (~4000 lines of text)

Single-segment Performance

- 1280: 609Mbps
- 1460: 684Mbps

Simple UDP/IPv4 Packets Over Native
Ethernet Interface (1500 MTU)

- 2000: 775Mbps
- 4000: 1450Mbps
- 8000: 2335Mbps
- 9000: 2537Mbps
- 10000: 2664Mbps
- 12000: 3042Mbps
- 14000: 3288Mbps
- 18000: 3668Mbps
- 24000: 4130Mbps
- 28000: 4268Mbps
- 30000: 4359Mbps
- 32000: 4616Mbps

UDP/IPv4 Parcels Over OMNI
Interface ((64KB-1)-128 MTU)

758% increase from 1280 octets to 32000 octets
596% increase from 2000 octets to 32000 octets

➢ Proof that increasing segment size multiplies
➢ performance even with IPv6 fragmentation

Multi-segment Performance

- 1 Segment: 2000:   775Mbps / 4000: 1450Mbps
- 4 Segment: 2000:   965Mbps / 4000: 1636Mbps
- 6 Segment: 2000: 1029Mbps / 4000: 1730Mbps
- 8 Segment: 2000: 1037Mbps / 4000: 1810Mbps
- 10 Segment: 2000: 1078Mbps / 4000: 1754Mbps
- 12 Segment: 2000: 1095Mbps / 4000: 1812Mbps
- 16 Segment: 2000: 1072Mbps / 4000: 1862Mbps
- 20 Segment: 2000: 1076Mbps
- 24 Segment: 2000: 1078Mbps
- 28 Segment: 2000: 1108Mbps
- 30 Segment: 2000: 1144Mbps
- 32 Segment: 2000: 1137Mbps

28% increase for 16 segments @ 4000 octets
38% increase for 16 segments @ 2000 octets
47% increase for 32 segments @ 2000 octets

Next Steps

- Improve ION-DTN parcel integration robustness
- Support full (64KB-1) OMNI interface MTU
- System call; kernel segmentation support for large parcels (64KB+)
- Kernel UDP/IPv6 parcel support with "IPv6 Jumbo Payload" option
- Path qualification for parcels/jumbos over 64KB+ MTU links
- TCP/IP parcels and performance analysis

Backups

Github

https://github.com/fltemplin/ip-parcels

Drafts

IP Parcels

OMNI

AERO

ATN/BGP