

# IP Networks in the TV Studio

Recent work  
by BBC R&D



Stuart Grace

April 2016

**BBC** | Research & Development





Part One:

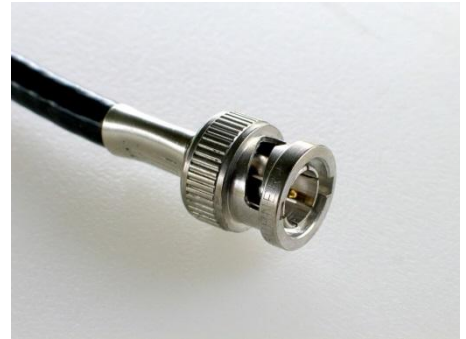
# The IP Studio Project at BBC R&D

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# Current TV Studio Technology: Video

- SDI (serial digital interface) for raw video feeds
- Coax cables with BNC connectors
- Synchronous, circuit switched



- Blanking intervals for compatibility with CRT displays

# Current TV Studio Technology: Other Systems

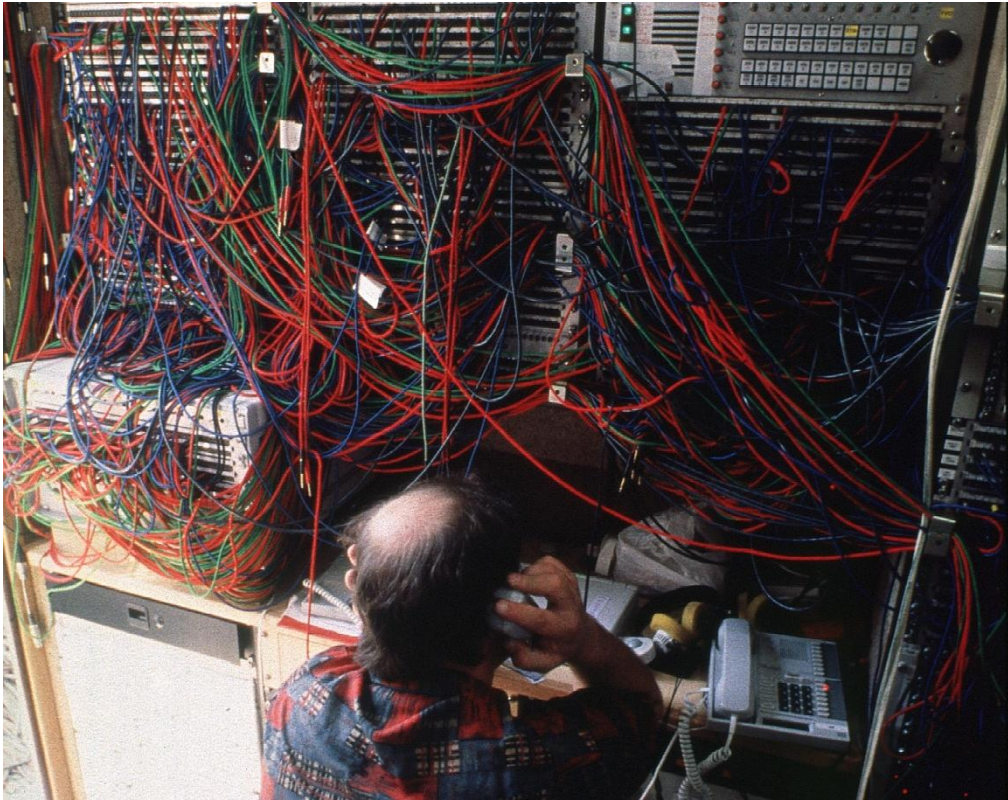
- Digital Audio (AES3 and AES10)
- Timing and synchronisation
- Talkback between locations
- Tally lights
- Teleprompter

...all with separate cables



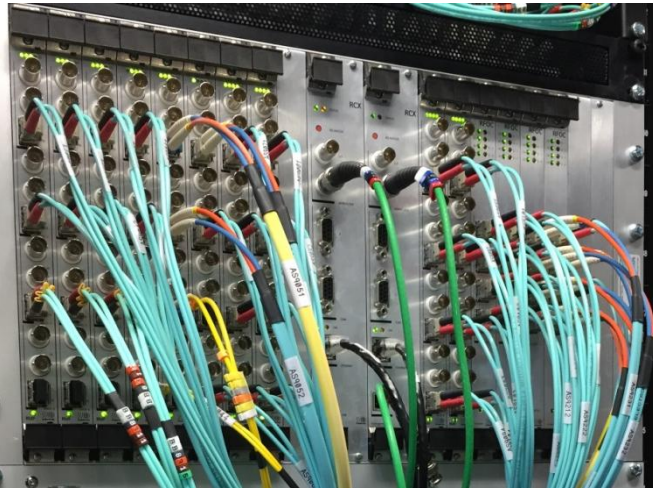


# Manual Patching in an OB Van



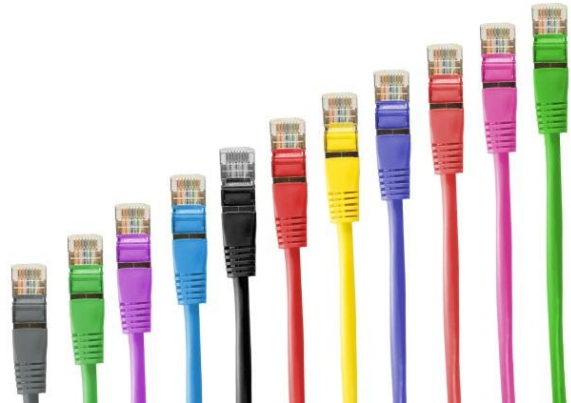
# Current Studio

- Expensive specialist hardware
- Multiple cabling systems
- Formats fixed in hardware

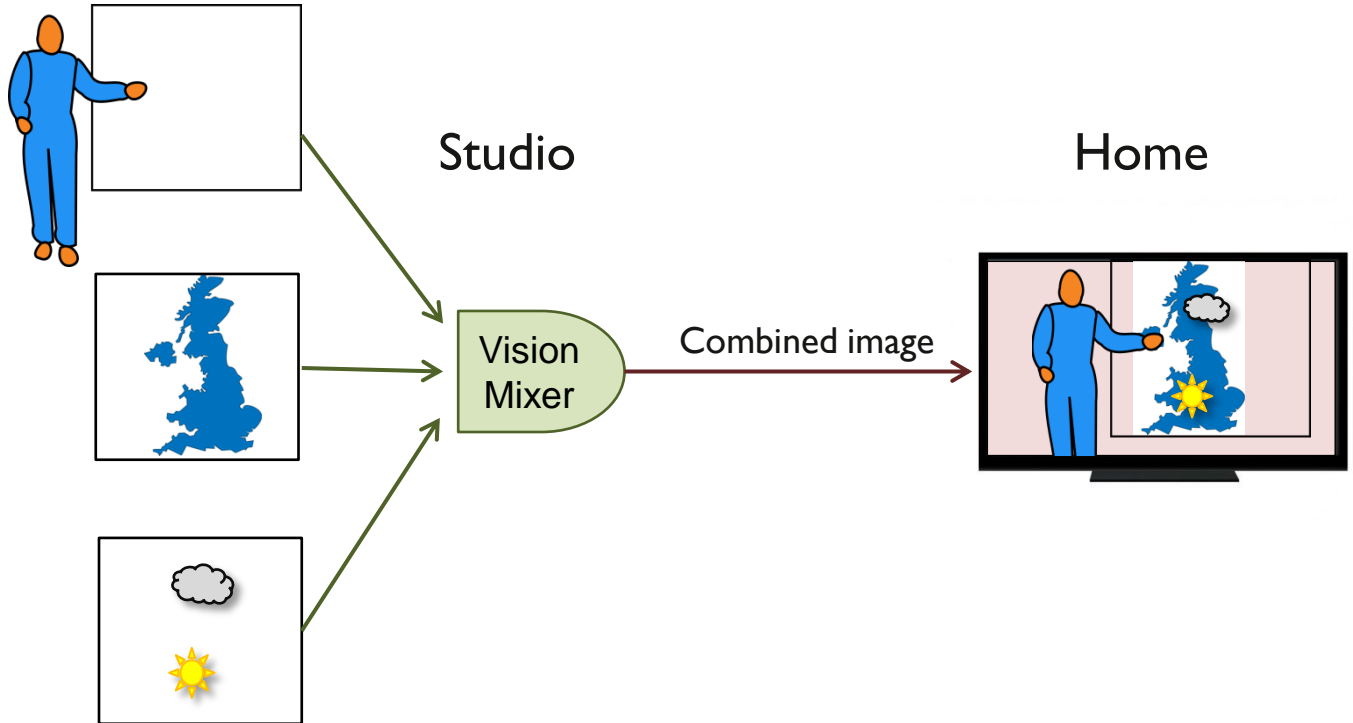


# IP-based Studio

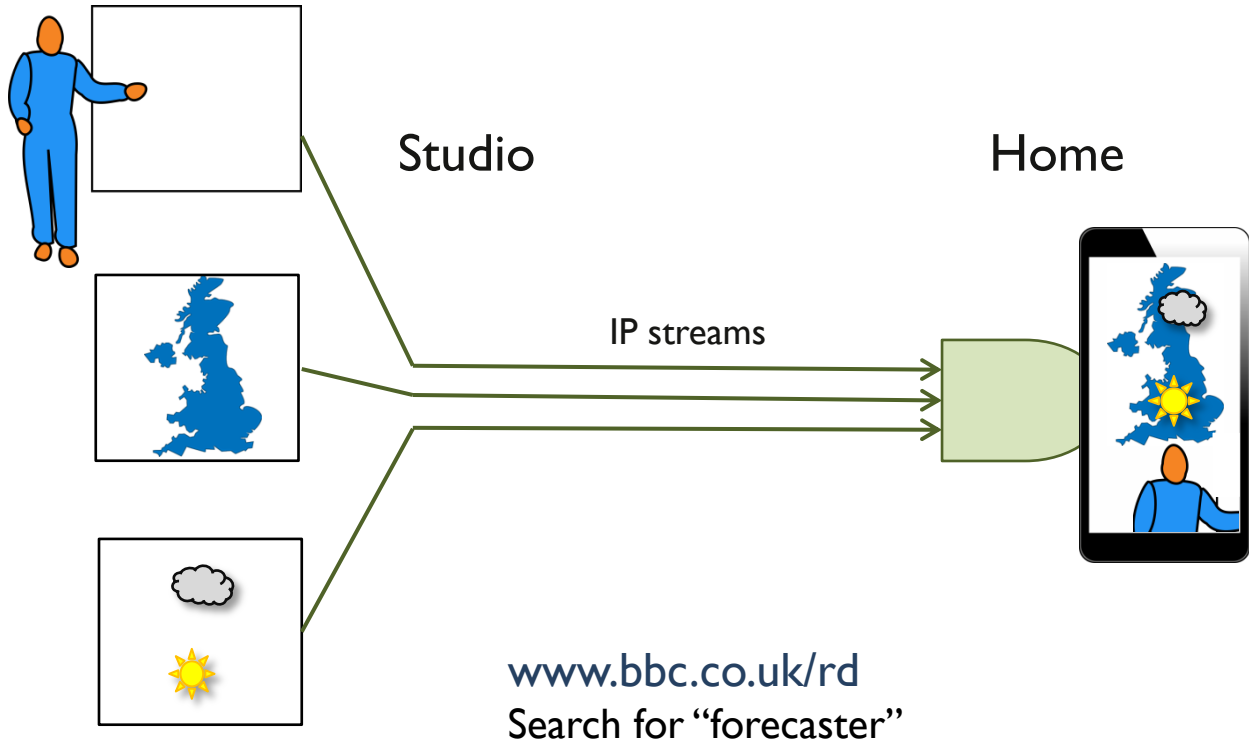
- Commodity hardware
- Single multipurpose network
- Software defined formats
- New production techniques
- New forms of content



# Image Composition at the Studio

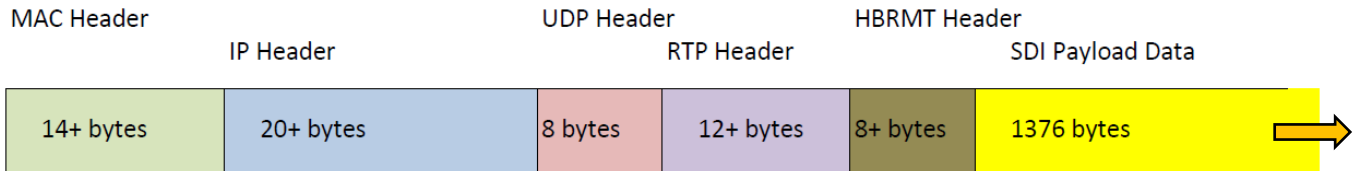


# Image Composition at the Display





# SMPTE 2022-6: SDI video data over UDP





networked media  
**NMOS**  
open specifications



Society of Motion Picture &  
Television Engineers

**EBU**

OPERATING EUROVISION AND EURORADIO

European Broadcasting Union

# Recommended Protocols

RFC 768 – User Datagram Protocol

RFC 3550 – RTP: A Transport Protocol for Real-Time Applications

RFC 4175 – RTP Payload Format for Uncompressed Video

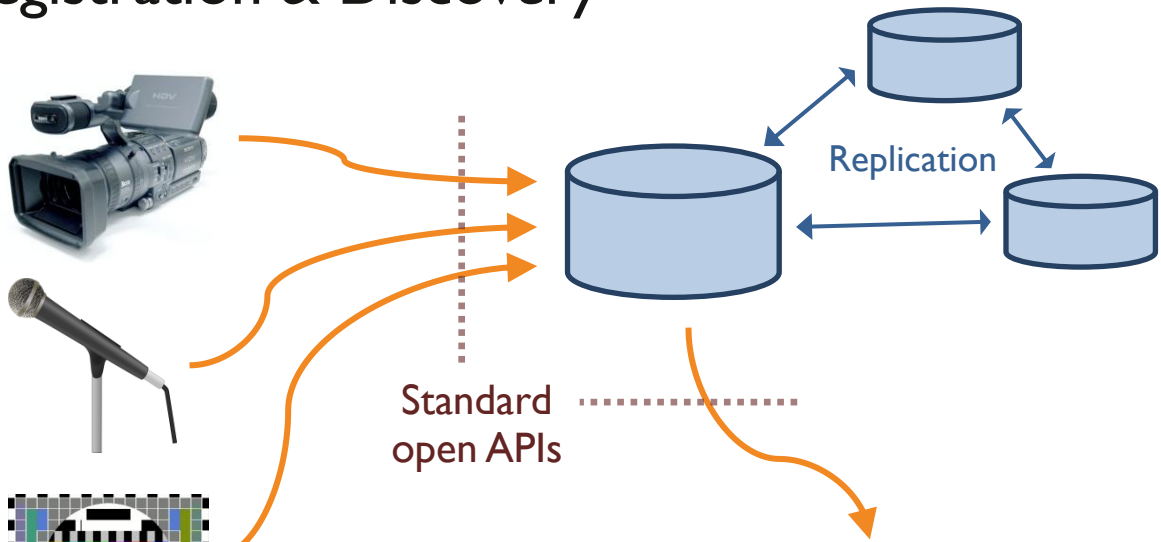
RFC 3190 – RTP Payload Format for 12-bit DAT Audio and 20- and 24-bit Linear Sampled Audio

RFC 4566 – SDP: Session Description Protocol

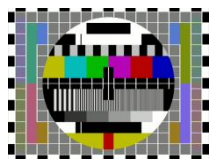
PTP: Precision Time Protocol

*IEEE 1588-2008 – Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*

# Registration & Discovery



Standard open APIs



The screenshot shows a video production control interface. On the left is a list of sources including video quads, audio mixers, and studio cameras. On the right is a "Destinations" grid with buttons for various inputs and outputs, such as "Clean\_Switch Input 0-5", "LCH 4k Viewer", and "LCH GoPro Quad 1-5". Below the destinations is a "Sources" row with buttons for "AWB Audio", "AWB Coded Video", "LCH CS Mix Out", "LCH CS Mix Out", "LCH Gallery Lead CS Out", and "LCH 888 Player 1 HD".



Part Two:

# Streaming UHD Video – Uncompressed

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# Uncompressed Studio Video

Data format: 10-bit YCbCr 4:2:2 → 20 bits per pixel

HD (high definition):



41.5 Mbits per frame

25 frames / sec → 1.04 Gbit/s

# Uncompressed Studio Video

Data format: 10-bit YCbCr 4:2:2 → 20 bits per pixel

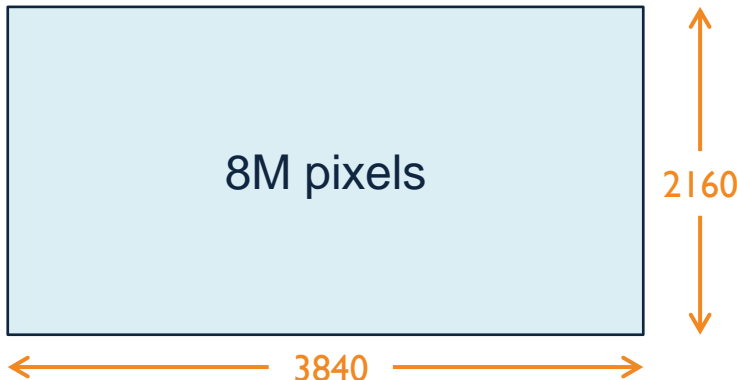
HD (high definition):



41.5 Mbits per frame

25 frames / sec → 1.04 Gbit/s

UHD-I (ultra high definition, 4K):



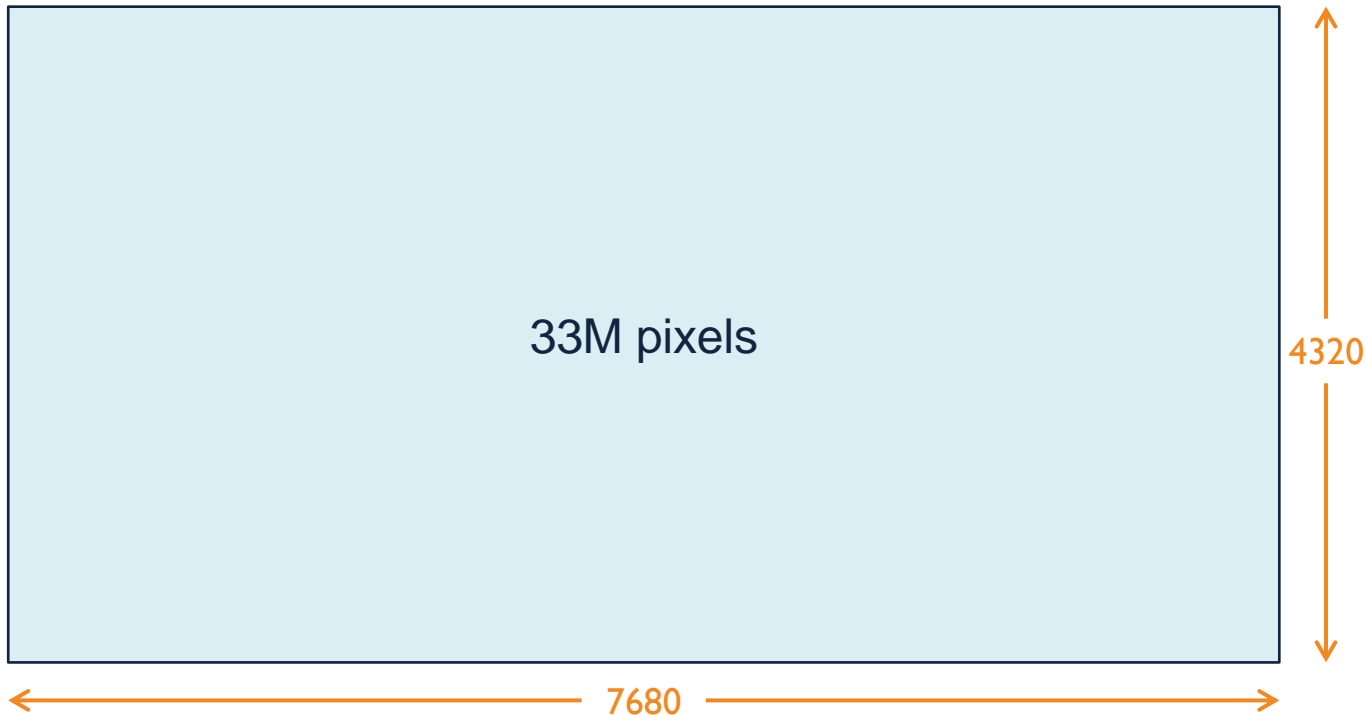
166 Mbits per frame

100 frames / sec →  
16.6 Gbit/s

# BBC News Gallery



# UHD-2 (Super Hi-Vision, 8K):



664 Mbits per frame    120 frames / sec → 80 Gbit/s

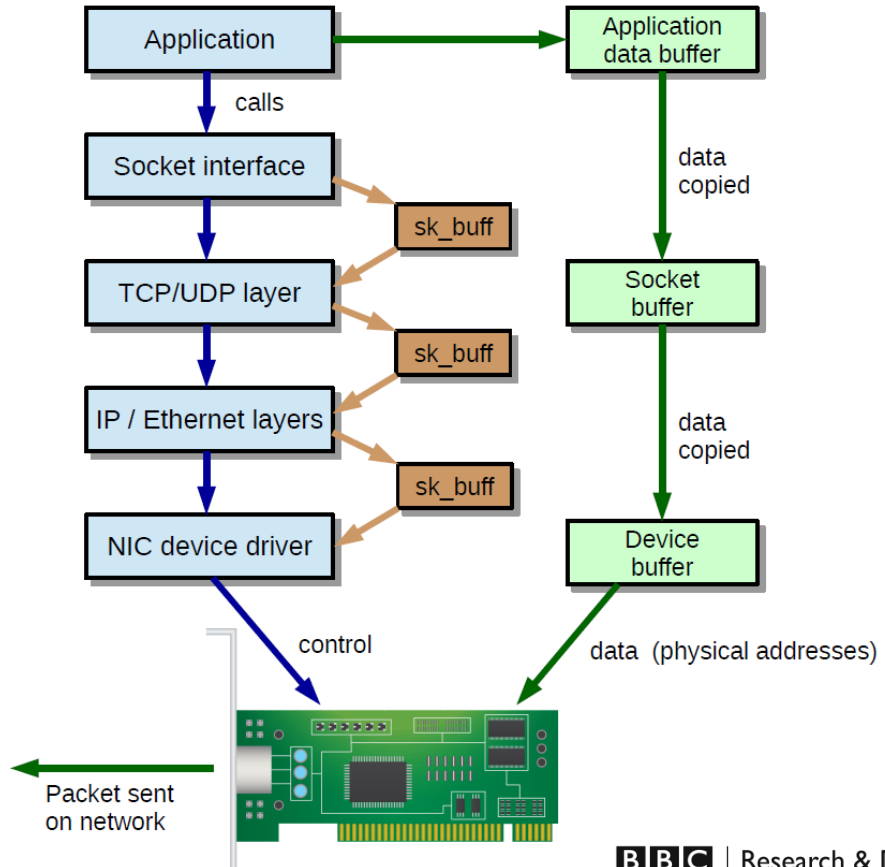
# UHD Trial at the 2014 Commonwealth Games, Glasgow



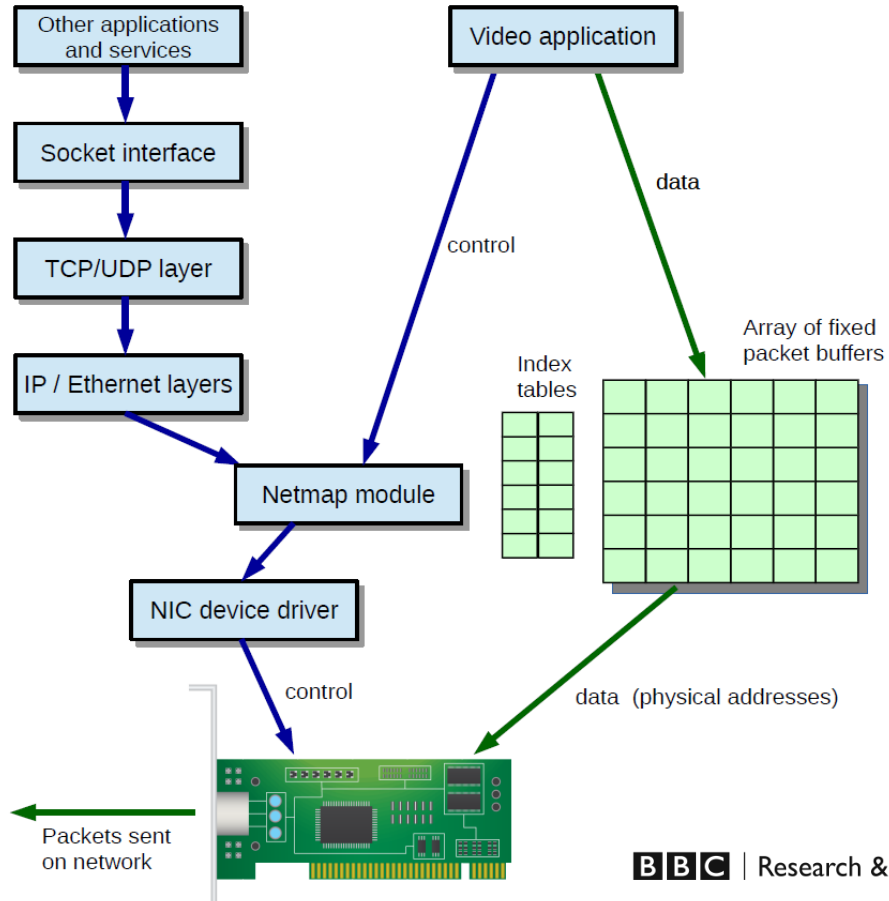
UHD-I @ 50 frames / sec → 8.3 Gbit/s



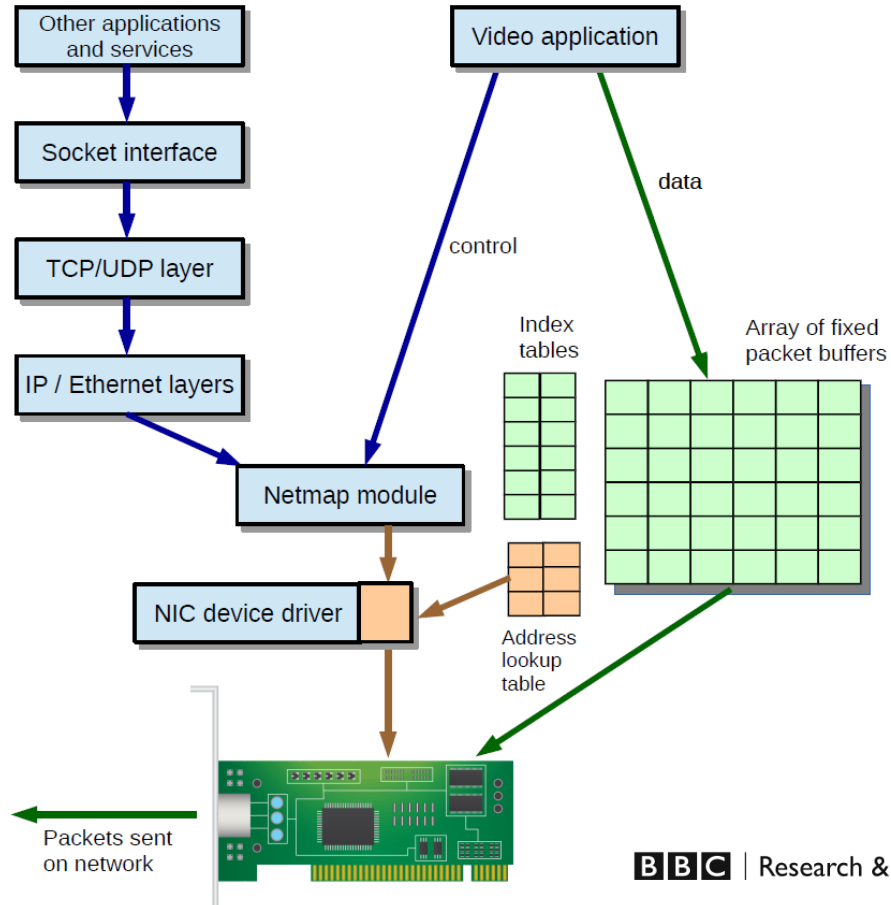
# Linux Network Stack



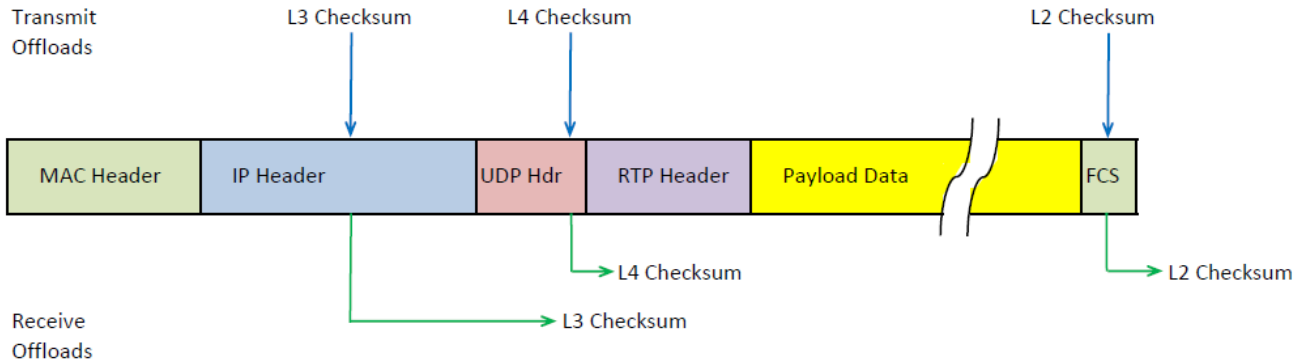
# Netmap with Standard NIC Driver



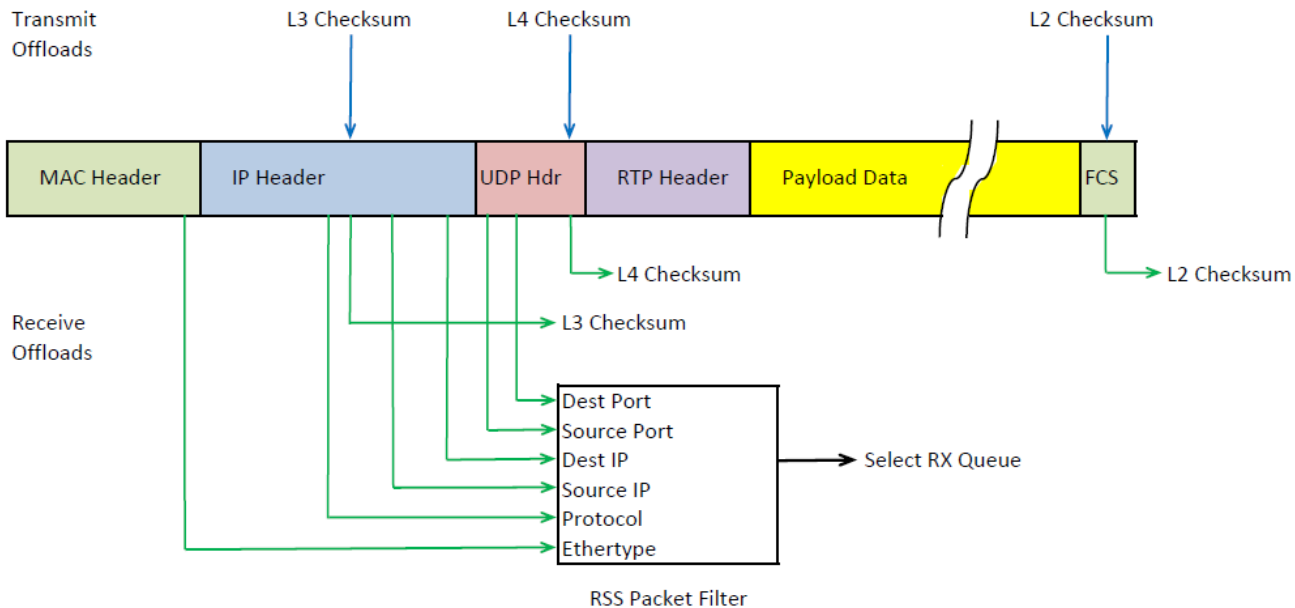
# Netmap with Optimised NIC Driver



# NIC Hardware Offloads

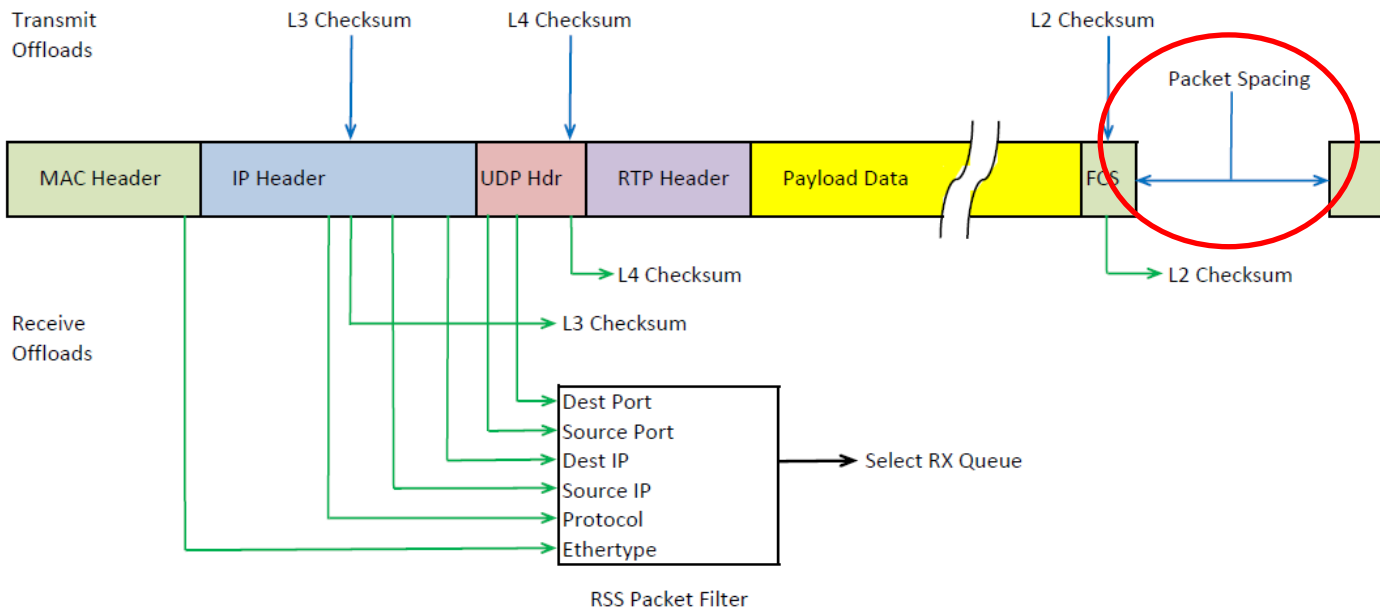


# NIC Hardware Offloads

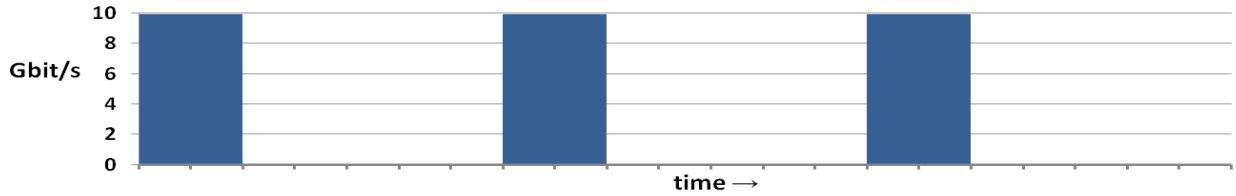




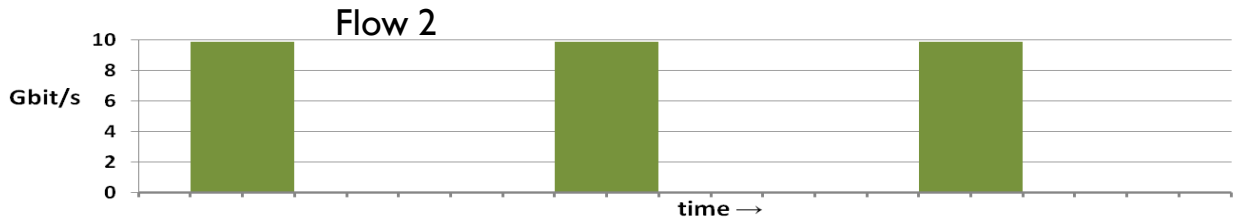
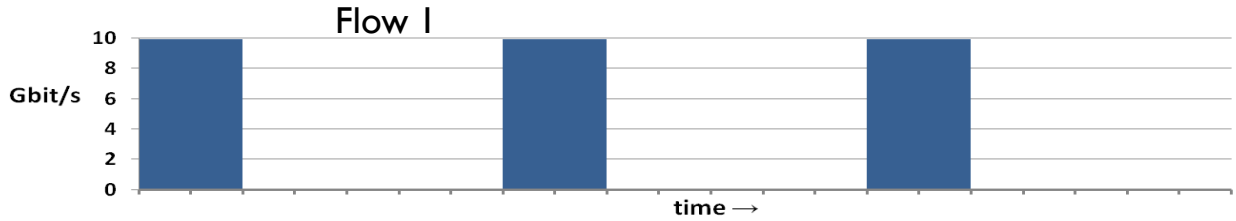
# NIC Hardware Offloads



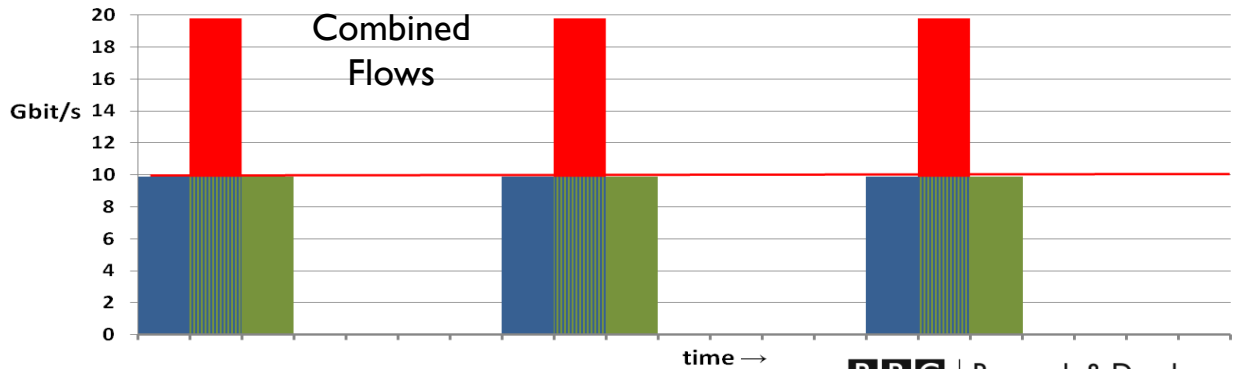
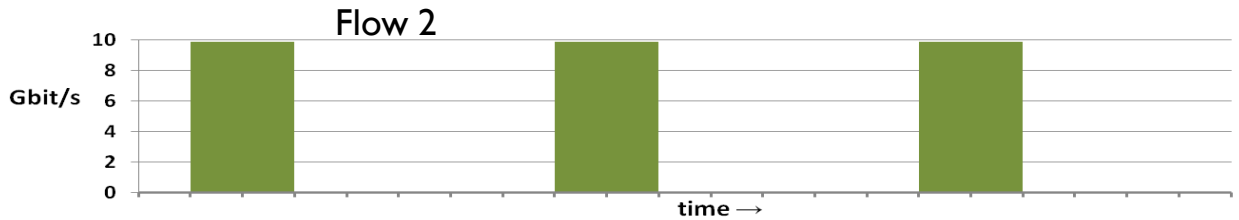
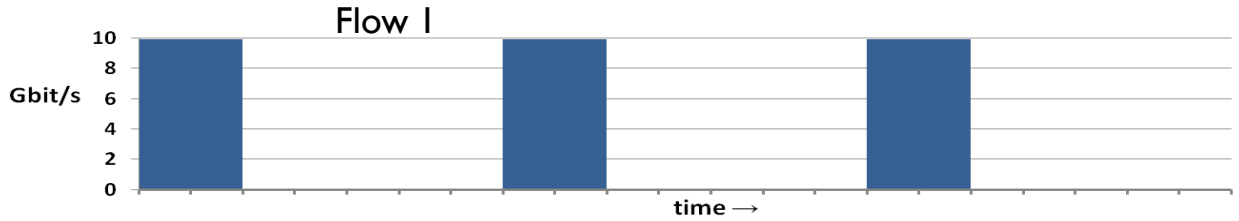
# Bursts of Traffic



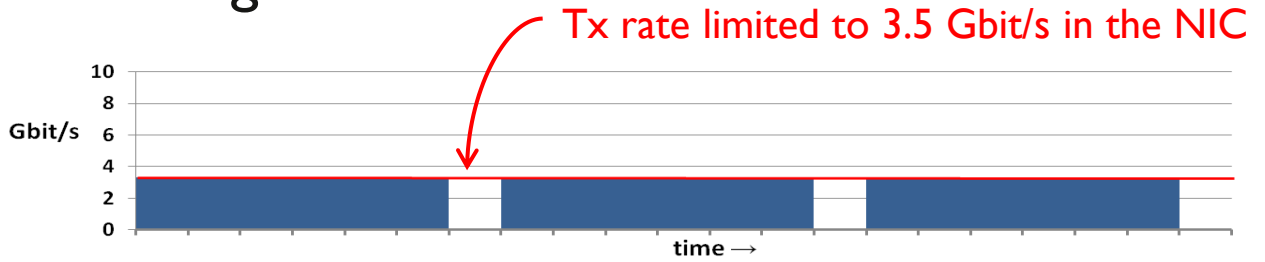
# Bursts of Traffic



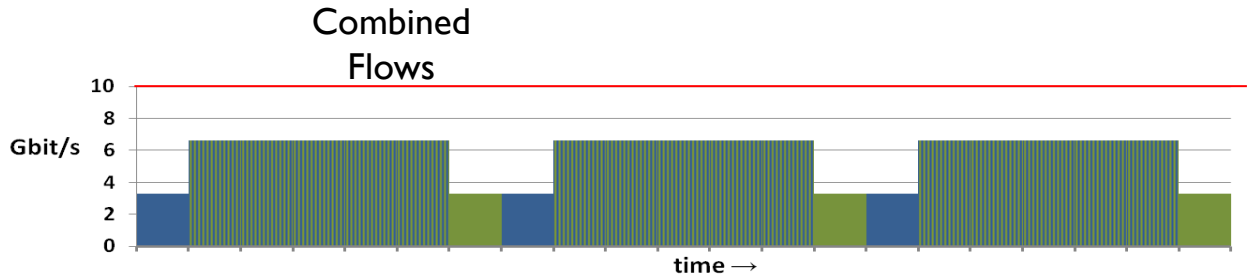
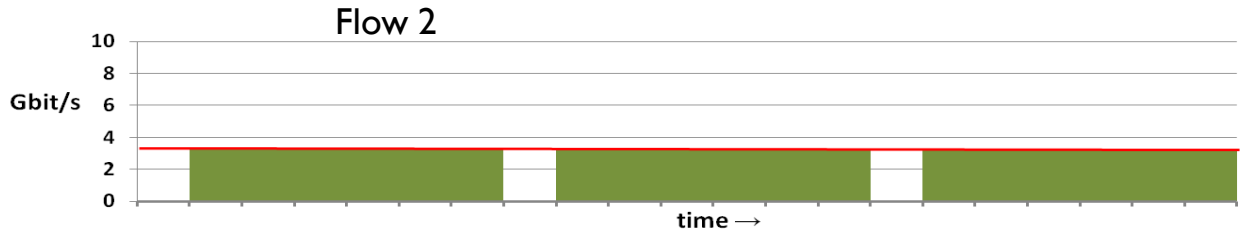
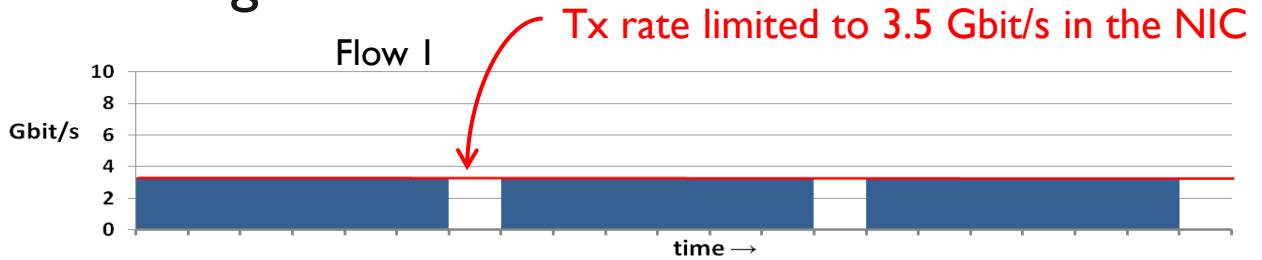
# Bursts of Traffic



# Packet Pacing



# Packet Pacing



# Limitations

- UDP ✓    TCP ✗
- Security – app sees all network traffic
  - Use separate interface for media streaming
- Monolithic – app builds all headers from L2 upwards

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- UDP ✓    TCP ✗
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But we get **75x** increase in network I/O performance using COTS hardware



# CPU Load of RTP Sender

Sending UHD-I @ 50Hz

The image displays three terminal windows from a Linux system. The top window shows the configuration of a network interface (eth7) with a tap. The middle window shows network statistics for eth7, indicating a transmission rate of 8.6 Gbit/s with no packet loss. The bottom window shows system resource usage, including memory, swap, and CPU load, with a callout indicating that only one CPU core is busy.

```
ipstudio-admin@ap-r730-0: ~
File Edit View Search Terminal Help
Seg Ch Segment-Name Tap Seg Max Writing-Process Rate Frame Type Format
size frm PID cmd (est) size

0 0 113667.lpp_sdmulticapture8f98.output_v1 2000M 10 113667 lpp_sd..apture 0.0 0
1 0 113667.lpp_sdmulticapture8f98.output_v0 2000M 10 113667 lpp_sd..apture 50.0 21M video 3840x2160 p50 V210
2 0 113667.lpp_sdmulticapture8f98.output_v3 2000M 10 113667 lpp_sd..apture 0.0 0
3 0 113667.lpp_sdmulticapture8f98.output_v2 2000M 10 113667 lpp_sd..apture 0.0 0
4 0 113667.lpp_sdmulticapture8f98.output_a0 10M 10 113667 lpp_sd..apture 50.0 5760 audio 24-bit interleaved, 2 chans
5 0 113667.lpp_sdmulticapture8f98.output_e0 10M 10 113667 lpp_sd..apture 0.0 0

ipstudio-admin@ap-r730-0: ~
File Edit View Search Terminal Help
BBC R&D netmap-gateway v0.1 ctrl-C to quit

----- Receive -----
packets Mbit/s

eth7 24 0.00

----- Transmit -----
packets Mbit/s Dropped packets Filter

eth7 60448671 8568.04 0

kernel 24 0.00 44 0.00 0

Client0 0 0.00 604486827 8568.04 0

ipstudio-admin@ap-r730-0: ~
File Edit View Search Terminal Help

1 5.9% 13 [|||||] 72.0% 25 [|||||] 0.0% 37 [|||||] 0.0%
2 33.8% 14 [|||||] 2.0% 26 [|||||] 0.0% 38 [|||||] 0.0%
3 10.2% 15 [|||||] 2.6% 27 [|||||] 0.0% 39 [|||||] 0.0%
4 1.3% 16 [|||||] 2.0% 28 [|||||] 0.7% 40 [|||||] 0.0%
5 2.0% 17 [|||||] 11.3% 29 [|||||] 0.0% 41 [|||||] 0.0%
6 2.0% 18 [|||||] 1.3% 30 [|||||] 0.0% 42 [|||||] 0.0%
7 3.2% 19 [|||||] 7.1% 31 [|||||] 0.0% 43 [|||||] 0.0%
8 0.8% 20 [|||||] 0.7% 32 [|||||] 0.0% 44 [|||||] 0.0%
9 18.9% 21 [|||||] 3.3% 33 [|||||] 0.0% 45 [|||||] 0.0%
10 6.8% 22 [|||||] 3.3% 34 [|||||] 0.0% 46 [|||||] 0.0%
11 10.3% 23 [|||||] 3.3% 35 [|||||] 0.0% 47 [|||||] 0.0%
12 2.0% 24 [|||||] 0.7% 36 [|||||] 0.0% 48 [|||||] 0.7%

Mem [|||||] 2178/64060MB Tasks: 90; 3 running
Swap [|||||] 0/32543MB Load average: 2.55 2.48 3.87
Uptime: 13 days, 05:09:08

PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
113666 ipstudio 20 0 3740M 621M 612M S 80.3 1.0 10:01.43 lpp_rtpix --mipr ipc:///tmp/lpp-apps-processor_zmq_08fbf85f_21
113667 ipstudio 20 0 10.2G 1907M 1890M S 13.8 3.0 1:44:85 lpp_sdmulticapture --mipr ipc:///tmp/lpp-apps-processor_zmq_22
3639 ipstudio 20 0 581M 46912 12236 S 3.9 0.1 2h38:33 /usr/bin/python /usr/bin/nodefacade
3638 ipstudio 20 0 16.4G 43900 13476 S 2.0 0.1 43:08.42 /usr/bin/python /usr/bin/pipelinemanager
3640 ipstudio 20 0 619M 35340 11972 S 1.3 0.1 1h33:52 /usr/bin/python /usr/bin/nodestatus
F1 Help F2 Setup F3 Search F4 Filter F5 Tree F6 Sort By F7 Tce F8 Hlce F9 Kill F10 Quit
```

Transmitting 8.6 Gbit/s with no packet loss

Only one CPU core is busy

# Thank you

[www.bbc.co.uk/rd](http://www.bbc.co.uk/rd)

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