FIFA World Cup Finals

how to stream a BIG sports event live

FUDO SECURITY

AFTER HOURS

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…)

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live 00:03:46 | 00:14:59

Who Am I?

1992-1997 1997-2003 2004-2016

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2004-2010 – iTVP project

funded by the Polish government (KBJ)

It all started in the pre-smartphone era… (2005+)

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What TVP did earlier…

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What TVP did earlier…

2006 2005

2 Mbit/s PAL 720x576 5.1 surround sound

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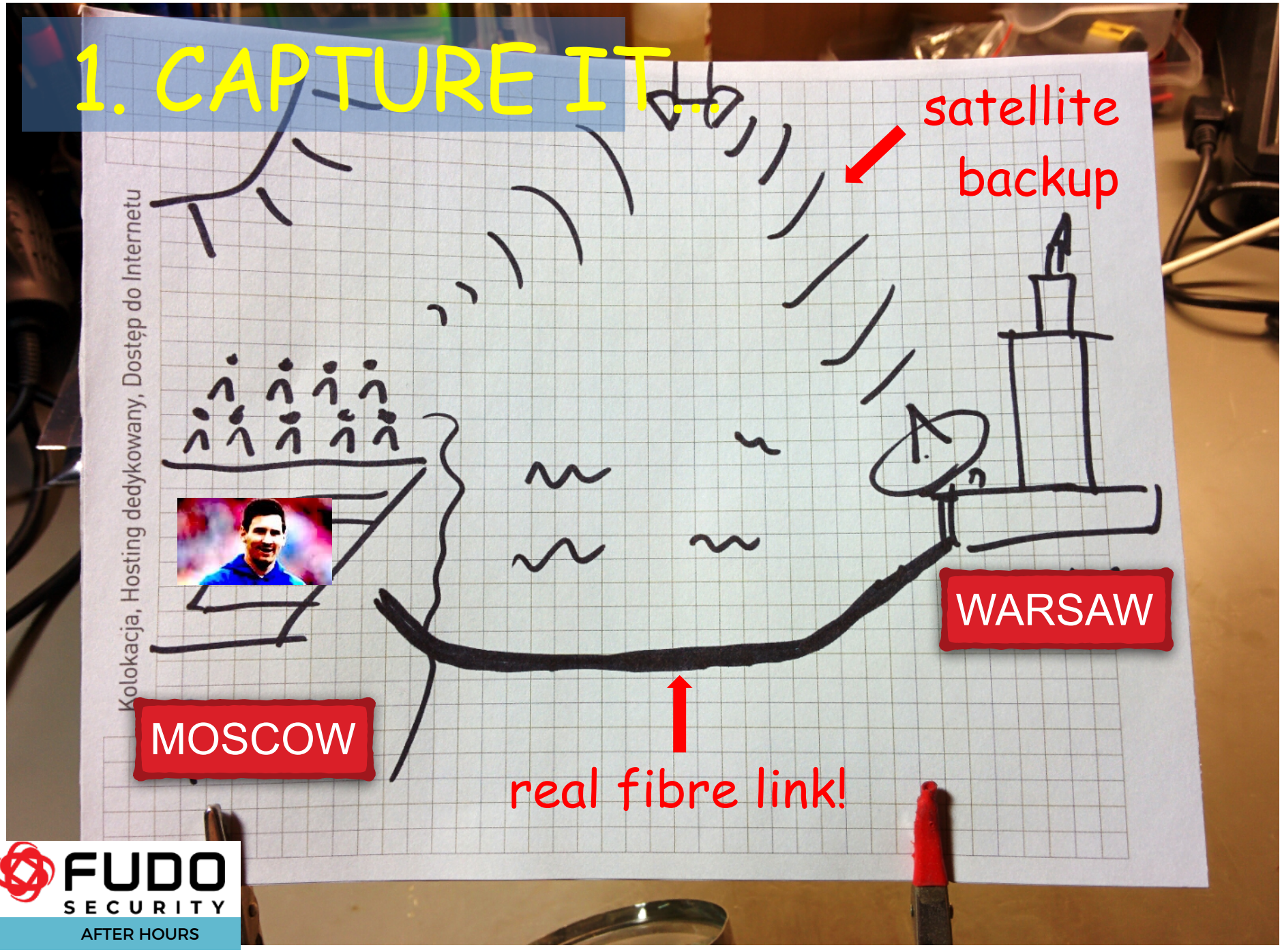
AFTER HOURS

1. CAPTURE IT
2. PREPARE IT
3. BROADCAST IT
FUDO
SECURITY
AFTER HOURS

1. CAPTURE IT...



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1. CAPTURE IT…

12 VENUES

MOSCOW

- 2X MOSCOW
- KALININGRAD
- ST. PETERSBURG
- NIZNY NOVGOROD
- KAZAN
- YEKATERINBURG
- SARANSK
- SAMARA
- VOLGOGRAD
- ROSTOV-ON-DON
- SOCHI

OBS*

~ 2800 km
~1740 miles

*Olympic Broadcasting Services

FIBRE/SAT

GENEVE

ARISTA
www.arista.com

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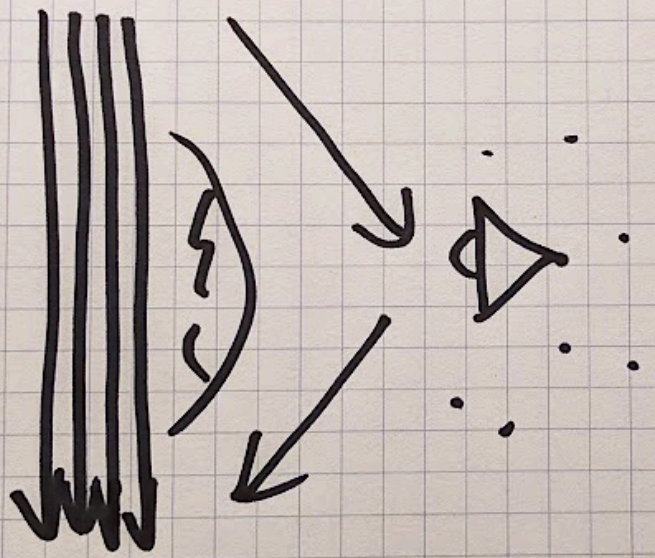
1. GET IT...

GENEVE
EBU HQ

4K SDI x16
HD SDI x8
(UPSAMPLED TO 4K)

ARISTA
www.arista.com



TVP HQ WARSAW

... and every other licensee

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1. GET IT...

WHAT IS SDI?

SDI is _NOT_ Strategic Defense Initiative

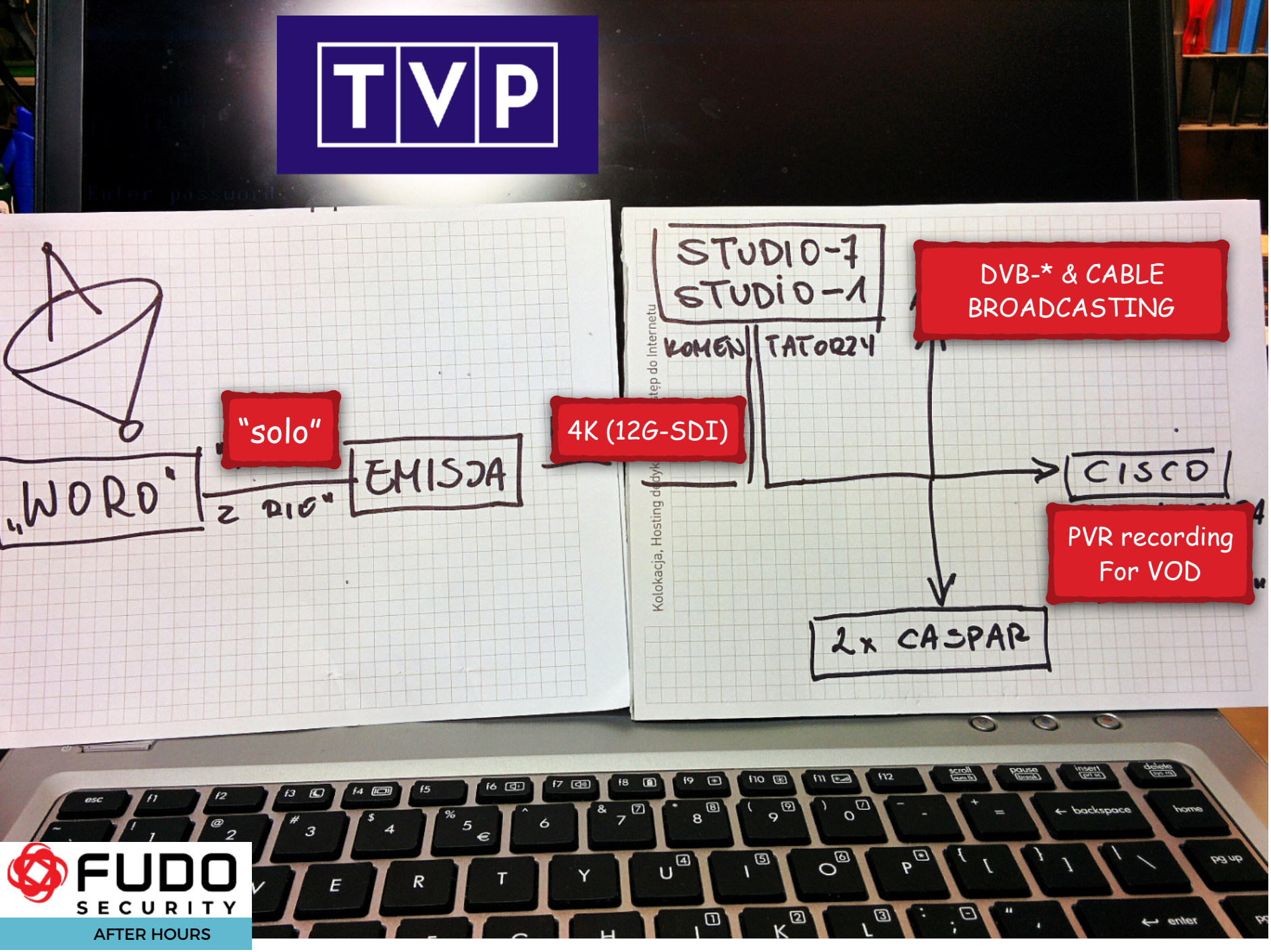
https://en.wikipedia.org/wiki/Serial_digital_interface:

*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+).



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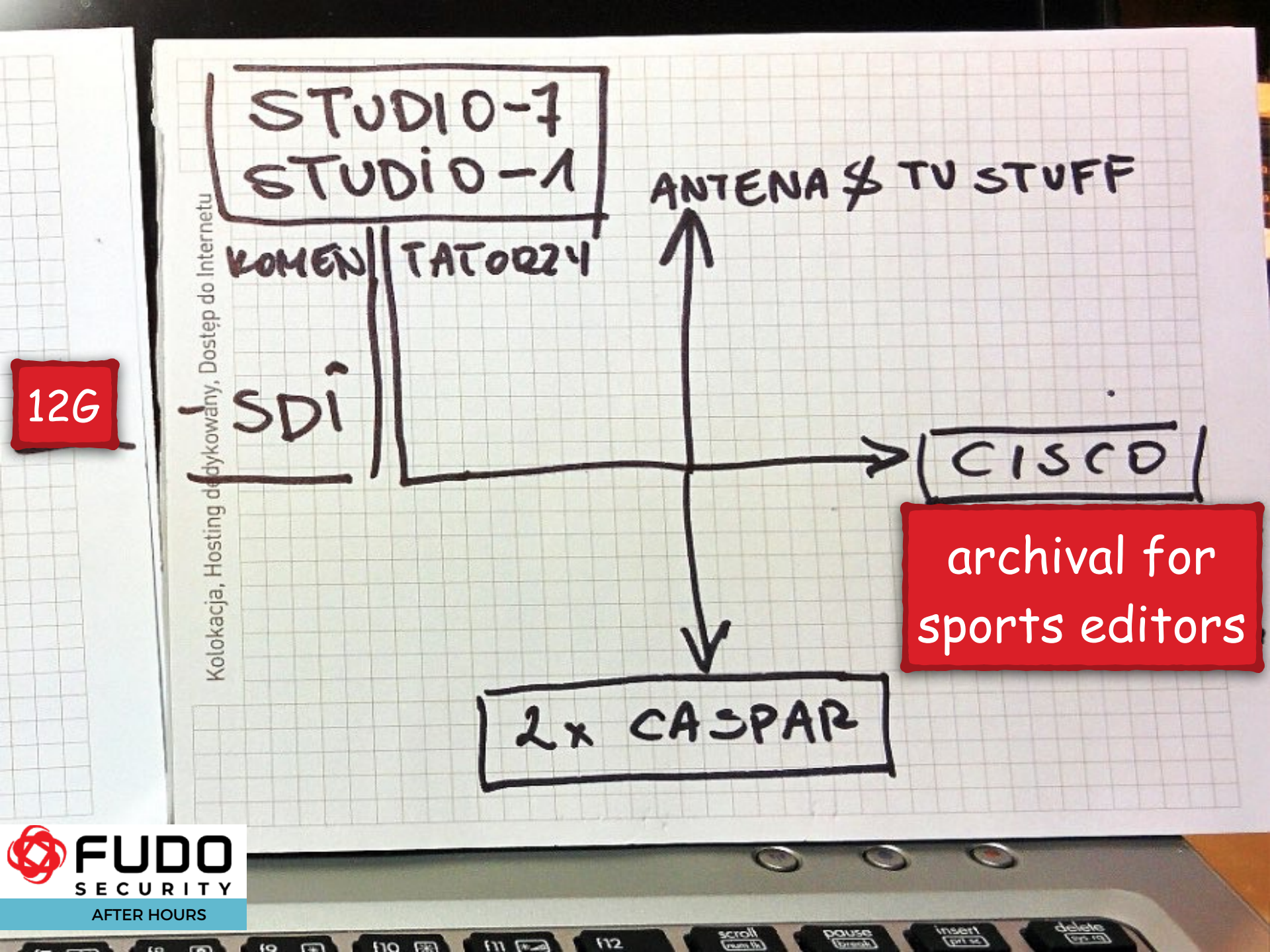

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Cisco D9036 Modular Encoding Platform

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

... or harmonic ViBE:

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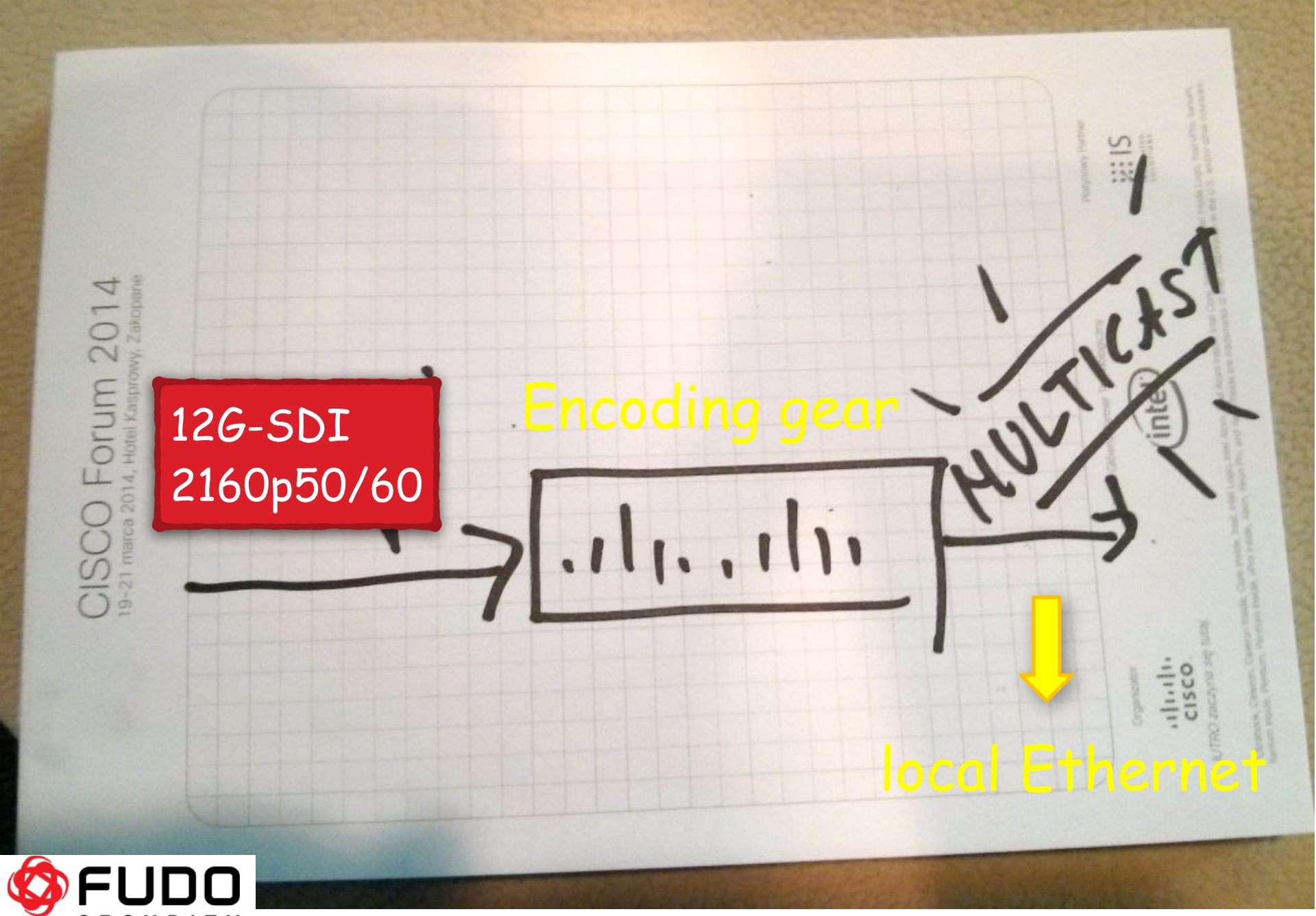

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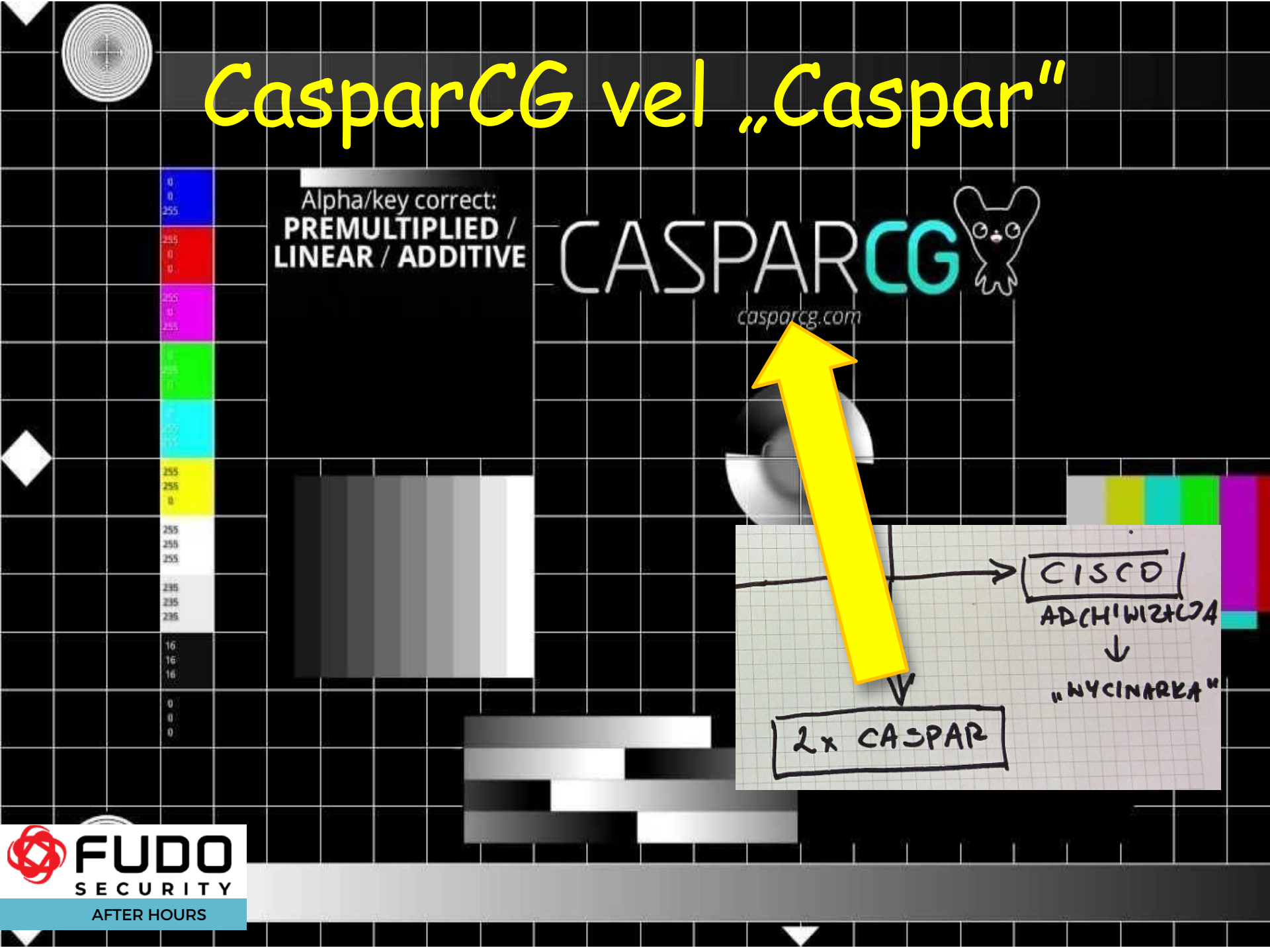
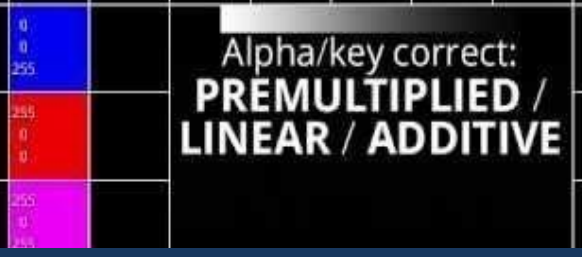
CasparCG vel „Caspar"



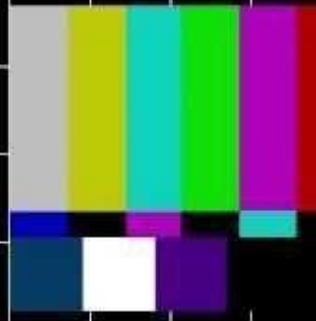
CasparCG vel „Caspar"



CASPARCG
casparcg.com

FREE broadcasting software developed by svt

Works flawlessly with a cheap Black Magic Decklink HD video card and SQUADAQ-like gear



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SQUADAQ gear…

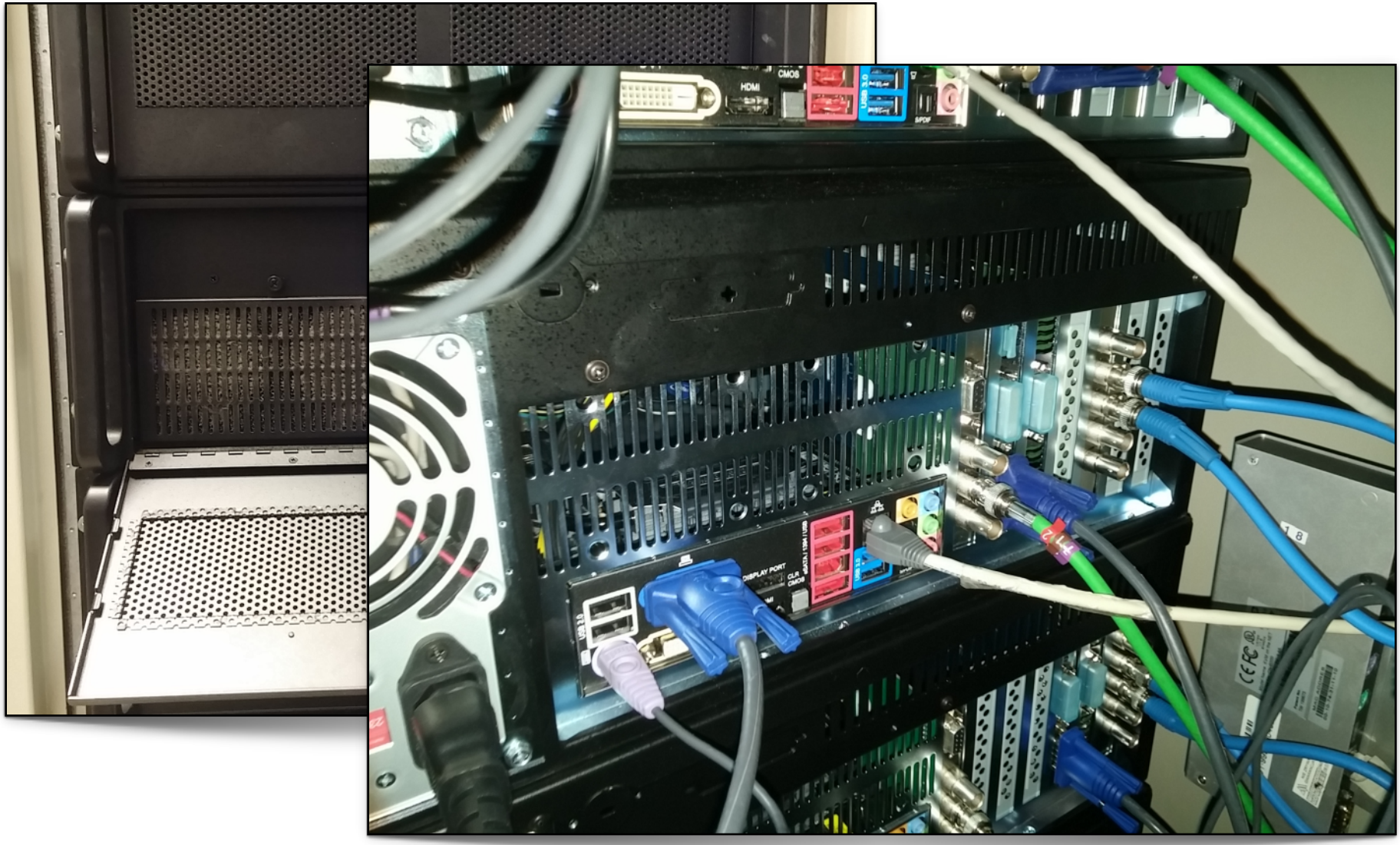
CasparGC is there to:

-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)

SQUADAQ style...



L***x + specially crafted ffmpeg

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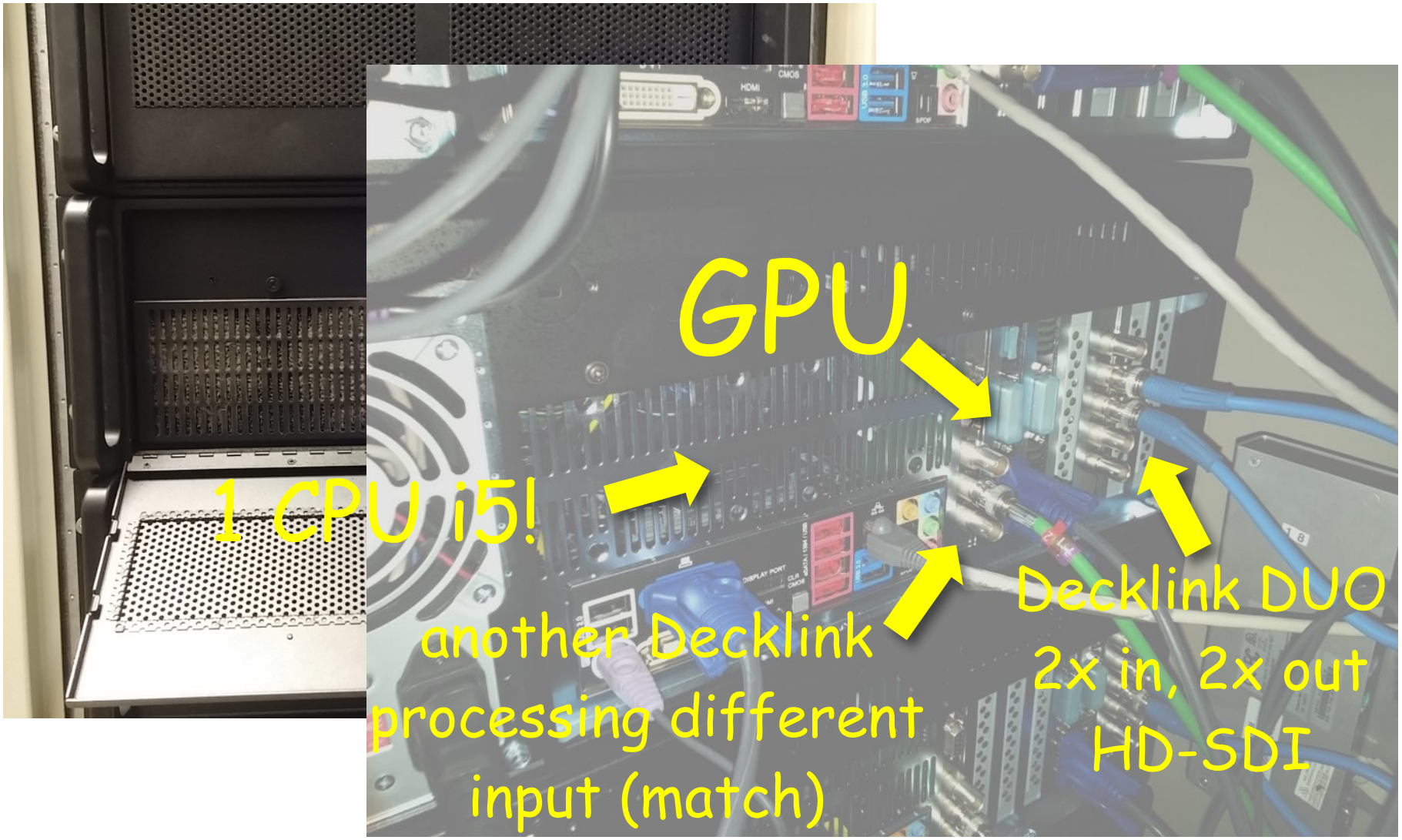
SQUADAQ style...



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STADION NON STOP
TRANSMISJA TVP
3. BROADCAST IT
GRUPA A
CONFEDERAÇÃO BRASILEIRA DE FUTEBOL
Zwycięstwo lub śmierć
live
00:14:25 | 00:14:59

sport.tvp.pl/2014fifaworldcup

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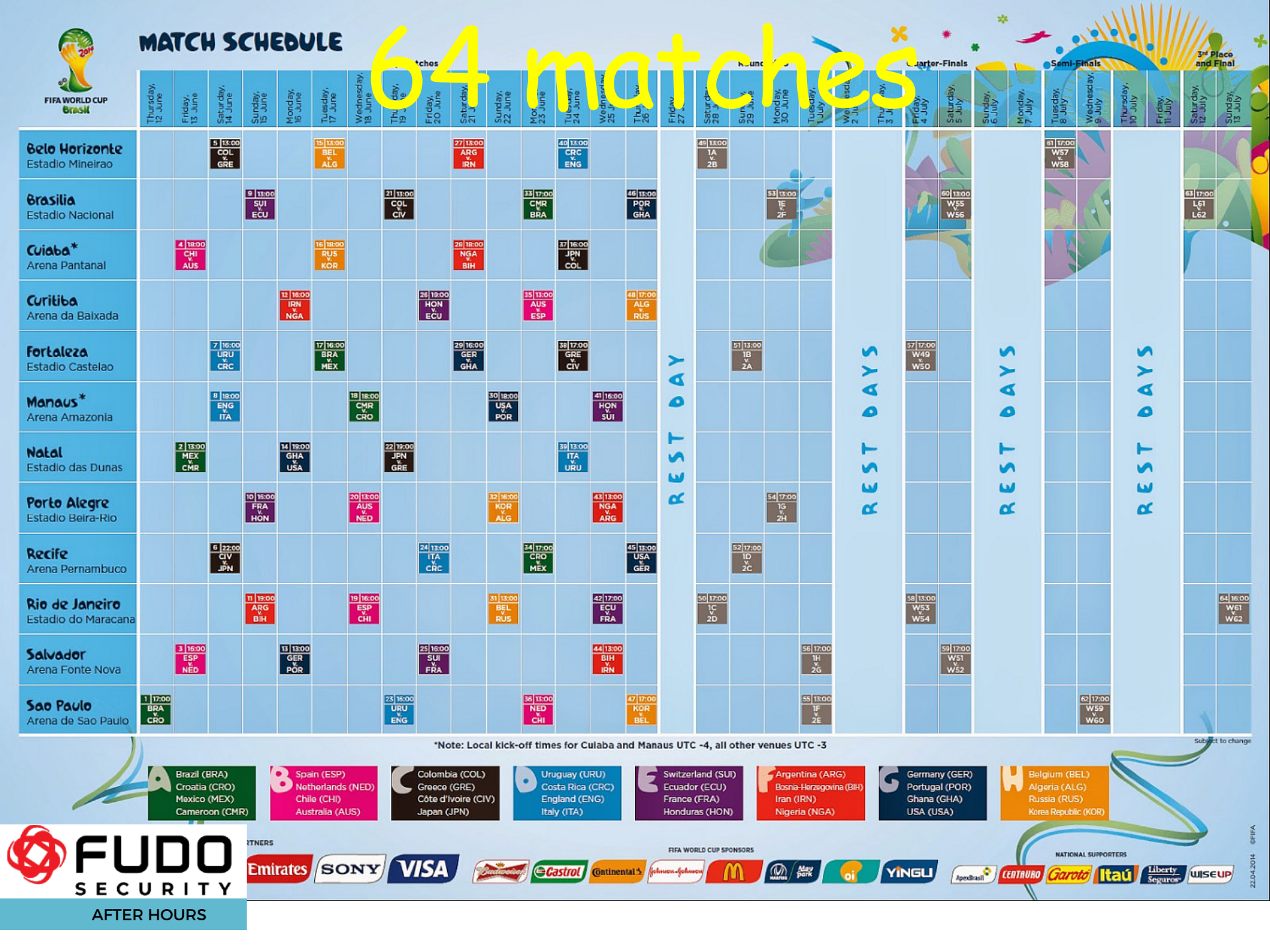
sport.tvp.pl/2014fifaworldcup

rio.tvp.pl

FUDO SECURITY

AFTER HOURS



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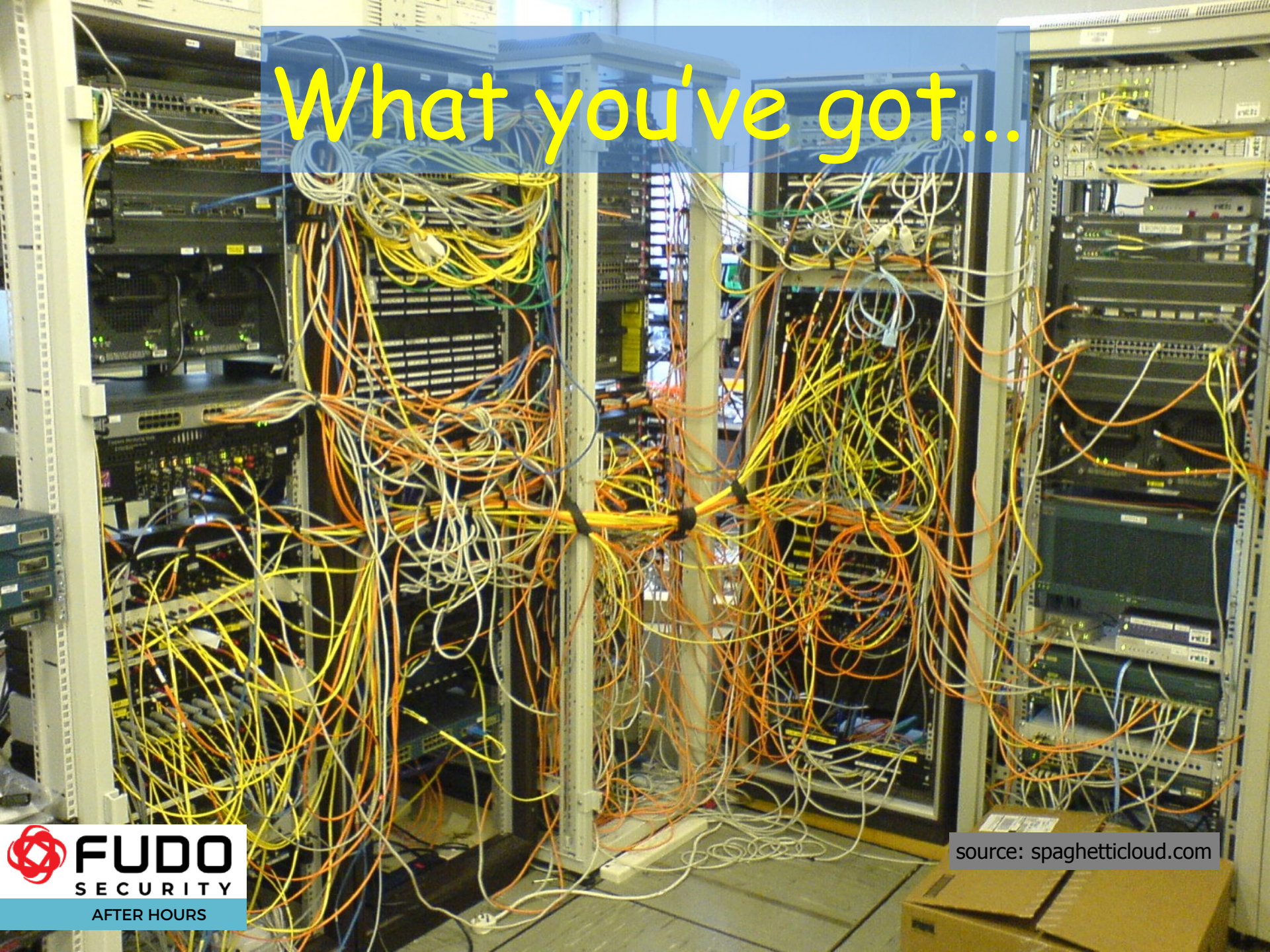
What you've got...



source: spaghetticloud.com

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And this is what you really need..

source: Google

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```
RP/0/RSP0/CPU0:g11asr#sh int hu0/3/0/0
Wed Apr  9 12:40:27.816 CET
HundredGigE0/3/0/0 is up, line protocol is up
  Interface state transitions: 277
  Hardware is HundredGigE, address is c067.af[redacted] (bia c067.af[redacted]
  Layer 1 Transport Mode is LAN
  Description: PLIX
  Internet address is 195.182.218.20/23
  MTU 1514 bytes, BW 100000000 Kbit (Max: 100000000 Kbit)
     reliability 255/255, txload 3/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 100000Mb/s, link type is force-up
  output flow control is off, input flow control is off
  loopback not set,
  ARP type ARPA, ARP timeout 04:00:00
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters 01:10:29
  5 minute input rate 6[redacted] bits/sec, [redacted] packets/sec
  5 minute output rate 1291884000 bits/sec, 109622 packets/sec

CFP EEPROM port: 0
  Xcvr Type: CFP
  Ext Type: 24W, Host Lane n:m, LANWDM, CLEI,
  Connector Type: SC
  Ethernet Application Codes: 100GE-LR4,
  Number of Lanes: Network 4, Host 10
     [redacted] broadcast packets, [redacted] multicast packets
     [redacted] errors, 0 underruns, 0 applique, 0 resets
     [redacted] buffer failures, 0 output buffers swapped out
     [redacted]r transitions
```

...and a few of these, please...

TVP tested 100 GbE in April 2014

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WHAT DO YOU NEED?

1. GEAR
2. CDN
3. GIGABITS
4. LUCK

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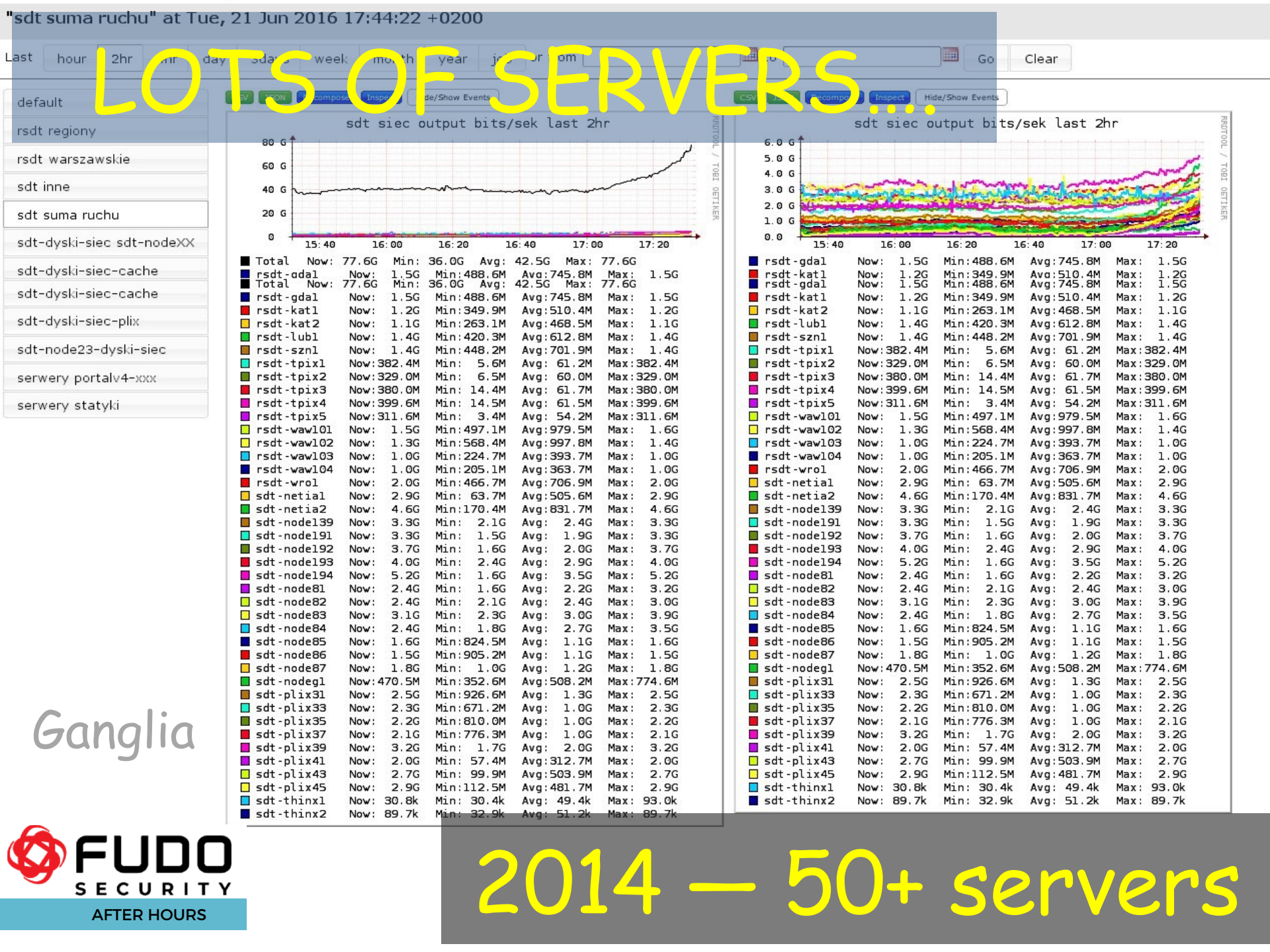
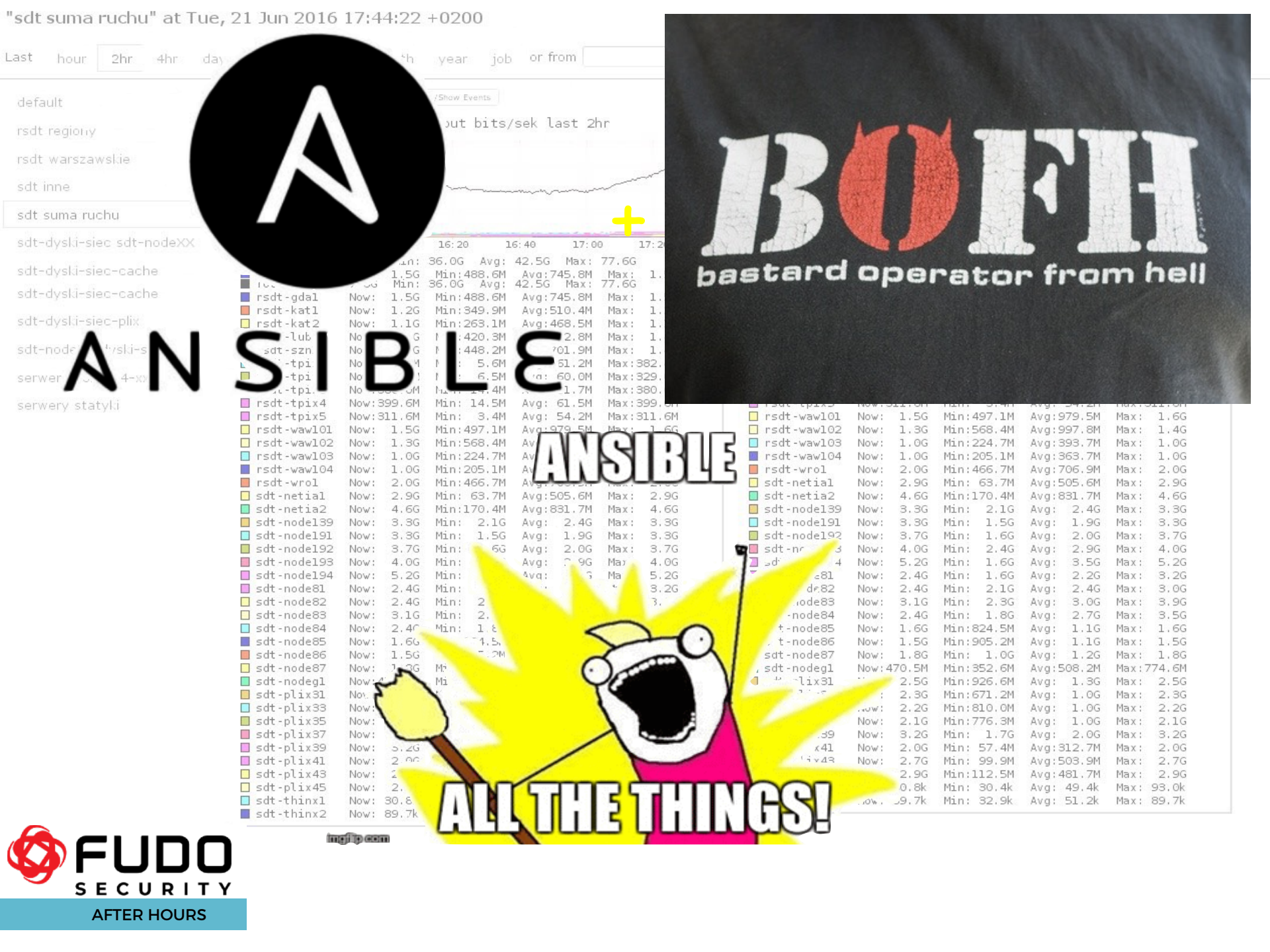

"sdt suma ruchu" at Tue, 21 Jun 2016 17:44:22 +0200
LOTS OF SERVERS...
Last hour 2hr day week year Go Clear
default
rsdt regiony
rsdt warszawskie
sdt inne
sdt suma ruchu
sdt-dyski-siec sdt-nodeXX
sdt-dyski-siec-cache
sdt-dyski-siec-cache
sdt-dyski-siec-plix
sdt-node23-dyski-siec
serwery portalv4-xxx
serwery statyki
sdt siec output bits/sek last 2hr
sdt siec output bits/sek last 2hr
Ganglia
2014 — 50+ servers
FUDO SECURITY
AFTER HOURS


"sdt suma ruchu" at Tue, 21 Jun 2016 17:44:22 +0200
Last hour 2hr 4hr year job or from
default
rsdt regiony
rsdt warszawskie
sdt inne
sdt suma ruchu
sdt-dyski-siec sdt-nodeXX
sdt-dyski-siec-cache
sdt-dyski-siec-cache
sdt-dyski-siec-plix
serwery statyki
out bits/sek last 2hr
16:20
16:40
17:00
ANSIBLE
BOFH
bastard operator from hell
ANSIBLE
ALL THE THINGS!
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CDN – either you buy it or DYI

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,

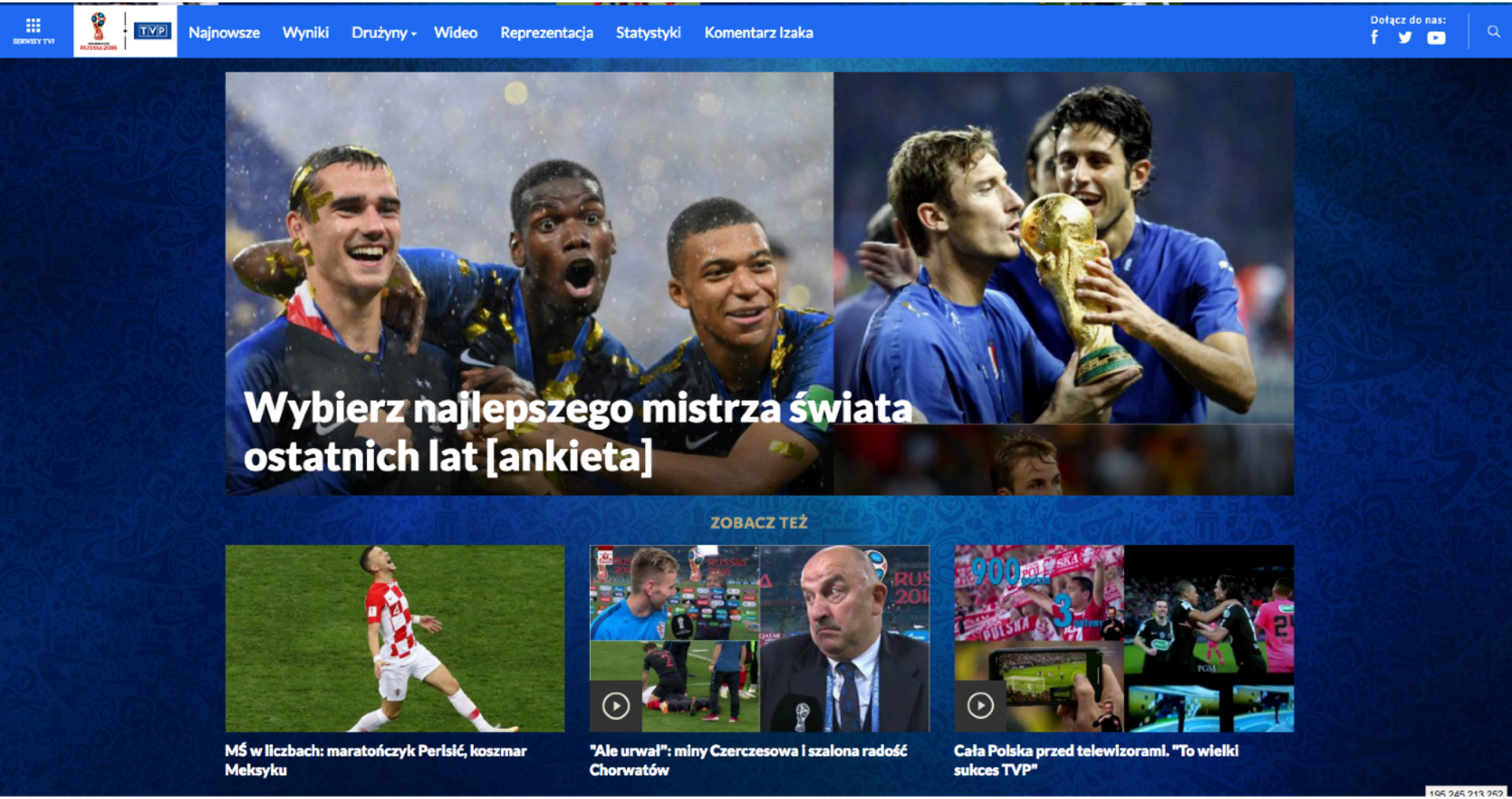
… think Akamai CDN, L3 CDN, Fastly, Amazon (for VODs), etc.

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…



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and LUCK…

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AFTER HOURS

FUDO SECURITY
AFTER HOURS

FUDO SECURITY
AFTER HOURS

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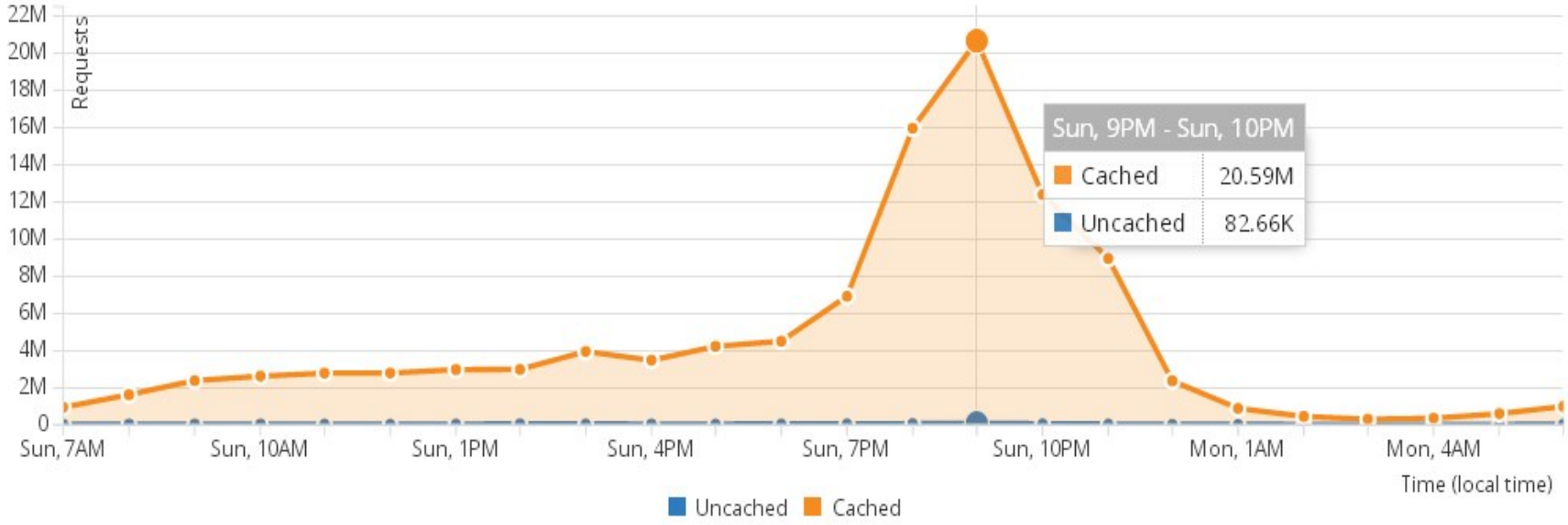
AFTER HOURS

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



Help ▸

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Let's skip the boring stuff and talk about...

The 2014 RIO FINALS

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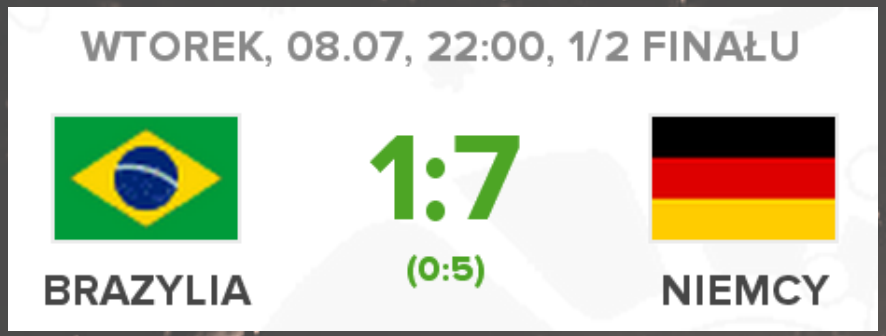
Skip the boring stuff, let's talk about...

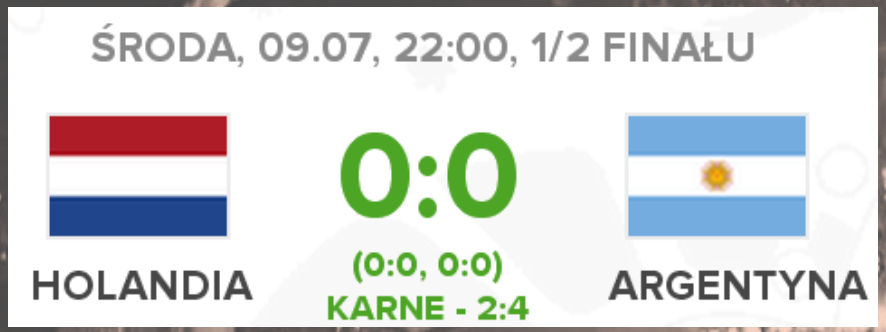
200,97 Gbit/s

FUDO SECURITY
AFTER HOURS

Skip the boring stuff, let's talk about...



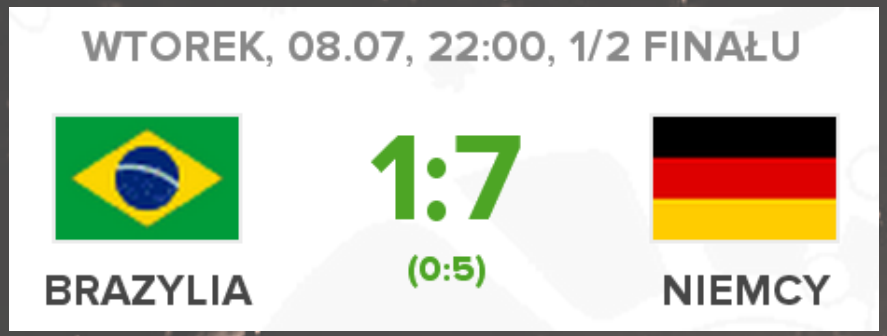
200,97 Gbit/s



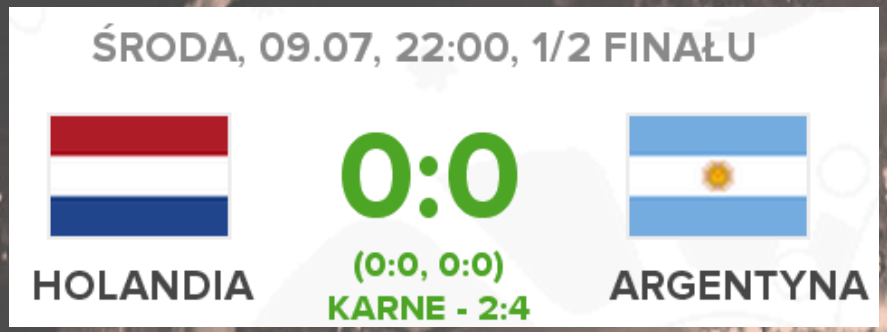
208,71 Gbit/s

FUDO SECURITY
AFTER HOURS

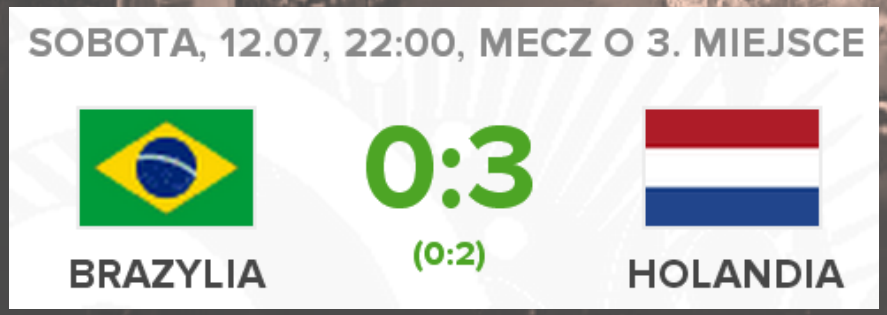
Skip the boring stuff, let's talk about...



200,97 Gbit/s



208,71 Gbit/s



161,23 Gbit/s

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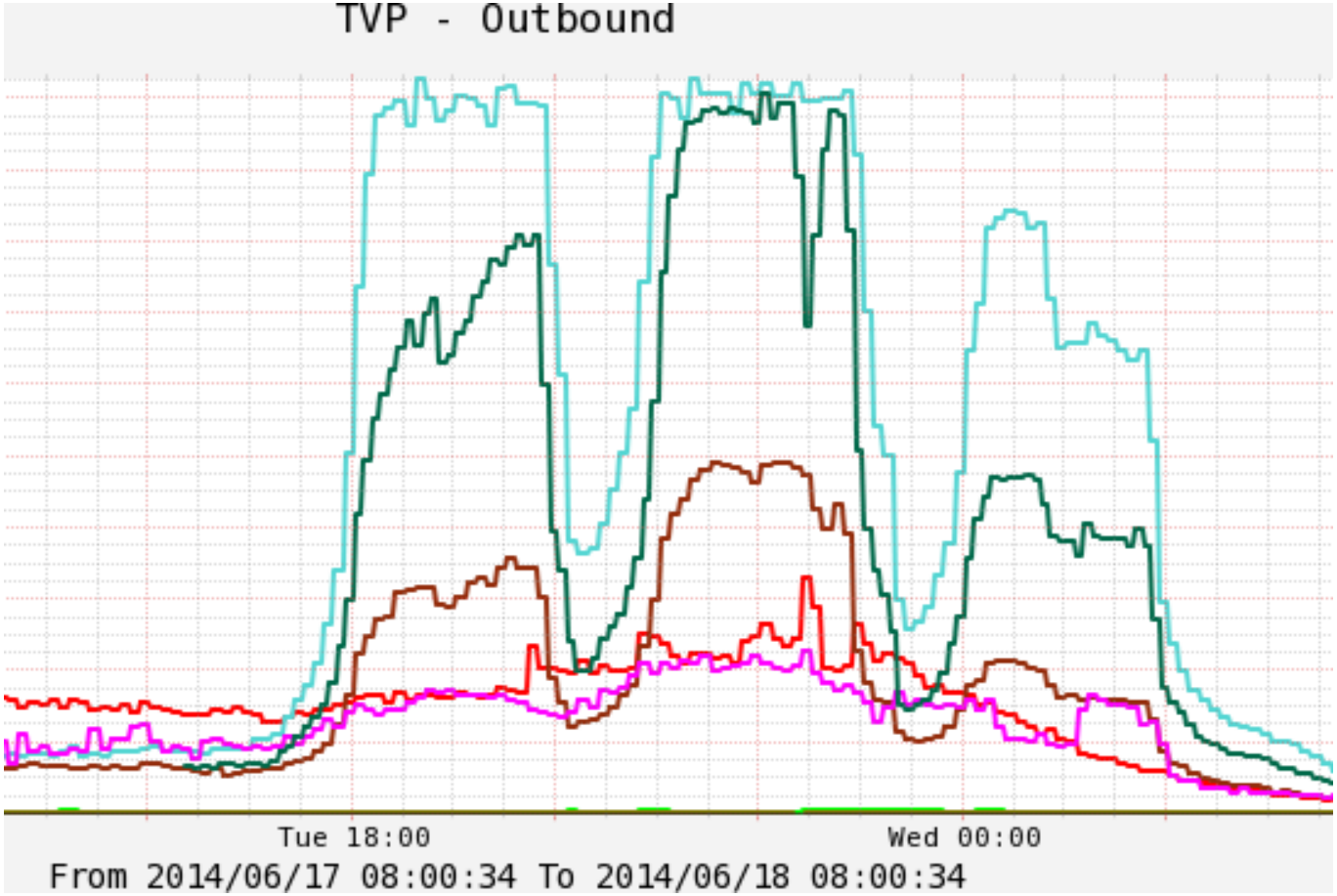
TVP
SPORT HD
SPORT.TVP.PL
THE FINAL
July 13th
FUDO
SECURITY
AFTER HOURS
live
00:08:13 | 00:14:59

NIEDZIELA, 13.07, 21:00, FINAŁ
NIEMCY
1:0
(0:0, 0:0)
ARGENTYNA
TVP
SPORT
SPORT.TVP.PL
211,40
Gbit/s
FUDO
SECURITY
AFTER HOURS



WTOREK, 17.06, 18:00, GRUPA H

BELGIA **2:1** (0:1) ALGIERIA

WTOREK, 17.06, 21:00, GRUPA A

BRAZYLIA **0:0** MEKSYK

ŚRODA, 18.06, 00:00, GRUPA H

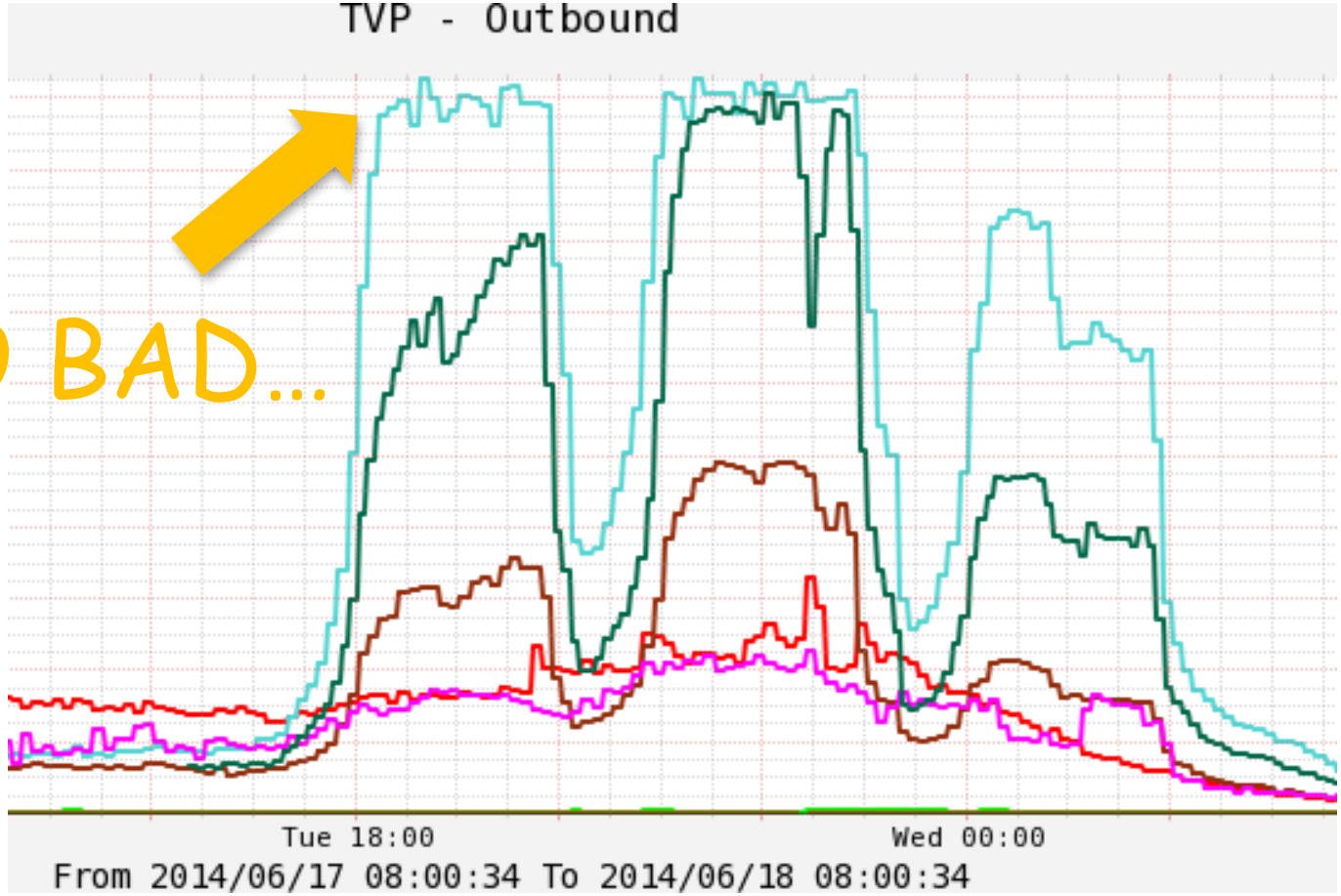
ROSJA **1:1** (0:0) KOREA PŁD.

FUDO SECURITY

AFTER HOURS

BGP PEERS UPLINKS

TOO BAD...



WTOREK, 17.06, 18:00, GRUPA H

BELGIA 2:1 (0:1) ALGIERIA

WTOREK, 17.06, 21:00, GRUPA A

BRAZYLIA 0:0 MEKSYK

ŚRODA, 18.06, 00:00, GRUPA H

ROSJA 1:1 (0:0) KOREA PŁD.

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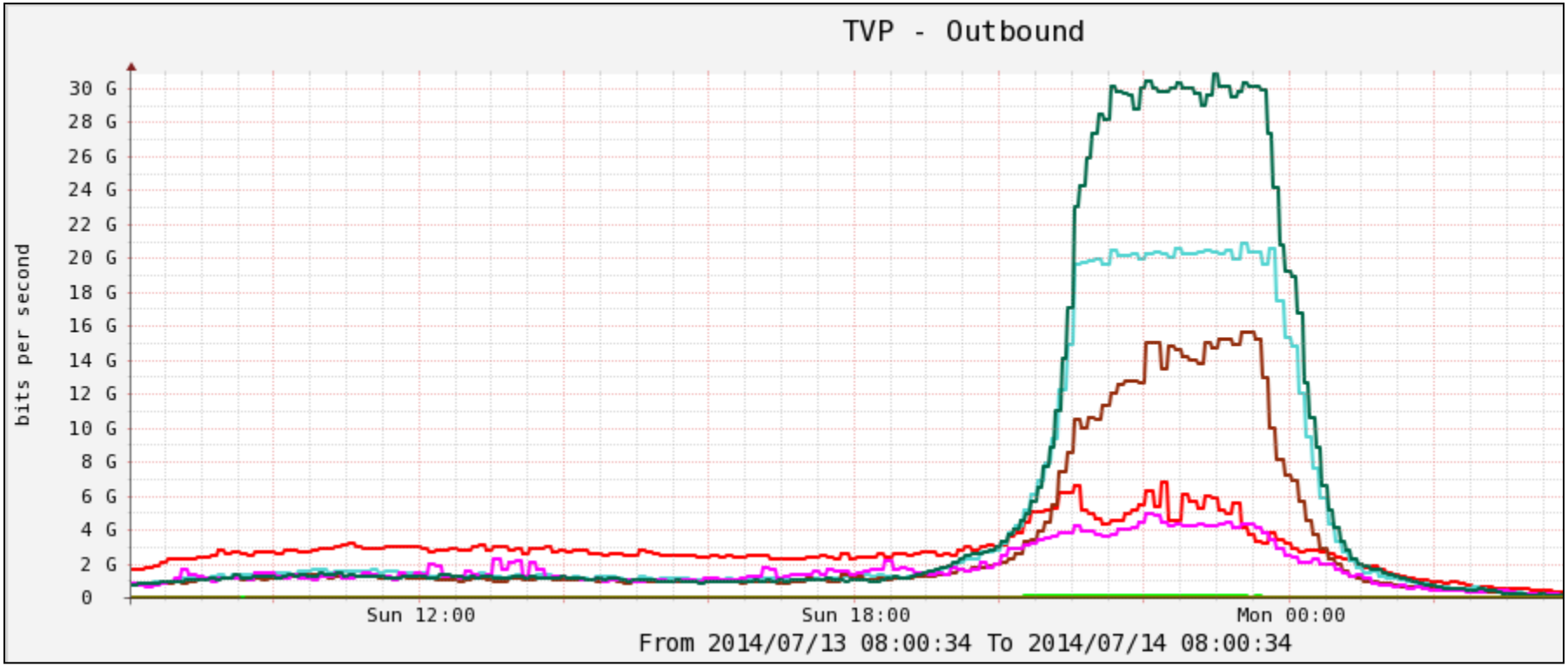
BGP PEERS UPLINKS



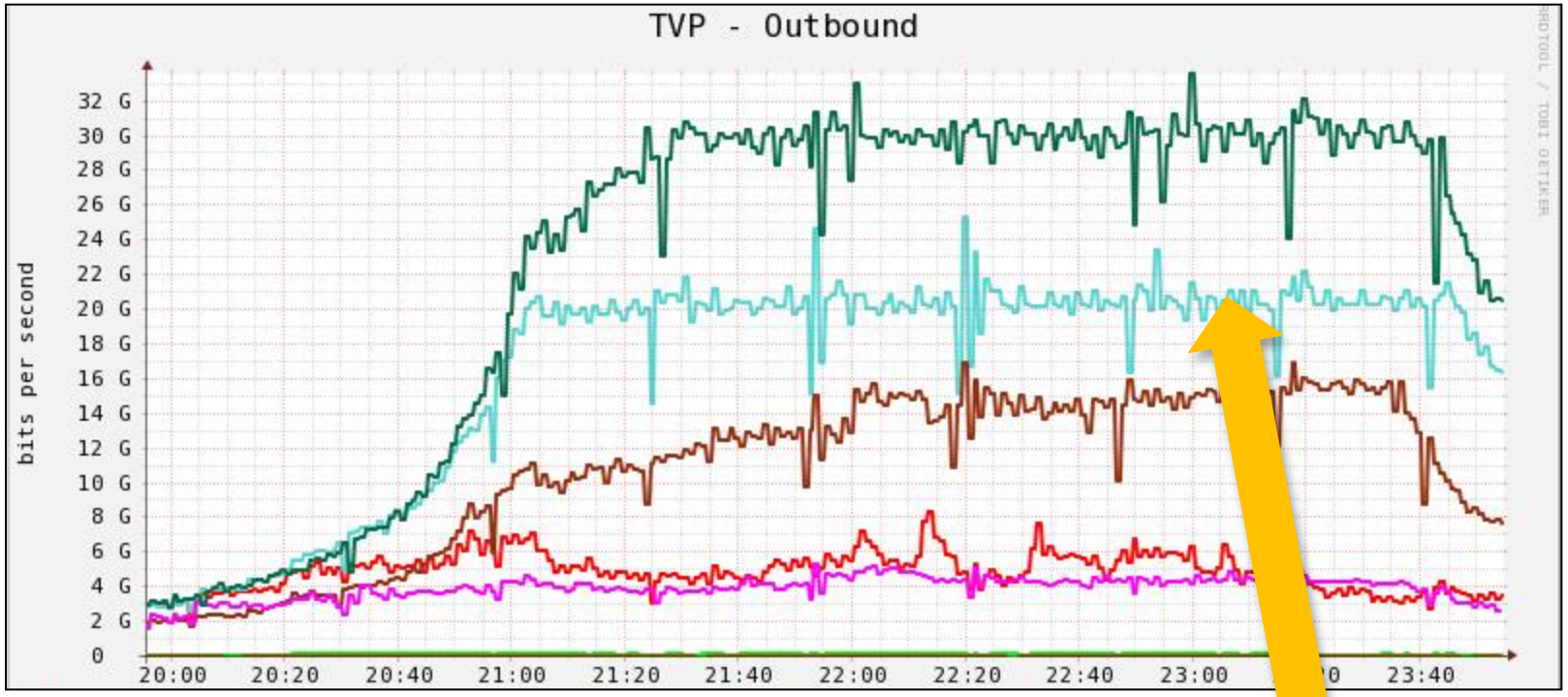
NIEDZIELA, 13.07, 21:00, FINAŁ

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

FUDO SECURITY

AFTER HOURS

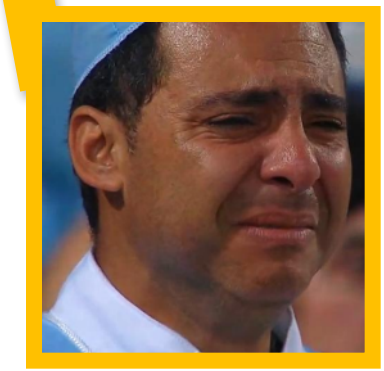
BGP PEERS UPLINKS



NIEDZIELA, 13.07, 21:00, FINAŁ

NIEMCY **1:0** ARGENTYNA

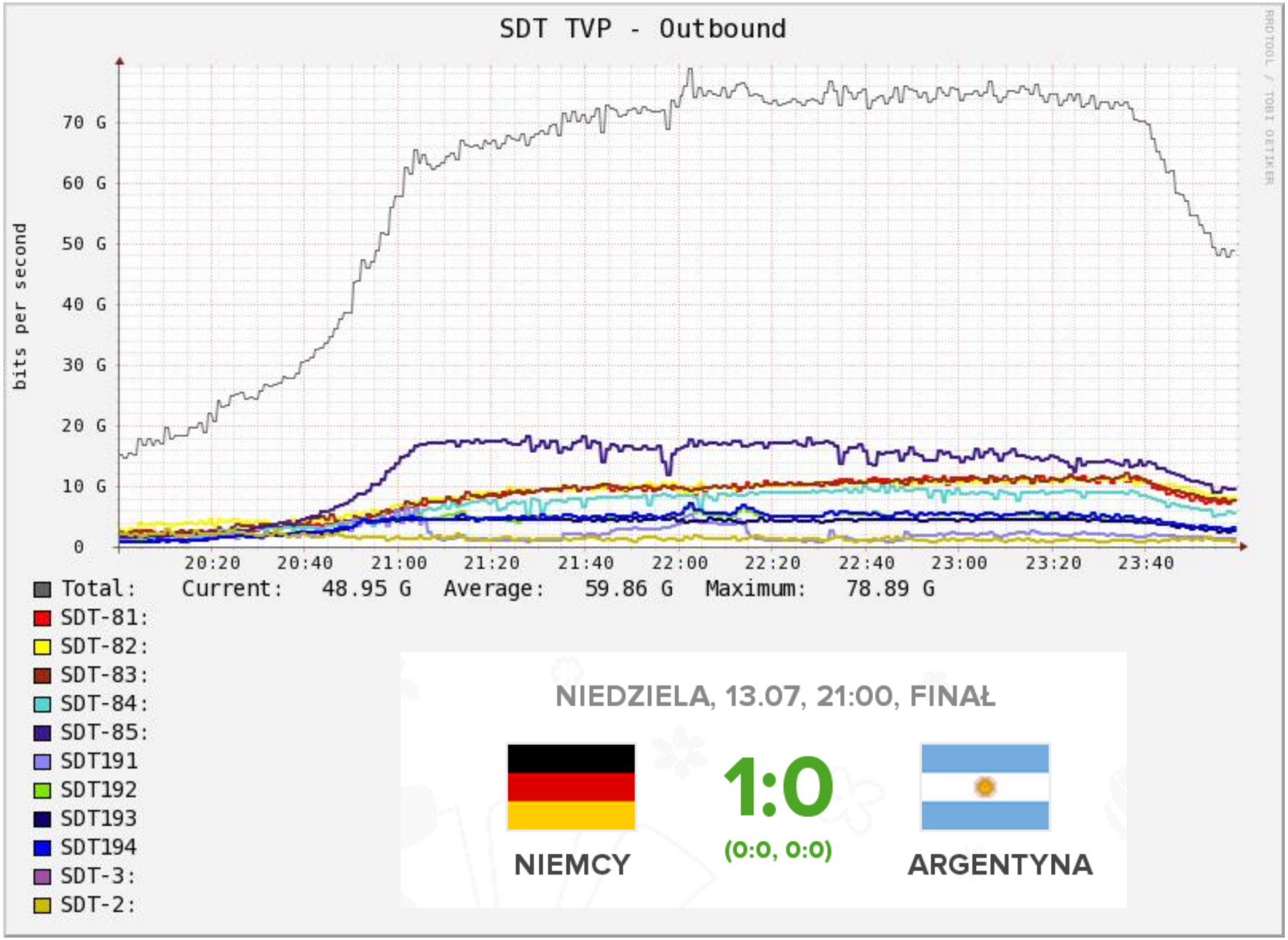
(0:0, 0:0)



FUDO SECURITY

AFTER HOURS

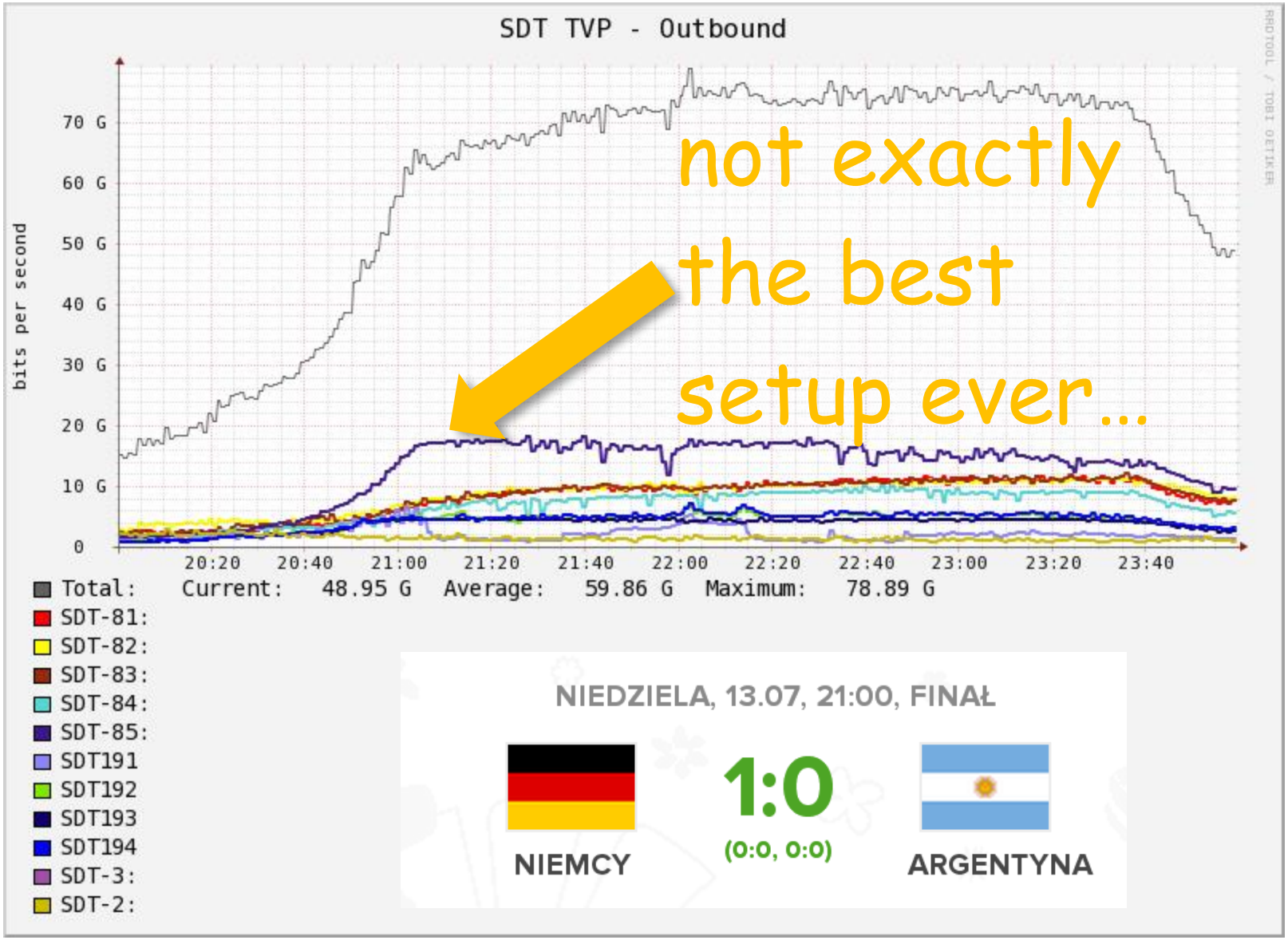
BGP PEERS UPLINKS



FUDO SECURITY

AFTER HOURS

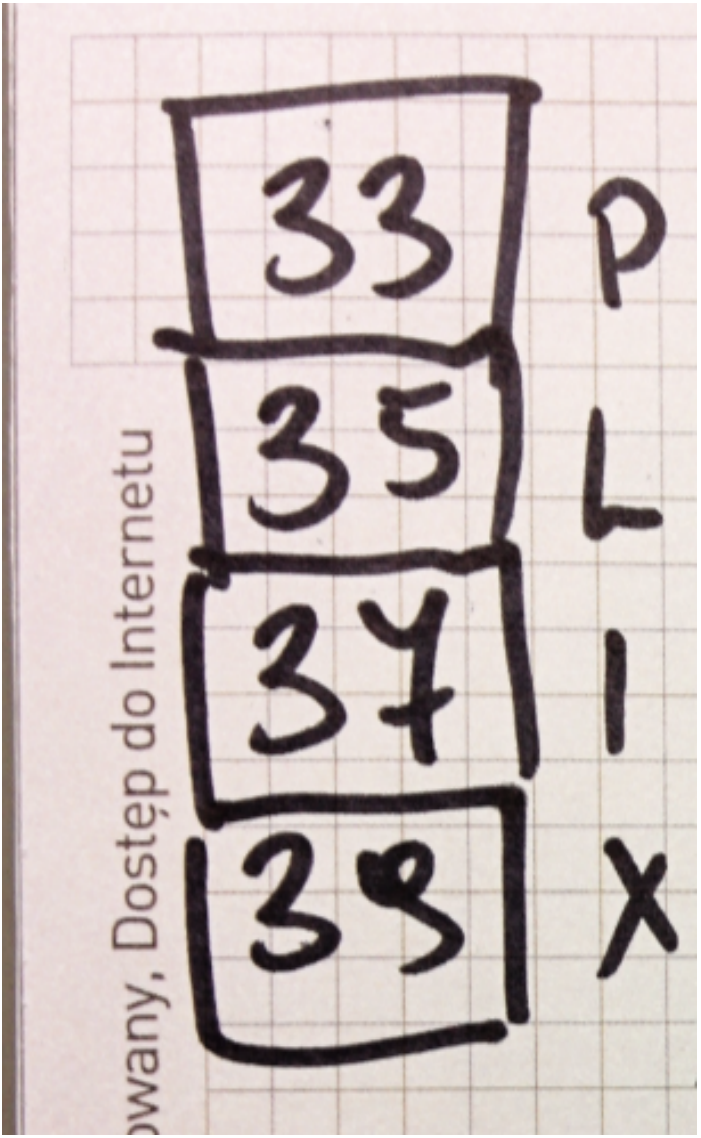
BGP PEERS UPLINKS



FUDO SECURITY

AFTER HOURS

BGP PEERS UPLINKS



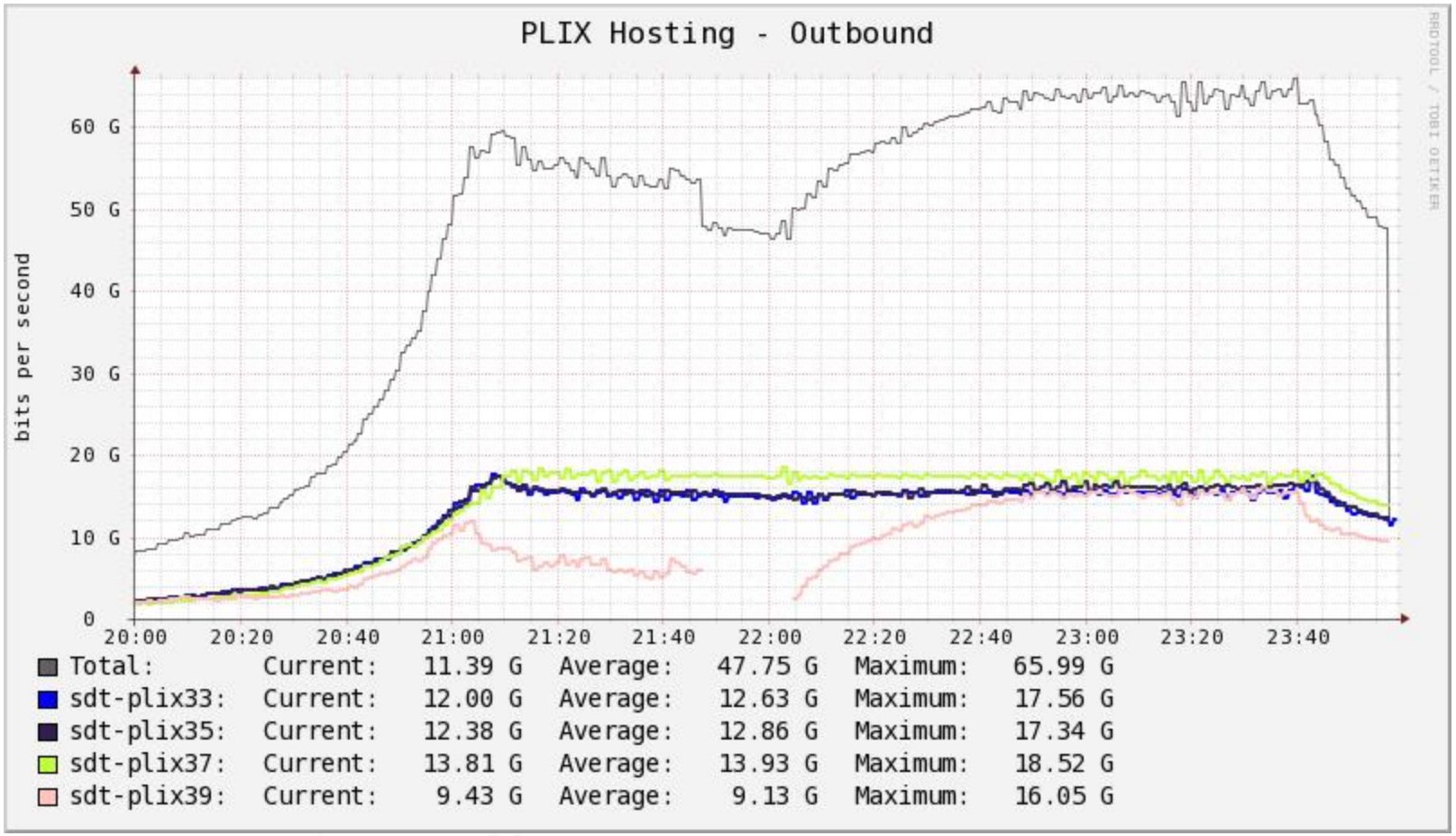

```
root@sdt-plix33:~# dmidecode |grep -A2 IBM
        Vendor: IBM Corp.
        Version: -[D6E154AUS-1.13]-
        Release Date: 09/23/2011
--
        Manufacturer: IBM
        Product Name: System x3550 M3 -[794472G]-
        Version: 00
--
        Manufacturer: IBM
        Product Name: 94Y7614
        Version: (none)
--
        Manufacturer: IBM
        Type: Rack Mount Chassis
        Lock: Not Present
--
        String 1: IBM SystemX
```

```
root@sdt-plix33:~# free
             total       used       free     shared    buffers     cached
Mem:      74375600   72792244    1583356     316700     384128   63873076
-/+ buffers/cache:    8535040   65840560
Swap:       974844      19108     955736
root@sdt-plix33:~# lspci|grep Emu
1a:00.0 Ethernet controller: Emulex Corporation OneConnect 10Gb NIC (rev 02)
1a:00.1 Ethernet controller: Emulex Corporation OneConnect 10Gb NIC (rev 02)
root@sdt-plix33:~# df
Filesystem                1K-blocks       Used Available Use% Mounted on
/dev/mapper/vg1-ROOT       19092180    1807968  16291344  10% /
udev                          10240          0     10240   0% /dev
tmpfs                       7437560       3216   7434344   1% /run
tmpfs                          5120          0      5120   0% /run/lock
tmpfs                      14875120          0  14875120   0% /run/shm
/dev/mapper/vgssd-lvssd   576240192  450214876 126008932  79% /ssd
/dev/mapper/vg1-STORAGE  1607230788 1141295040 465919364  72% /storage
/dev/mapper/vg1-VAR_       95987468   61887636  29200812  68% /var
```

FUDO SECURITY

AFTER HOURS

PLIX SERVERS



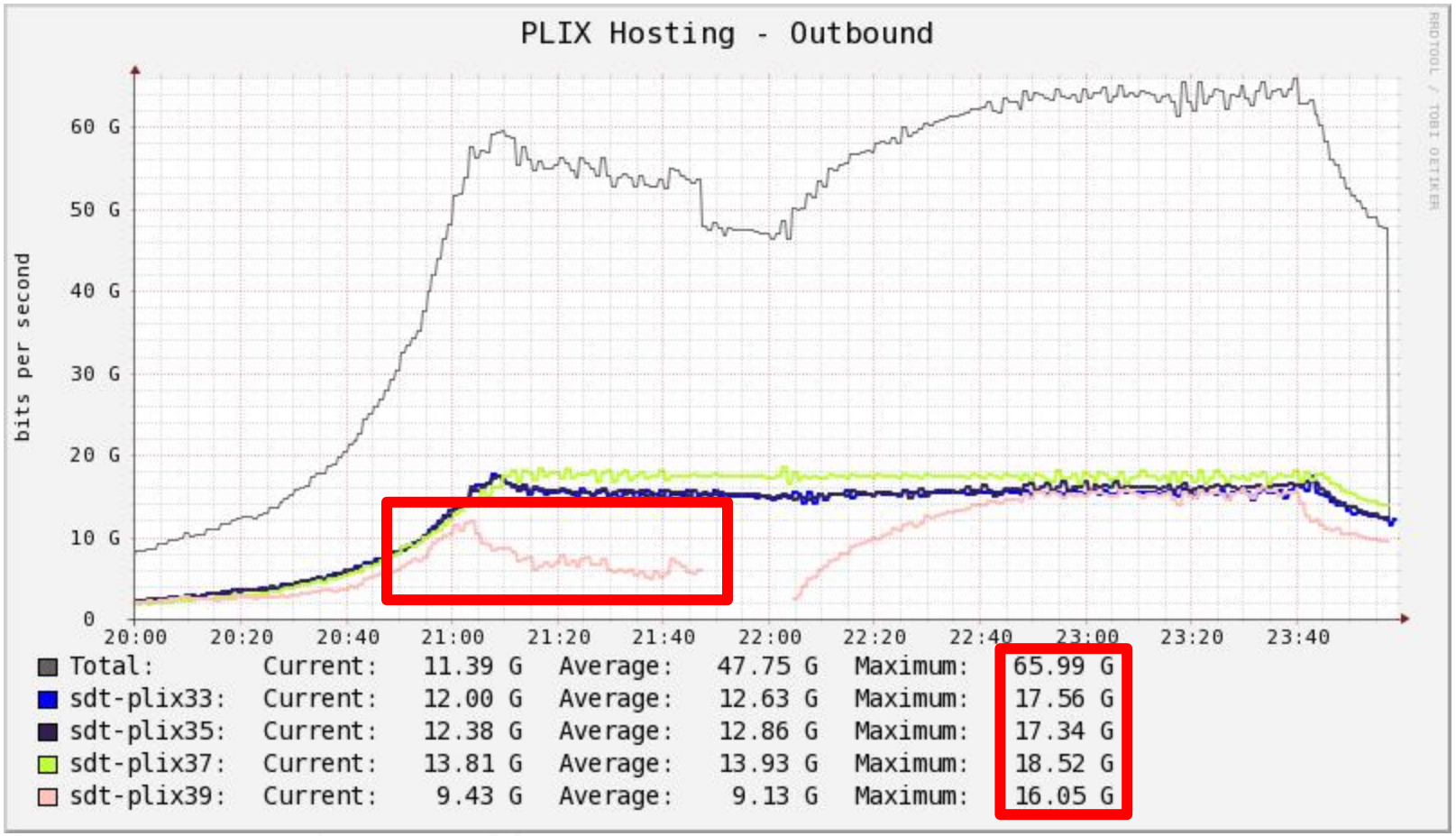
NIEDZIELA, 13.07, 21:00, FINAŁ

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

FUDO SECURITY

AFTER HOURS

PLIX SERVERS

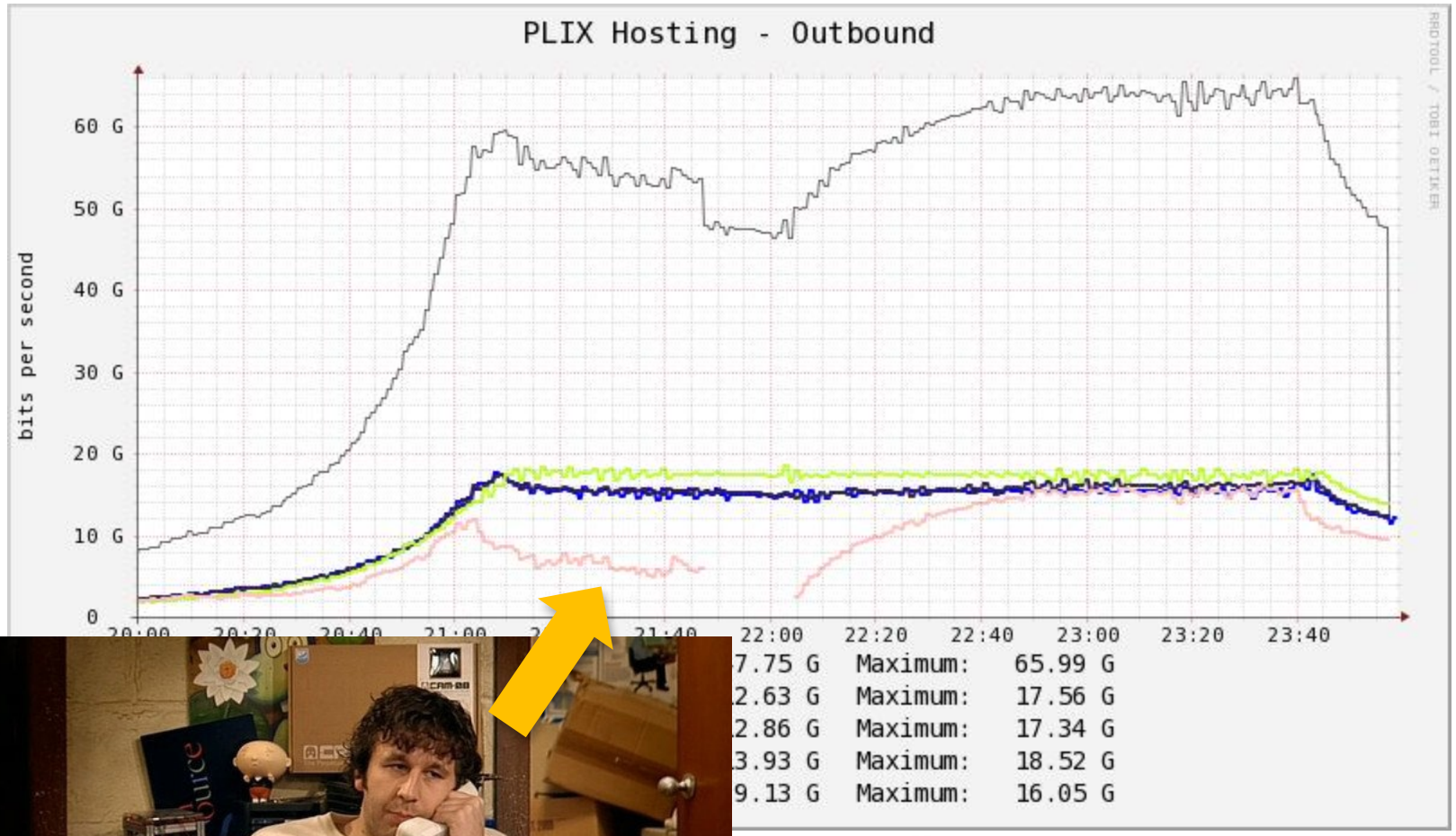


NIEDZIELA, 13.07, 21:00, FINAŁ

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

FUDO SECURITY
AFTER HOURS

PLIX SERVERS



07, 21:00, FINAŁ

:0

, 0:0)

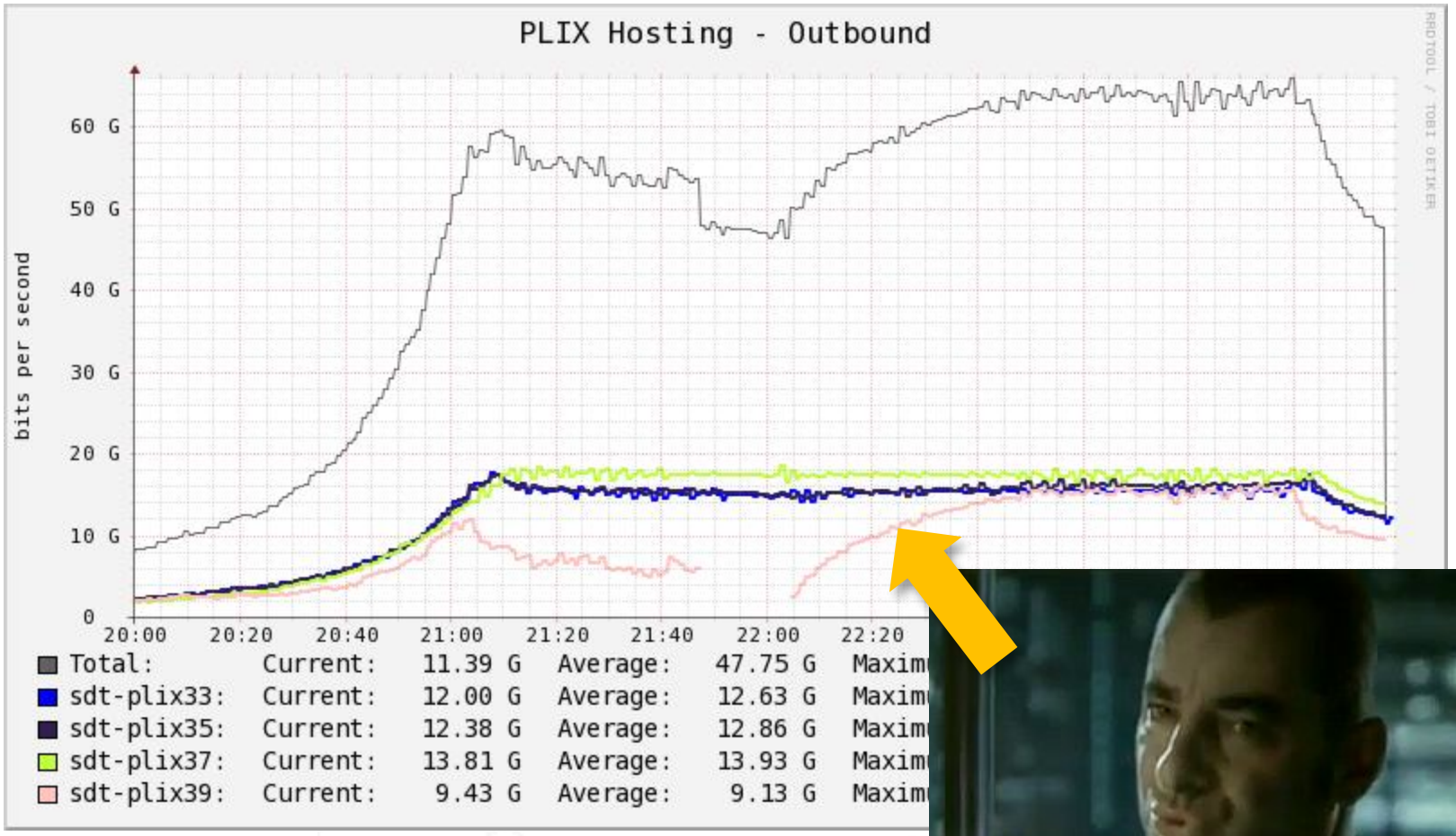
NIEMCY

ARGENTYNA

FUDO SECURITY

AFTER HOURS

PLIX SERVERS



NIEDZIELA, 13.07, 21:00, FI

NIEMCY

1:0

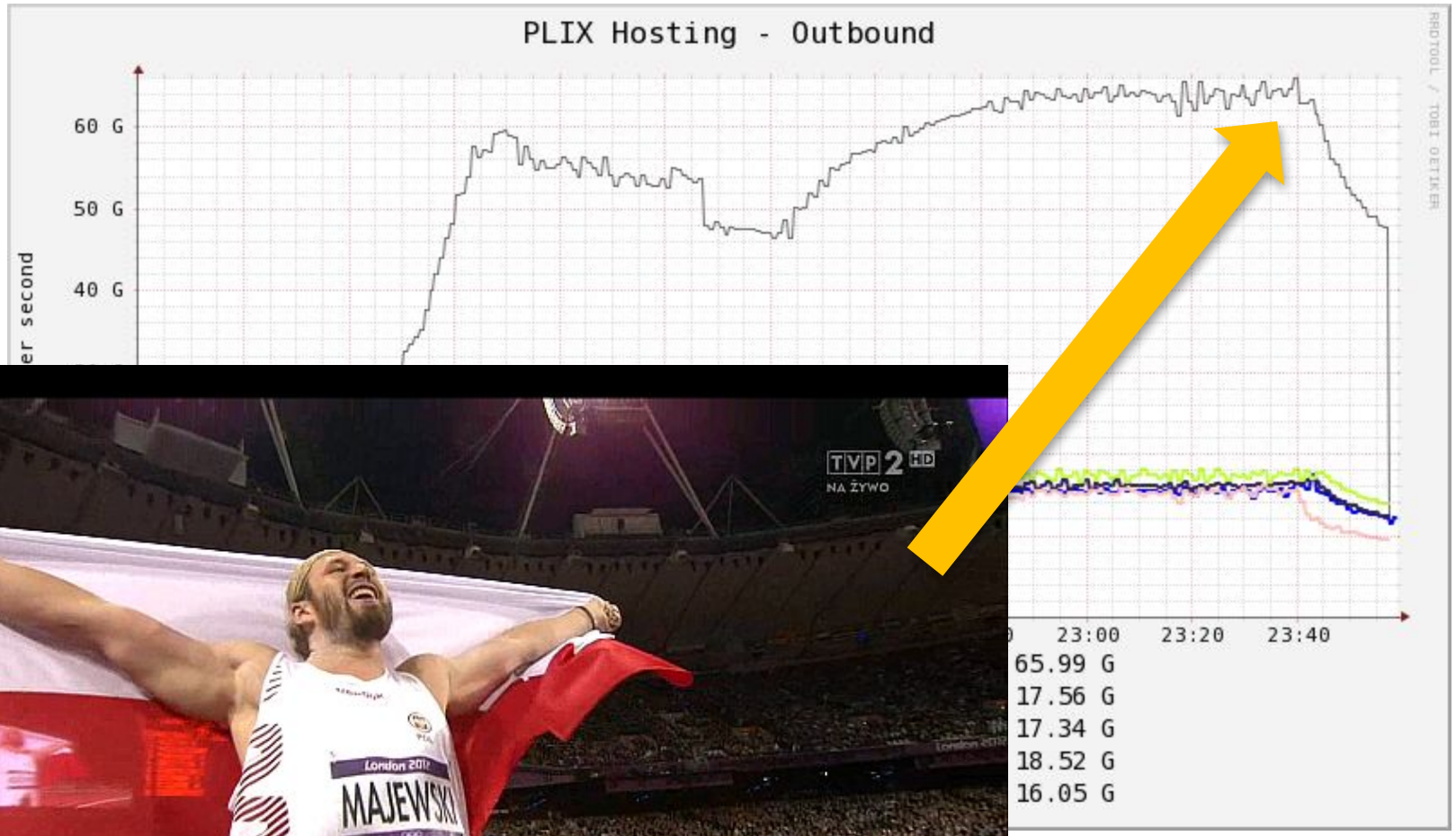
(0:0, 0:0)

ARGENTYNA

FUDO SECURITY

AFTER HOURS

PLIX SERVERS



NIEMCY ARGENTYNA

FUDO SECURITY

AFTER HOURS

PLIX SERVERS

A 2011 server sending 17,579 Gbit/s

```
ATOP - sdt-plix37                                2014/07/13  22:50:17                                f-----                                2s elapsed
PRC | sys   14.79s | user   1.44s | #proc    420 | #trun     19 | #tslpi  12e3 | #tslpu     0 | #zombie    0 | clones     1 |                   | #exit      ? |
CPU | sys     190% | user     62% | irq      708% | idle   1437% | wait      4% |              | steal     0% | guest     0% | avgf 2.08GHz | avgscal  68% |
cpu | sys      8% | user     0% | irq      100% | idle     0% | cpu023 w  0% |              | steal     0% | guest     0% | avgf 3.06GHz | avgscal 100% |
cpu | sys      2% | user     0% | irq       96% | idle     2% | cpu009 w  0% |              | steal     0% | guest     0% | avgf 3.06GHz | avgscal 100% |
cpu | sys      2% | user     1% | irq       95% | idle     2% | cpu021 w  0% |              | steal     0% | guest     0% | avgf 3.06GHz | avgscal 100% |
cpu | sys      4% | user     1% | irq       92% | idle     4% | cpu011 w  0% |              | steal     0% | guest     0% | avgf 3.05GHz | avgscal  99% |
cpu | sys      4% | user     1% | irq       91% | idle     4% | cpu015 w  0% |              | steal     0% | guest     0% | avgf 3.06GHz | avgscal 100% |
cpu | sys      8% | user     1% | irq       75% | idle    16% | cpu017 w  0% |              | steal     0% | guest     0% | avgf 2.86GHz | avgscal  93% |
cpu | sys      9% | user     1% | irq       73% | idle    17% | cpu019 w  0% |              | steal     0% | guest     0% | avgf 2.83GHz | avgscal  92% |
cpu | sys      7% | user     2% | irq       73% | idle    19% | cpu013 w  0% |              | steal     0% | guest     0% | avgf 2.77GHz | avgscal  90% |
cpu | sys     17% | user     6% | irq        0% | idle    77% | cpu003 w  1% |              | steal     0% | guest     0% | avgf 1.85GHz | avgscal  60% |
cpu | sys     16% | user     5% | irq        1% | idle    79% | cpu006 w  0% |              | steal     0% | guest     0% | avgf 1.67GHz | avgscal  54% |
cpu | sys     14% | user     4% | irq       10% | idle    71% | cpu000 w  0% |              | steal     0% | guest     0% | avgf 1.64GHz | avgscal  53% |
cpu | sys     14% | user     5% | irq        0% | idle    81% | cpu008 w  0% |              | steal     0% | guest     0% | avgf 1.61GHz | avgscal  52% |
cpu | sys     12% | user     6% | irq        0% | idle    82% | cpu010 w  0% |              | steal     0% | guest     0% | avgf 1.60GHz | avgscal  52% |
cpu | sys     13% | user     5% | irq        1% | idle    80% | cpu002 w  0% |              | steal     0% | guest     0% | avgf 1.60GHz | avgscal  52% |
cpu | sys     11% | user     5% | irq        0% | idle    84% | cpu007 w  0% |              | steal     0% | guest     0% | avgf 1.60GHz | avgscal  52% |
CPL | avg1  12.53 | avg5  12.90 |                | avg15  12.38 |              | csw   172953 | intr  275491 |              |                   | numcpu    24 |
MEM | tot   94.6G | free  11.7G | cache  72.4G | dirty   0.0M | buff    1.2G | slab    1.7G |              |              |                   |              |
SWP | tot  952.0M | free 647.7M |              |              |              |              |              |              | vmcom  15.4G      | vmlim  48.2G |
PAG | scan      0 |             | stall     0  |              |              |              |              | swin      0  |                   | swout     0  |
LVM |      vg1-VAR | busy     10% | read      0  | write   211  | KiB/r     0  | KiB/w    85  | MBr/s   0.00 | MBw/s   8.79 | avq     6.78      | avio 0.97 ms |
LVM |  vg1-STORAGE | busy      6% | read      0  | write   228  | KiB/r     0  | KiB/w     4  | MBr/s   0.00 | MBw/s   0.53 | avq    61.93      | avio 0.53 ms |
LVM |  VGSSD-LVSSD | busy      2% | read     38  | write    23  | KiB/r    81  | KiB/w    72  | MBr/s   1.52 | MBw/s   0.81 | avq     2.60      | avio 0.66 ms |
LVM |     vg1-ROOT | busy      0% | read      0  | write     0  | KiB/r     0  | KiB/w     0  | MBr/s   0.00 | MBw/s   0.00 | avq     0.00      | avio 0.00 ms |
LVM |     vg1-SWAP | busy      0% | read      0  | write     0  | KiB/r     0  | KiB/w     0  | MBr/s   0.00 | MBw/s   0.00 | avq     0.00      | avio 0.00 ms |
MDD |          md0 | busy      0% | read      0  | write   440  | KiB/r     0  | KiB/w    43  | MBr/s   0.00 | MBw/s   9.32 | avq     0.00      | avio 0.00 ms |
MDD |          md1 | busy      0% | read     38  | write    23  | KiB/r    81  | KiB/w    72  | MBr/s   1.52 | MBw/s   0.81 | avq     0.00      | avio 0.00 ms |
DSK |          sdf | busy     10% | read    156  | write   216  | KiB/r    26  | KiB/w    28  | MBr/s   2.00 | MBw/s   3.00 | avq     9.31      | avio 0.52 ms |
DSK |          sdh | busy      9% | read    157  | write   136  | KiB/r    31  | KiB/w    28  | MBr/s   2.39 | MBw/s   1.88 | avq     8.00      | avio 0.61 ms |
DSK |          sdd | busy      9% | read    198  | write   114  | KiB/r    25  | KiB/w    50  | MBr/s   2.50 | MBw/s   2.80 | avq    10.37      | avio 0.55 ms |
NET | transport     | tcpi 1524901 | tcpo 2998738 | udpi      0  | udpo      0  | tcpao    61  | tcppo  7244  | tcprs 143869 | tcpie     2       | udpip     0  |
NET | network       | ipi  1524922 | ipo  1157052 | ipfrw     0  | deliv 1525e3 |              |              |              | icmpi    17       | icmpo     0  |
NET | eth0      0%  | pcki       0 | pcko       0 | si    0 Kbps | so    0 Kbps | coll      0  | erri      0  | erro      0  | drpi      0       | drpo      0  |
NET | bond10  ----  | pcki 1543739 | pcko 3027175 | si  538 Mbps | so   17 Gbps | coll      0  | erri      0  | erro      0  | drpi  19376       | drpo      0  |
NET | eth10   ----  | pcki  759939 | pcko 1572852 | si  244 Mbps | so 9114 Mbps | coll      0  | erri      0  | erro      0  | drpi   2463       | drpo      0  |
NET | eth11   ----  | pcki  783790 | pcko 1454306 | si  293 Mbps | so 8465 Mbps | coll      0  | erri      0  | erro      0  | drpi  16913       | drpo      0  |
NET | lo      ----  | pcki     408 | pcko     408 | si  400 Kbps | so  400 Kbps | coll      0  | erri      0  | erro      0  | drpi      0       | drpo      0  |

  PID        SYSCPU        USRCPU        VGROW        RGROW        RUID          EUID          THR    ST    EXC    S    CPU    CMD        1/54
 3355        10.27s         1.09s       17408K       18220K        varnish       varnish     11323    --     -     S    577%    varnishd
  125         1.40s         0.00s           0K           0K        root          root            1    --     -     R     71%    ksoftirqd/23
  540         0.51s         0.00s           0K           0K        root          root            1    --     -     R     26%    kworker/23:2
```

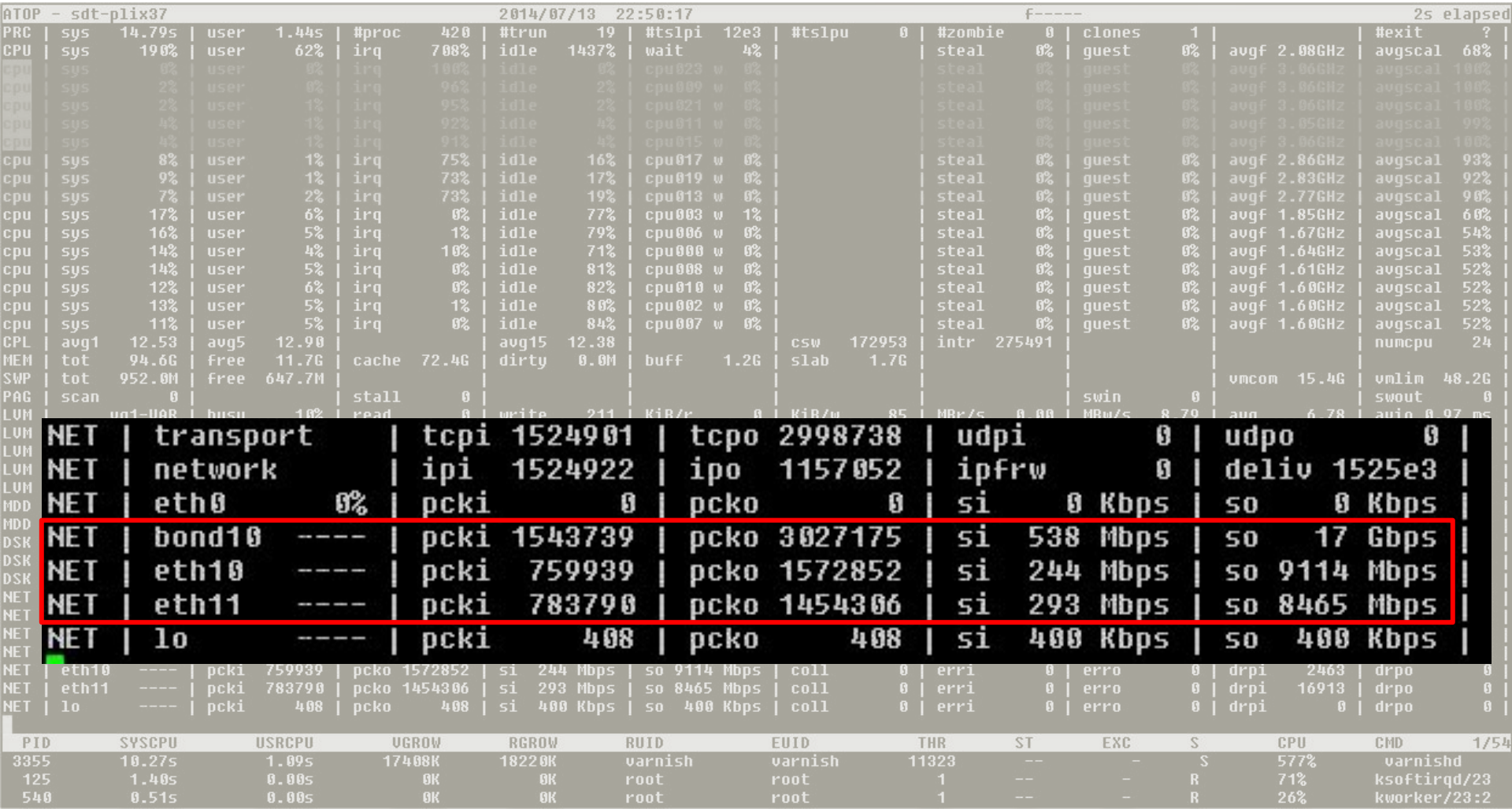
FUDO SECURITY

AFTER HOURS

2 x Intel x520 NIC

PLIX SERVERS

A 2011 server sending 17,579 Gbit/s



FUDO SECURITY

AFTER HOURS

2 x Intel x520 NIC

PLIX SERVERS

OK, LET'S TRY 40 G

FUD SECURITY

AFTER HOURS

2016

Mellanox MCX414A-BCAT

FUD SECURITY

AFTER HOURS

2016

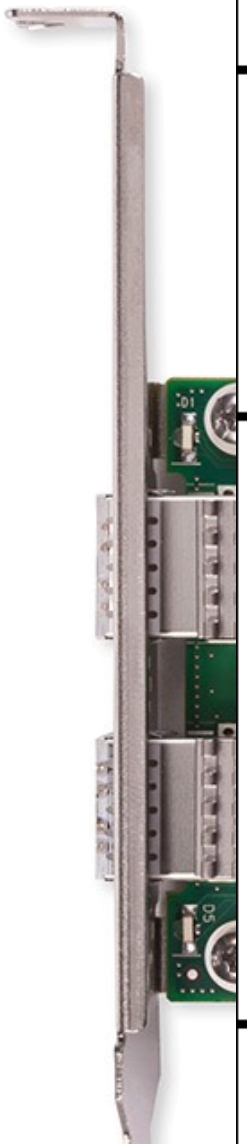


Table 9 - MCX414A-BCAT Specifications Table

Physical	**Size:** 2.71 in. x 5.6 in. (68.90mm x 142.24 mm) – low profile
	Connector: Dual QSFP28 (Copper and optical)
Protocol Support	**Ethernet:** 56GBASE-R4, 50GBASE-R2, 50GBASE-R4, 40GBASE-CR4, 40GBASE-KR4, 40GBASE-SR4, 40GBASE-LR4, 40GBASE-ER4, 40GBASE-R2, 25GBASE-R, 20GBASE-KR2, 1000BASE-CX, 1000BASE-KX, 10GBASE-SR, 10GBASE-LR,10GBASE-ER, 10GBASE-CX4, 10GBASE-KX4, 10GBASE-CR, 10GBASE-KR, SGMII
	Data Rate: 1/10/25/40/56 Gb/s – Ethernet
	PCI Express Gen3: SERDES @ 8.0GT/s, 8 lanes (2.0 and 1.1 compatible)
Power and Environmental	**Voltage:** 12V, 3.3V
	Typical Power[a], Passive Cables: 40GbE – 11.86W 56GbE – 12.26W
	Maximum Power: Passive Cables: 40GbE – 13.50W 56GbE – 13.98W **1.5W Active Cables:** 40GbE – 16.83W 56GbE – 17.31W
	Maximum power available through QSFP28 port: 3.5W
	Temperature: Operational 0°C to 55°C Non-operational -40°C to 70°C
	Humidity: 90% relative humidity[b]
	Air Flow: See Airflow Specifications on page 65
Regulatory	**Safety:** CB / cTUVus / CE
	EMC: CE / FCC / VCCI / ICES / RCM
	RoHS: RoHS-R6

a. Typical power for ATIS traffic load.
b. For both operational and non-operational states.

PCI Epress 3.0 8x

FUD SECURITY
AFTER HOURS

016

PCI Epress 3.0 8x

PCI Express link performance[27][30]

PCI Express version	Line code	Transfer rate[i]	Throughput[i]			
			×1	×4	×8	×16
1.0	8b/10b	2.5 GT/s	250 MB/s	1 GB/s	2 GB/s	4 GB/s
2.0	8b/10b	5 GT/s	500 MB/s	2 GB/s	4 GB/s	8 GB/s
3.0	128b/130b	8 GT/s	984.6 MB/s	3.938 GB/s	7.877 GB/s	15.754 GB/s
4.0 (*expected in 2017*)	128b/130b	16 GT/s	1.969 GB/s	7.877 GB/s	15.754 GB/s	31.508 GB/s
5.0 (*far future*)[28][29]	128b/130b	32 or 25 GT/s[ii]	3.9, or	15.8, or	31.5, or	63.0, or

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

ii. ^ Both rates are being considered for technical feasibility.

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

FUD SECURITY

AFTER HOURS

2016

PCI Epress 3.0 8x

PCI Express link performance[27][30]

PCI Express version	Line code	Transfer rate[i]	Throughput[i]			
			×1	×4	×8	×16
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3.0	128b/130b	8 GT/s	984.6 MB/s	3.938 GB/s	7.877 GB/s	15.754 GB/s
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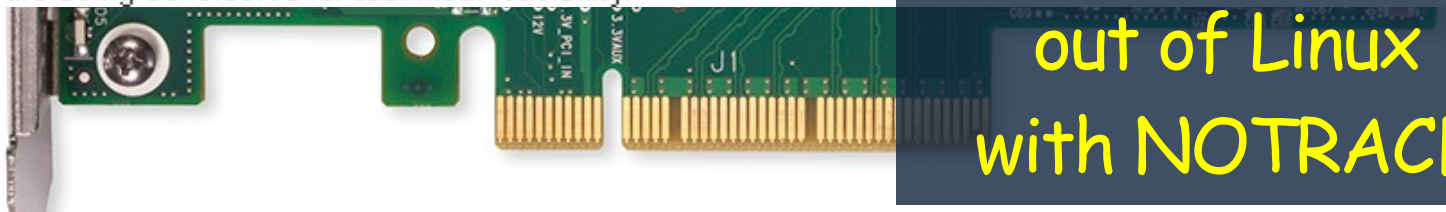
5.0 (*far future*)[28][29]	128b/130b	32 or 25 GT/s[ii]	3.9, or 3.08 GB/s	15.8, or 12.3 GB/s	31.5, or 24.6 GB/s	63.0, or 49.2 GB/s

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

ii. ^ Both rates are being considered for technical feasibility.

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

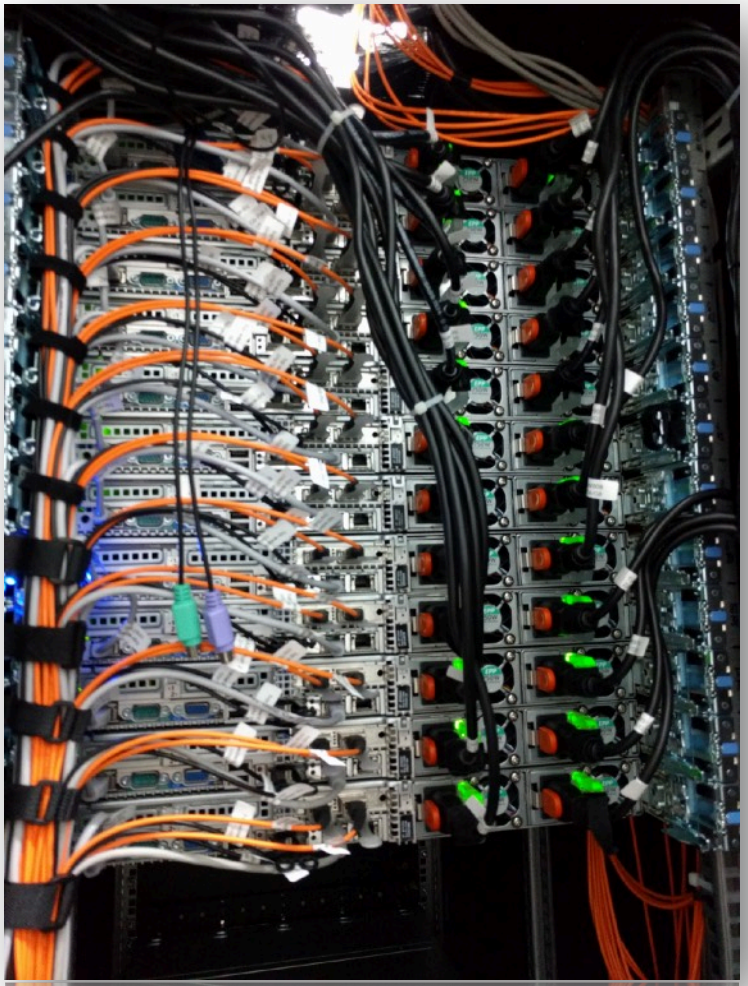


FUD SECURITY

AFTER HOURS

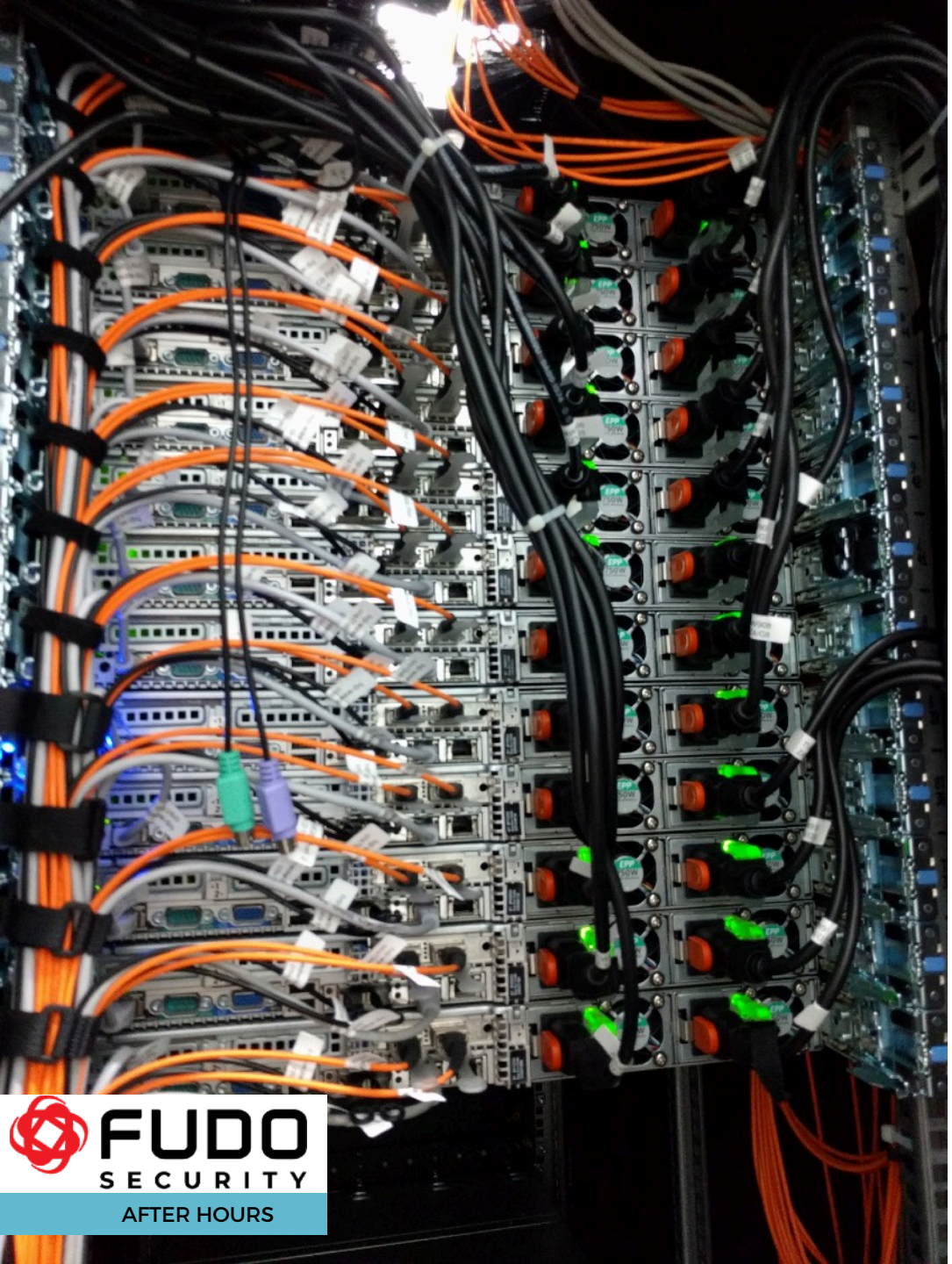
2016

And here comes 2018…



FUDO SECURITY

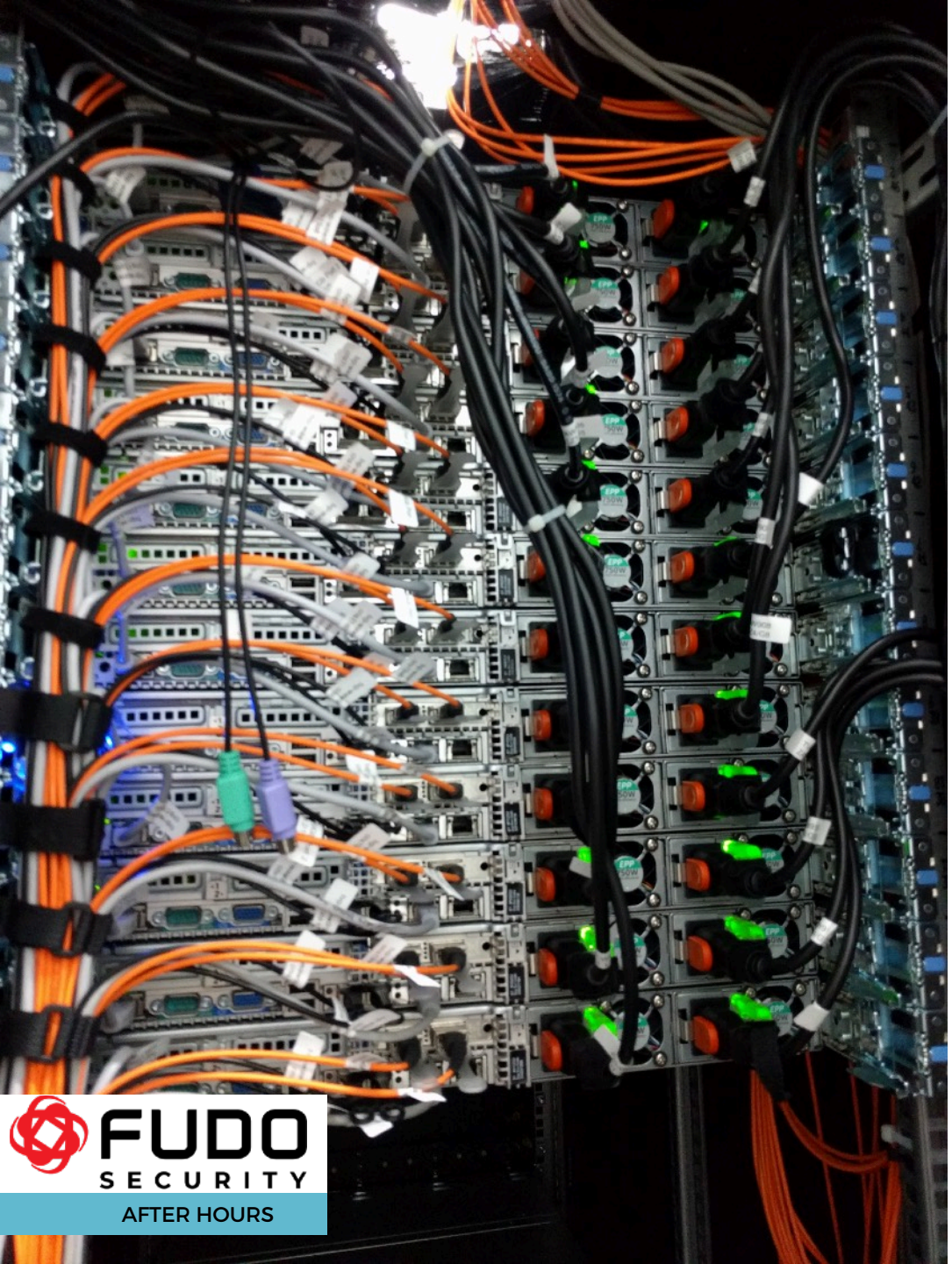
AFTER HOURS



IN 2018...

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

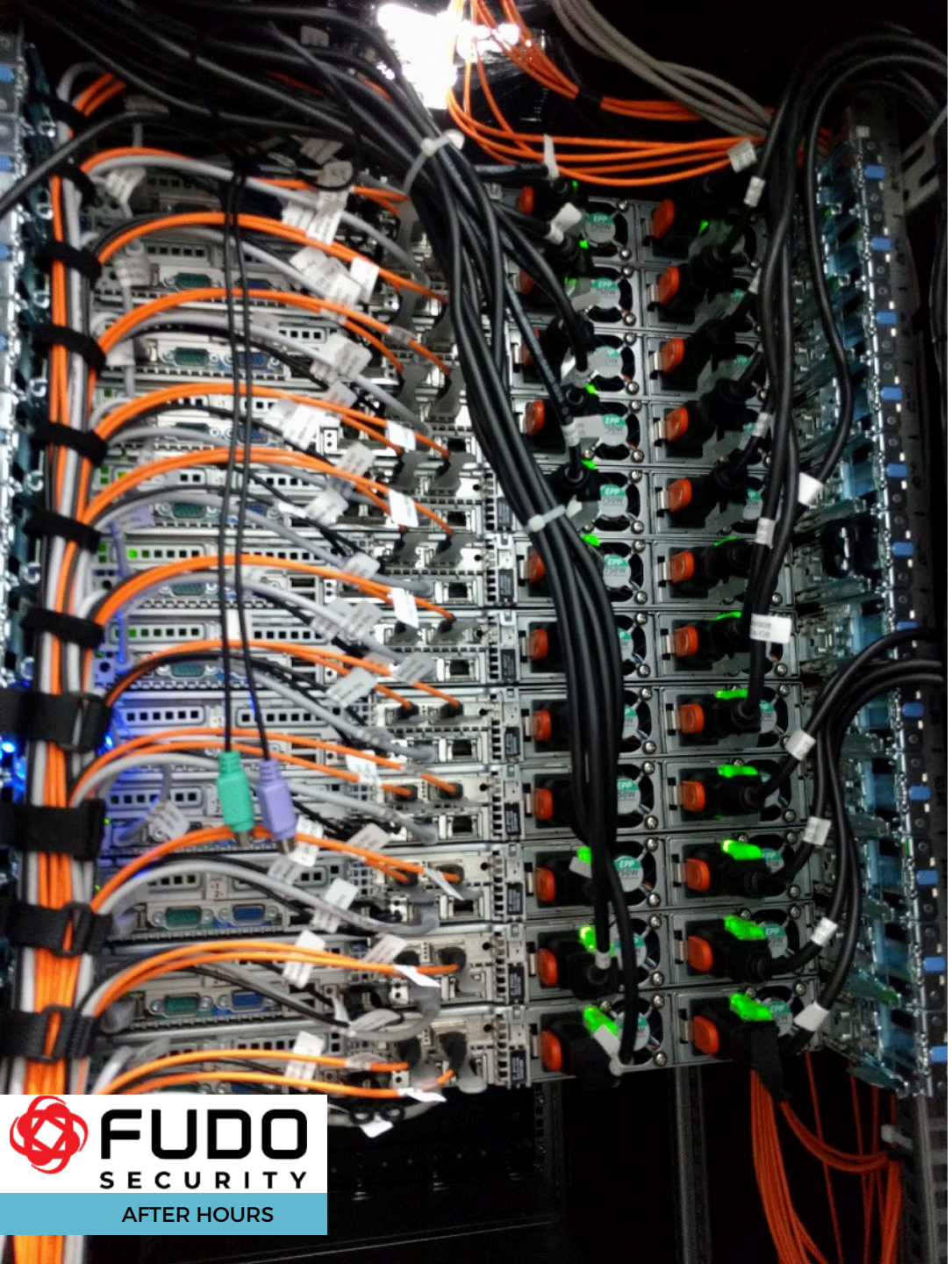
this gives over 800 Gbit/s of <u>real</u> "internet broadcasting power"



2014
211+ Gbit/s

2018
463+ Gbit/s

2018
? Gbit/s



2014

211+ Gbit/s

2018

463+ Gbit/s

2018

860+ Gbit/s*

*does not include NCplus' internet broadcasts

Source: internet