FIFA World Cup Finals
how to stream a BIG sports event live
First-hand experiences of the 2014 FIFA World Cup Finals in Brazil internet broadcast preparation and execution (and some Euro 2016 stuff...) (works for 2018 Finals too...)
Who Am I?

1992-1997

1997-2003

2004-2016
2004-2010 – iTVP project funded by the Polish government (KBJ)

It all started in the pre-smartphone era...

(2005+)
What TVP did earlier...

torino 2006

Beijing 2008

vancouver 2010

FIFA WORLD CUP

london

UEFA EURO 2012
What TVP did earlier...

2006 2 Mbit/s PAL 720x576  5.1 surround sound

2005
HOW TO BRING A MATCH STRAIGHT FROM THE FIELD ONTO YOUR LAPTOP CELL PHONE TABLET IN 3 EASY STEPS
1. CAPTURE IT
2. PREPARE IT
3. BROADCAST IT
1. CAPTURE IT…

Real fibre link!

Satellite backup

MOSCOW

WARSAW

Fudo Security
After Hours
1. CAPTURE IT...

12 VENUES

- 2x Moscow
- Ulyanovsk
- St. Petersburg
- Nizhny Novgorod
- Kazan
- Yekaterinburg
- Saransk
- Samara
- Volgograd
- Rostov du Don
- Sochi

~ 2800 km
~ 1740 miles

*Olympic Broadcasting Services

FIBRE/SAT

GENEVE
1. GET IT...

GENEVE
EBU HQ

4K SDI x 16
HD SDI x 8

(upsampled to 4K)

... and every other licensee
WHAT IS SDI?

SDI is _NOT_ Strategic Defense Initiative

https://en.wikipedia.org/wiki/Serial_digitlal_interface:
Serial digital interface (SDI) is a family of digital video interfaces first standardized by SMPTE (The Society of Motion Picture and Television Engineers) in 1989 (...) used for transmission of uncompressed, unencrypted digital video* signals (optionally including embedded audio and time code) within television facilities.

* – includes color burst, V-sync, H-sync, etc...

It's Ethernet for Broadcasting. Key differences:
- don't care for content, care about the signal itself (vs I care a lot about what's inside this packet),
- mostly static, protein-based routing (vs dynamic rule-based routing, like BGP, ISIS or RIP),
- copper PHY is still BNC-based (vs “what’s a BNC?”),
- SDI-based PRO broadcasting gear costs a kidney and a liver (vs my Raspberry has a 1 GbE NIC),
- original SDI standard (SD-SDI, 576i in PAL) is almost exclusively 270 Mbit/s,
- HD-SDI (introduced in 1998) is 1.485 Gbit/s (or 1.485/1.001 for brain-dead fps rates), 720p or 1080i,
- Dual-link HD-SDI and later 3G-SDI (2002, 2006) is 3 Gbit/s (actually 2.970) at 1080p60,
- 6G-SDI/12G-SDI (2015) is used for 4K broadcasting, 2160p30 and 2160p60 respectively and usually uses LACP-like multiple BNC or fibre PHY (4x3 Gbit/s BNC or 2x10 SFP+).
2. PREPARE IT
archival for sports editors
Cisco D9036 Modular Encoding Platform

The Cisco® D9036 Modular Encoding Platform provides multi-resolution, multi-format encoding for applications requiring high levels of video quality. The modular platform is scalable to support as many as eight Standard Definition (SD), four High Definition (HD), or other combinations of video encoders within a single rack unit, while providing excellent broadcast quality video and consuming as little as 40 Watts per service.

Figure 1. Cisco D9036 Modular Encoder
Encoding gear

12G-SDI
2160p50/60

local Ethernet

MULTICS
CasparCG vel "Caspar"
CasparCG vel “Caspar”

FREE broadcasting software developed by svt

Works flawlessly with a cheap Black Magic Decklink HD video card and SQUADAQ-like gear
CasparGC is there to:
- convert multicast HD into HLS (400-2300 kbit/s streams),
- add the broadcaster logo (mandatory license requirement),
- mix signals (pre- and post-match + jingles during the pause)
SQUAD AO style...

L***x + specially crafted ffmpeg
SQUADAQ style...

1 CPU i5!

another Decklink
processing different input (match)

GPU

Decklink DUO
2x in, 2x out
HD-SDI
3. BROADCAST IT
sport.tvp.pl/2014fifaworldcup

Najpiękniejszego gola mundialu strzelił...

TRENER REWELACJI MUNDIALU ZREZYONOWAŁ
Najpiękniejszego gola mundialu strzelił...
64 matches
What you've got...
And this is what you really need..
When you need SPEED you use REAL hardware
... and some nice network switches

24x40 GbE
...and a few of these, please...

TVP tested 100 GbE in April 2014
WHAT DO YOU NEED?

1. GEAR
2. CDN
3. GIGABITS
4. LUCK
Krok po kroku... przed 1/8 finału

Ganglia

LOTS OF SERVERS...

2014 — 50+ servers
CDN - either you buy it or DIY

Usually a CDN (Content Delivery Network) consist of:

✓ redirector nodes - the more the better, this is the magic ingredient making the whole CDN smart (decisions are based on live BGP data, server load, viewer ISP and type of content),
✓ proxy nodes (kind of L2 cache) - usually grouped geographically,
✓ edge nodes (kind of L1 cache) - lots of them, cleverly deployed to take advantage of uplink asymmetries,
✓ origin nodes are usually provided by the CDN customer - live feeds need just two sources, VPN is used due to license restrictions,

... think Akamai CDN, L3 CDN, Fastly, Amazon (for VODs), etc.

or...

you can build a CDN yourself and use just collocated services (usually free of charge*) and borrowed servers...

It will take just 12 people, over a million+ Euro/$ investment and 5+ years to develop

... but the running cost is ~1/3 of what the commercial CDNs charge...
... and a nice webpage with live stuff...

and LUCK...
“You've got to ask yourself one question: Do I feel lucky? Well, do ya, punk?”
Internal Server Error

The server encountered an internal error or misconfiguration and was unable to complete your request.

Please contact the server administrator, admin@localhost and inform them of the time the error occurred, and anything you might have done that may have caused the error.

More information about this error may be available in the server logs.

Error 503 Service Unavailable

Service Unavailable

Guru Meditation:

XID: 1495675306

Varnish cache server
IT'S THE HOSTING, STUPID!
Requests Through CloudFlare

**Total Requests**
Last 24 Hours
106,277,748

**Cached Requests**
Last 24 Hours
105,548,148

**Uncached Requests**
Last 24 Hours
729,600
Let’s skip the boring stuff and talk about...

The 2014 RIO FINALS
Skip the boring stuff, let’s talk about...
Skip the boring stuff, let’s talk about…

WTOREK, 08.07, 22:00, 1/2 FINAŁU

BRAZYLIA 1:7 (0:5) NIEMCY

ŚRODA, 09.07, 22:00, 1/2 FINAŁU

HOLANDIA 0:0 (0:0, 0:0) KARNE - 2:4 ARGENTYNA

200,97 Gbit/s

208,71 Gbit/s
**Skip the boring stuff, let’s talk about…**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Match</th>
<th>Result</th>
<th>Gbit/s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WTOREK, 08.07, 22:00, 1/2 FINAŁU</strong></td>
<td></td>
<td><strong>1:7</strong></td>
<td><strong>0:5</strong></td>
<td><strong>200,97</strong></td>
</tr>
<tr>
<td>BRAZYLIA</td>
<td></td>
<td>NIEMCY</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ŚRODA, 09.07, 22:00, 1/2 FINAŁU</strong></td>
<td></td>
<td><strong>0:0</strong></td>
<td><strong>0:0, 0:0</strong></td>
<td><strong>208,71</strong></td>
</tr>
<tr>
<td>HOLANDIA</td>
<td></td>
<td>ARGENTYNA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SOBOTA, 12.07, 22:00, MECZ O 3. MIEJSCE</strong></td>
<td></td>
<td><strong>0:3</strong></td>
<td><strong>0:2</strong></td>
<td><strong>161,23</strong></td>
</tr>
<tr>
<td>BRAZYLIA</td>
<td></td>
<td>HOLANDIA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
THE FINAL
July 13th
NIEDZIELA, 13.07, 21:00, FINAŁ

NIEMCY 1:0 ARGENTYNA
(0:0, 0:0)

211,40 Gbit/s

FUDO SECURITY
AFTER HOURS
TOO BAD...
not exactly the best setup ever...
AFTER HOURS

PLIX SERVERS

HAVE YOU TRIED TURNING IT OFF AND ON AGAIN?

ARGENTyna

NIEMCY

FUDO SECURITY

AFTER HOURS
A 2011 server sending 17,579 Gbit/s

2 x Intel x520 NIC
A 2011 server sending 17,579 Gbit/s

2 x Intel x520 NIC
OK, LET'S TRY 40 G
Mellanox MCX414A-BCAT
### Table 9 - MCX414A-BCAT Specifications Table

<table>
<thead>
<tr>
<th>Physical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
<td>2.71 in. x 5.6 in. (68.90mm x 142.24 mm) – low profile</td>
</tr>
<tr>
<td>Connector:</td>
<td>Dual QSFP28 (Copper and optical)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protocol Support</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Rate:</td>
<td>1/10/25/40/56 Gb/s – Ethernet</td>
</tr>
<tr>
<td><strong>PCI Express Gen3:</strong></td>
<td>SERDES @ 8.0GT/s, 8 lanes (2.0 and 1.1 compatible)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power and Environmental</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage:</td>
<td>12V, 3.3V</td>
</tr>
<tr>
<td>Type: 4P Power Cables:</td>
<td>40GbE – 11.86W</td>
</tr>
<tr>
<td>Maximum Power:</td>
<td>13.50W</td>
</tr>
<tr>
<td>1.5W Active Cables:</td>
<td>40GbE – 16.83W</td>
</tr>
<tr>
<td></td>
<td>56GbE – 17.31W</td>
</tr>
<tr>
<td>Maximum power available through QSFP28 port:</td>
<td>3.5W</td>
</tr>
</tbody>
</table>

| Temperature:           | Operational 0°C to 55°C |
|                       | Non-operational -40°C to 70°C |
| Humidity:              | 90% relative humidityb |
| Air Flow:              | See Airflow Specifications on page 65 |

<table>
<thead>
<tr>
<th>Regulatory</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety:</td>
<td>CB / cTUVus / CE</td>
</tr>
<tr>
<td>EMC:</td>
<td>CE / FCC / VCCI / ICES / RCM</td>
</tr>
<tr>
<td>RoHS:</td>
<td>RoHS-R6</td>
</tr>
</tbody>
</table>

---

- Typical power for ATIS traffic load.
- For both operational and non-operational states.
PCI Epress 3.0 8x

<table>
<thead>
<tr>
<th>PCI Express version</th>
<th>Line code</th>
<th>Transfer rate</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>×1</td>
</tr>
<tr>
<td>1.0</td>
<td>8b/10b</td>
<td>2.5 GT/s</td>
<td>250 MB/s</td>
</tr>
<tr>
<td>2.0</td>
<td>8b/10b</td>
<td>5 GT/s</td>
<td>500 MB/s</td>
</tr>
<tr>
<td>3.0</td>
<td>128b/130b</td>
<td>8 GT/s</td>
<td>984.6 MB/s</td>
</tr>
<tr>
<td>4.0 (expected in 2017)</td>
<td>128b/130b</td>
<td>16 GT/s</td>
<td>1.969 GB/s</td>
</tr>
<tr>
<td>5.0 (far future)</td>
<td>128b/130b</td>
<td>32 or 25 GT/s</td>
<td>3.9, or</td>
</tr>
</tbody>
</table>

Theoretically a dual port 40 GbE 8x PCIe card can do only ~63 Gbit/s due to 8 PCIe lanes being used.

source: [https://en.wikipedia.org/wiki/PCI_Express](https://en.wikipedia.org/wiki/PCI_Express)
## PCI Express 3.0 8x

### PCI Express link performance

<table>
<thead>
<tr>
<th>PCI Express version</th>
<th>Line code</th>
<th>Transfer rate</th>
<th>Throughput</th>
<th>Throughput</th>
<th>Throughput</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>×1</td>
<td>×4</td>
<td>×8</td>
<td>×16</td>
</tr>
<tr>
<td>1.0</td>
<td>8b/10b</td>
<td>2.5 GT/s</td>
<td>250 MB/s</td>
<td>1 GB/s</td>
<td>2 GB/s</td>
<td>4 GB/s</td>
</tr>
<tr>
<td>2.0</td>
<td>8b/10b</td>
<td>5 GT/s</td>
<td>500 MB/s</td>
<td>2 GB/s</td>
<td>4 GB/s</td>
<td>8 GB/s</td>
</tr>
<tr>
<td>3.0</td>
<td>128b/130b</td>
<td>8 GT/s</td>
<td>984.6 MB/s</td>
<td>3.938 GB/s</td>
<td>7.877 GB/s</td>
<td>15.754 GB/s</td>
</tr>
<tr>
<td>4.0 (expected in 2017)</td>
<td>128b/130b</td>
<td>16 GT/s</td>
<td>1.969 GB/s</td>
<td>7.877 GB/s</td>
<td>15.754 GB/s</td>
<td>31.508 GB/s</td>
</tr>
<tr>
<td>5.0 (far future)</td>
<td>128b/130b</td>
<td>32 or 25 GT/s</td>
<td>3.9, or 12.3 GB/s</td>
<td>31.5, or 63.0 GB/s</td>
<td>49.2 GB/s</td>
<td></td>
</tr>
</tbody>
</table>

---

In practice you can can squeeze 50-55 Gbit/s max out of Linux with NOTRACK

---

*^ In each direction (each lane is a dual simplex channel).

*^ Both rates are being considered for technical feasibility.
And here comes 2018...
IN 2018...

12 servers
- each one having 2x40 Gbit/s NIC
- and 2x10 Gbit/s NIC

this gives over 800 Gbit/s of real "internet broadcasting power"
AFTER HOURS

2014
211+ Gbit/s

2018
463+ Gbit/s

2018
? Gbit/s