Goufone

TV Stack Evolution

Joan Gaudes
Network & Systems
jgaudes@goufone.com

Jaume Sala
Software & TV
jsala@goufone.com

Angel Elena
Systems & VoIP
aelena@goufone.com

Goufone
Engineering

Core Services

Goufone

- Broadband provider
- Landline phone Operator
- Mobile phone Operator
- Digital TV provider

Digital TV provider

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Goufone TV

Goufone TV

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- Live streaming
  DVB channels
- VoD platform
  Media providers
- Whatever we can think of
  What if...

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Fase I

Fase I – Goals

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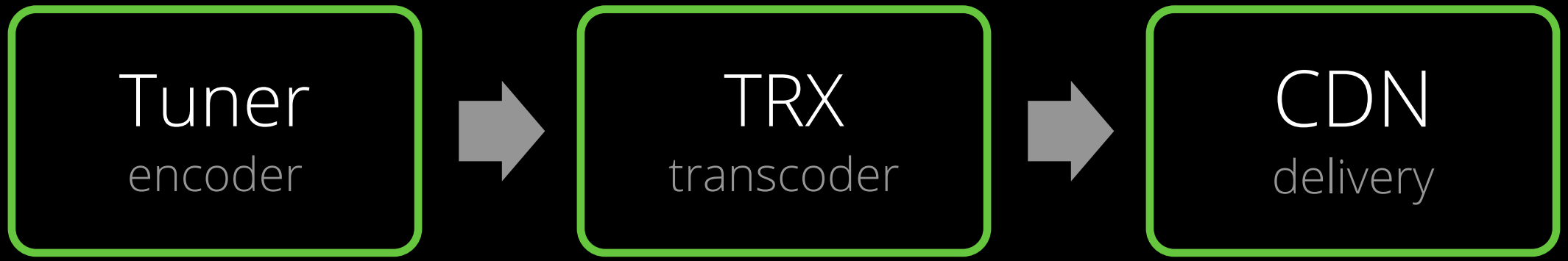
- In-house R&D
  How can we do it
- From DVB-T to live streams
  First approach

Fase I – Infraestructure

Goufone

tv stack



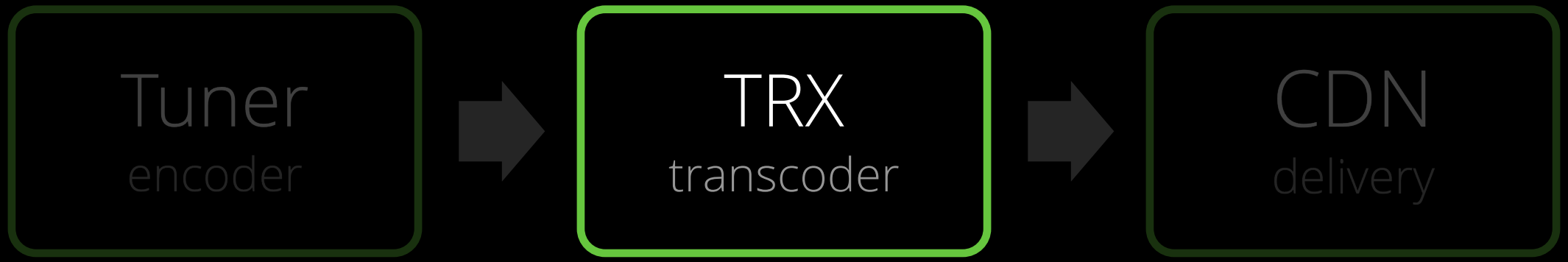
Fase I – Infraestructure

Goufone

- From DVB-T to UDP
- From MPEG2/H.264 to HLS
- From HLS to clients

Fase I – Infraestructure

Goufone



- From DVB-T to UDP
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Fase I – Infraestructure

Goufone

- From DVB-T to UDP
- From MPEG2/H.264 to HLS
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Fase I – Infraestructure

Goufone

- From DVB-T to UDP
- From MPEG2/H.264 to HLS
- From HLS to clients

Fase I – Encoder

Tuner → TRX → CDN

Goufone

- TBS MOI Pro (x2)
  Price: ~600€/unit
- Config & Setup
  Price: ~1000€ (Third party company)
- Cesbo Astra
  Price: 540€ + 220€ *

* Lifetime license + 1yr updates

Fase I – Transcoder

Tuner → TRX → CDN

Goufone

- HP 380 G5 Server (x3)
  CPUs: 16 cores
  RAM: 40 Gb
  Price: ~600€/unit

- Python Scripts
  Price: ~1000€ (third party company)

Fase I – Delivery

Tuner → TRX → CDN

Goufone

- VM Server
  vCPU: 32 core
  vRAM: 128 Gb
  vPrice: ~30€
- CentOS
  Kernel tuned
- Nginx Server
  Tuned

Fase I – The good, the bad, the evil

Goufone

- ✅ We have live streams 🙌
- ❌ Encoder: *black box* 💵
  - High price
- ❌ Transcoder: GPU transcoding 🚀
  - Low performance
  - Only 1 profile (1080p)
  - Python scripts... 🤔

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Fase II

Fase II – Goals

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- Increase transcoding throughput
  CPUs are not viable
- Reduce resources
  Servers & Watts
- Reduce price
  Please!

Fase II – GPU Parallel Computing

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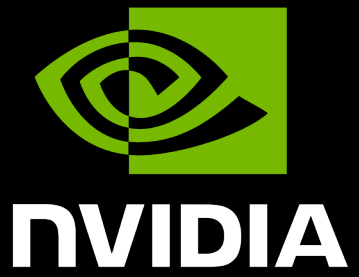
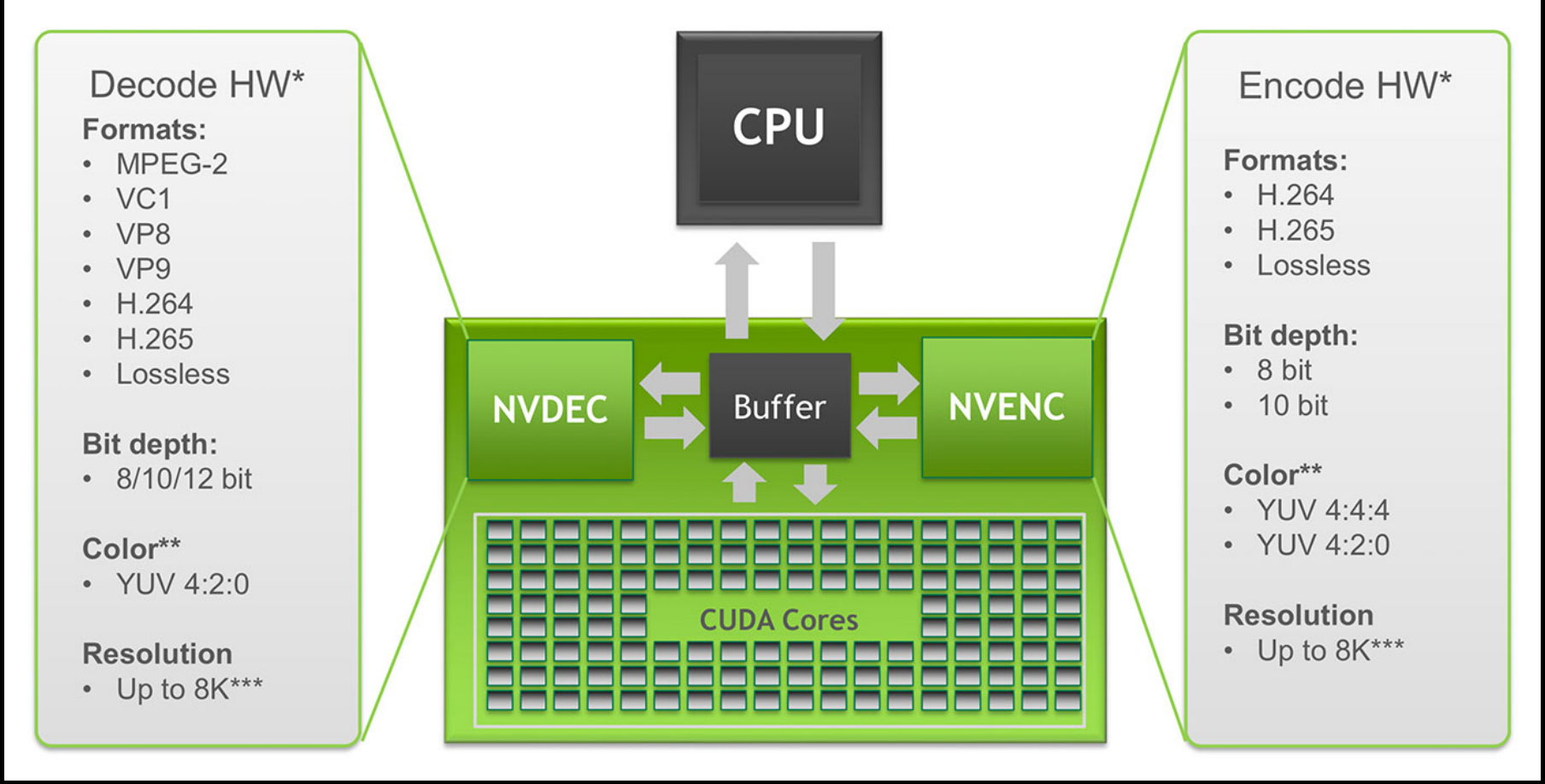
- Nvidia CUDA Toolkit
  Best in class
- Quadro M4000
  Cost/performance
- FFmpeg
  Hardware acceleration



Fase II – GPU capabilities

Goufone



Fase II – Quadro M4000

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Video Encode and Decode GPU Support Matrix

NVENC Support Matrix

BOARD	FAMILY	# OF NVENC /CHIP	Total # of NVENC	H.264 (AVCHD) YUV 4:2:0	H.264 (AVCHD) YUV 4:4:4	H.264 (AVCHD) Lossless	H.265 (HEVC) 4K YUV 4:2:0	H.265 (HEVC) 4K YUV 4:4:4	H.265 (HEVC) 4K Lossless	H.265 (HEVC) 8k	HEVC B Frame support
Quadro K4000	Kepler	1	1	YES	NO	NO	NO	NO	NO	NO	NO
Quadro M4000 / M5000	Maxwell (2nd Gen)	2	2	YES	YES	YES	YES	NO	NO	NO	NO
Quadro P4000	Pascal	1	1	YES	YES	YES	YES	YES	YES	YES	NO
Quadro RTX 5000/RTX 4000	Turing	1	1	YES	YES	YES	YES	YES	YES	YES	YES

NVDEC Support Matrix

BOARD	FAMILY	# OF NVDEC /CHIP	Total # of NDEC	MPEG-1	MPEG-2	VC-1	VP8	VP9			H.264 (AVCHD)	H.265 (HEVC) 4:2:0			*H.265 (HEVC) 4:4:4		
								8 bit	10 bit	12 bit		8 bit	10 bit	12 bit	8 bit	10 bit	12 bit
Quadro K4000	Kepler	1	1	YES	YES	YES	NO	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO
Quadro M4000 / M5000	Maxwell (2nd Gen)	1	1	YES	YES	YES	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO
Quadro P4000 / P5000	Pascal	1	1	YES	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	NO	NO	NO
Quadro RTX 4000/RTX 5000	Turing	2	2	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

https://developer.nvidia.com/video-encode-decode-gpu-support-matrix

Fase II – The good, the bad, the evil

Goufone

- ✅ We have MORE live streams 🙌
- ❌ Encoder: *black box* 💵
  - High price
- 💥 Transcoder: GPU transcoding 🚀
  - high performance (x2)
  - ⚠️ Only 1 profile (1080p)
  - ⚠️ Python scripts... 🤔
    - Memory leaks
- ⚠️ Network: packet loss 🚰

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Fase III

Fase III – Goals

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- Find memory leaks
  Scripts, ffmpeg, kernel...
- Fix packet loss
  Coax, switch, ethernet...
- Add multi-profile capabilities
  1080p, 720p, 360p...

Fase III – Memory leaks

Tuner → TRX → CDN

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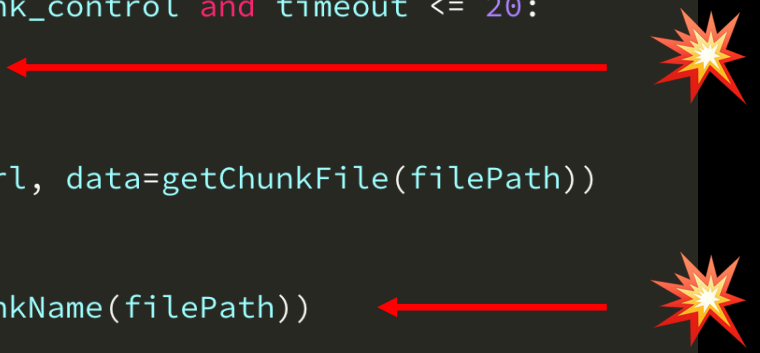
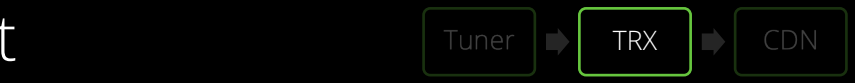
```
chunk_control = []

def http_put(filePath, remoteUrl):

    extension = getFileExtension(filePath)

    if extension == 'm3u8':
        last_chunk = getLastChunkName(filePath)
        timeout = 0
        while last_chunk not in chunk_control and timeout <= 20:
            time.sleep(0.1)
            timeout = timeout + 1

    response = requests.put(remoteUrl, data=getChunkFile(filePath))

    if extension == 'ts':
        chunk_control.append(getChunkName(filePath))
```



Fase III – Trxcast



Goufone

- Configurable
- Low memory footprint
- Low cpu usage
- Monitoring
- Autorestart on crash
- Reliable

- FFmpeg
  Video processing
- Node.js
  Stream processing
- PM2
  Process manager
- Watchman
  Filesystem watcher

Fase III – Trxcast

Tuner → TRX → CDN

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```
[
  {
    "name": "h264_1080p25_720p25_360p25",
    "description": "Streams: 16:9 AAC - 1080p25 720p25 360p25, HLS: time 6s, list 5",
    "beforeProcessing": [
      { "cmd": "prepareDir", "args": ["{{stream:output}}"] },
      { "cmd": "startDistribution", "args": { "origin": "{{stream:output}}" } }
    ],
    "afterProcessing": [
      { "cmd": "prepareDir", "args": ["{{stream:output}}"] },
      { "cmd": "stopDistribution", "args": {} }
    ],
    "template": {
      "global": [ "-y", "-nostdin", "-nostats" ],
      "input": [ "-hwaccel_device", "{{stream:gpu}}", "-hwaccel", "cuvid", "-c:v", "h264_cuvid", "-i", "{{stream:input}}" ],
      "output": [
        "-vf", "scale_npp=640:360", "-c:v", "h264_nvenc", "-c:a", "libfdk_aac", "-b:a", "64k",
        "-f", "hls", "{{stream:output}}360/{{stream:playlist}}",
        "-vf", "scale_npp=1280:720", "-c:v", "h264_nvenc", "-c:a", "libfdk_aac", "-b:a", "128k",
        "-f", "hls", "{{stream:output}}720/{{stream:playlist}}",
        "-vf", "scale_npp=1920:1080", "-c:v", "h264_nvenc", "-c:a", "libfdk_aac", "-b:a", "128k",
        "-f", "hls", "{{stream:output}}1080/{{stream:playlist}}"
      ]
    }
  }
]
```

```
[
  {
    "name": "vic.cdn.goufone.com",
    "protocol": "webdav",
    "writeUrl": "http://172.1.2.3/streams/",
    "readUrl": "https://vic.cdn.goufone.com/",
    "active": true
  },
  {
    "name": "bcn.cdn.goufone.com",
    "protocol": "webdav",
    "writeUrl": "http://172.3.2.1/streams/",
    "readUrl": "https://bcn.cdn.goufone.com/",
    "active": false
  }
]
```

```
[
  {
    "name": "TV3 HD",
    "description": "TV3 HD @ TRX1" ,
    "input": "udp://239.1.2.3:2000",
    "output": "tv_3_hd_trx_1/",
    "playlist": "index.m3u8",
    "profile": "h264_1080p25_720p25_360p25",
    "broadcast": true,
    "gpu": "1"
  },
]
```

Fase III – Trxcast

Tuner → TRX → CDN

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```
TC > broadcast status
```

#	Name	Profile	Broadcast	GPU	PID	Id	CPU	MEM	Status	Restarts	Uptime
1	Antena 3 HD	h264_1080p25_720p25_360p25	YES	0	38469	75	0.1 %	56.6 MB	ONLINE	0	10h 8m 11s
2	Atreseries HD	h264_1080p25_720p25_360p25	YES	0	38508	77	0.1 %	55.9 MB	ONLINE	0	10h 8m 6s
3	Be Mad TV HD	h264_1080p25_720p25_360p25	YES	0	38695	79	0.1 %	55.6 MB	ONLINE	0	10h 8m 1s
4	Clan HD	h264_1080p25_720p25_360p25	YES	0	38882	81	0.2 %	56.8 MB	ONLINE	0	10h 7m 57s
5	Real Madrid TV HD	h264_1080p25_720p25_360p25	YES	1	39068	83	0.1 %	56.9 MB	ONLINE	0	10h 7m 52s
6	Telecinco HD	h264_1080p25_720p25_360p25	YES	1	39255	85	0.1 %	55.4 MB	ONLINE	0	10h 7m 47s
7	Teledeporte HD	h264_1080p25_720p25_360p25	YES	1	39443	87	0.1 %	56.2 MB	ONLINE	0	10h 7m 42s
8	TV3 HD	h264_1080p25_720p25_360p25	YES	1	39630	89	0.2 %	56.2 MB	ONLINE	0	10h 7m 38s
9	Cuatro HD	h264_1080p25_720p25_360p25	YES	2	39816	91	0.1 %	55.3 MB	ONLINE	0	10h 7m 33s
10	La 1 HD	h264_1080p25_720p25_360p25	YES	2	40003	93	0.2 %	57.4 MB	ONLINE	0	10h 7m 28s
11	La 2 HD	h264_1080p25_720p25_360p25	YES	2	40200	95	0.2 %	57.5 MB	ONLINE	0	10h 7m 24s
12	La Sexta HD	h264_1080p25_720p25_360p25	YES	2	40386	97	0.2 %	58.6 MB	ONLINE	0	10h 7m 19s
13	24 Horas	mpeg2_720p25_360p25	YES	0	40571	99	0.1 %	56.4 MB	ONLINE	0	10h 7m 14s
14	3/24	mpeg2_720p25_360p25	YES	0	40755	101	0.1 %	56.3 MB	ONLINE	0	10h 7m 10s
15	8TV	mpeg2_720p25_360p25	YES	0	40891	103	0.1 %	56.4 MB	ONLINE	0	10h 7m 5s
16	Barça TV HD	h264_1080p25_720p25_360p25	YES	0	41040	105	0.2 %	57.4 MB	ONLINE	0	10h 7m 0s
17	Boing	mpeg2_720p25_360p25	YES	0	49832	107	0.1 %	49.7 MB	ONLINE	2	26m 7s
18	Canal Taronja	mpeg2_720p25_360p25	YES	0	41360	109	0.2 %	57.7 MB	ONLINE	0	10h 6m 51s
19	Disney Channel	mpeg2_720p25_360p25	YES	0	41496	111	0.3 %	57.4 MB	ONLINE	0	10h 6m 46s
20	Divinity	mpeg2_720p25_360p25	YES	0	41631	113	0.2 %	56.7 MB	ONLINE	0	10h 6m 41s
21	IB3 Global	mpeg2_720p25_360p25	YES	1	41766	115	0.2 %	56 MB	ONLINE	0	10h 6m 37s
22	Mega	mpeg2_720p25_360p25	YES	1	49790	117	0.2 %	50.4 MB	ONLINE	2	26m 13s
23	Neox	mpeg2_720p25_360p25	YES	1	41938	119	0.1 %	56.6 MB	ONLINE	0	10h 6m 27s
24	Nova	mpeg2_720p25_360p25	YES	1	42074	121	0.1 %	55.9 MB	ONLINE	0	10h 6m 23s
25	Paramount Network	mpeg2_720p25_360p25	YES	1	42209	123	0.1 %	56.4 MB	ONLINE	0	10h 6m 18s
26	RAC105	mpeg2_720p25_360p25	YES	1	42361	125	0.2 %	55.3 MB	ONLINE	0	10h 6m 13s
27	Super3/33	mpeg2_720p25_360p25	YES	1	42511	127	0.1 %	56.4 MB	ONLINE	0	10h 6m 9s
28	TEN	mpeg2_720p25_360p25	YES	1	42647	129	0.1 %	57.9 MB	ONLINE	0	10h 6m 4s
29	DKISS	mpeg2_720p25_360p25	YES	2	42783	131	0.2 %	57.6 MB	ONLINE	0	10h 5m 59s
30	DMAX	mpeg2_720p25_360p25	YES	2	42920	133	0.1 %	56 MB	ONLINE	0	10h 5m 55s
31	El 9 TV	mpeg2_720p25_360p25	YES	2	43055	135	0.2 %	58.5 MB	ONLINE	0	10h 5m 50s
32	El Punt Avui TV	mpeg2_720p25_360p25	YES	2	43190	137	0.1 %	56.2 MB	ONLINE	0	10h 5m 45s
33	Energy	mpeg2_720p25_360p25	YES	2	49818	139	0.2 %	50 MB	ONLINE	2	26m 7s
34	Esport3	mpeg2_720p25_360p25	YES	2	43472	141	0.1 %	57.5 MB	ONLINE	0	10h 5m 36s
35	FDF	mpeg2_720p25_360p25	YES	2	51210	143	0.1 %	48.4 MB	ONLINE	8	1m 6s
36	GOL	mpeg2_720p25_360p25	YES	2	43743	145	0.2 %	57.1 MB	ONLINE	0	10h 5m 27s
37	TRECE	mpeg2_720p25_360p25	YES	2	49804	147	0.1 %	49.6 MB	ONLINE	2	26m 8s

```
TC >
```

Fase III – FFmpeg performance considerations

Goufone

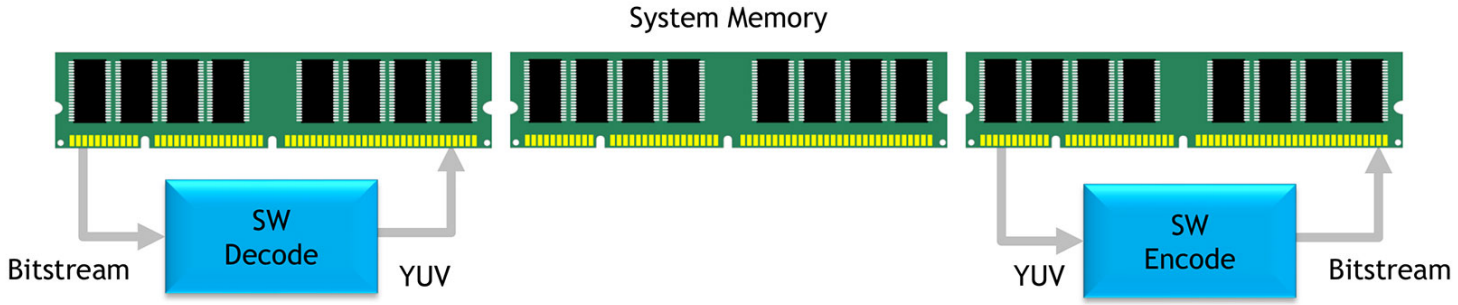
- Video transcoding = *performance / watt*
- Hardware accelerated transcode using ffmpeg
  - Minimize memory (PCIe) transfers
  - Saturate on-chip encoder/decoder
  - Efficient M:N command line
  - Minimize I/O
  - Encode settings
  - GPU Clocks

Fase III – FFmpeg optimization strategies 1/5

Goufone

SW TRANSCODE

```
ffmpeg -c:v h264 -i input.mp4 -c:a copy -c:v h264 -b:v 5M output.mp4
```



32 fps*

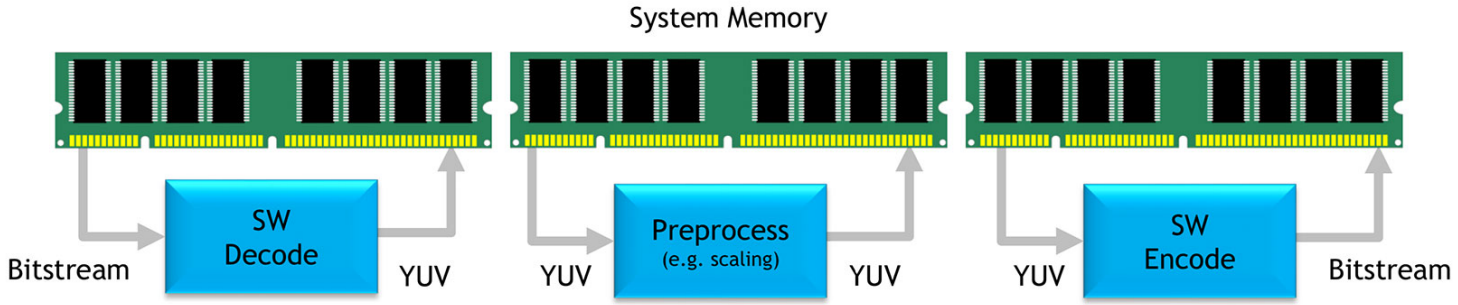
*1:2 transcode, fps per session
4 GHz Intel i7-6700K

Fase III – FFmpeg optimization strategies 2/5

Goufone

SW TRANSCODE + SCALE

```
ffmpeg -c:v h264 -i input.mp4 -vf scale=1280:720 -c:a copy -c:v h264 -b:v 5M output.mp4
```

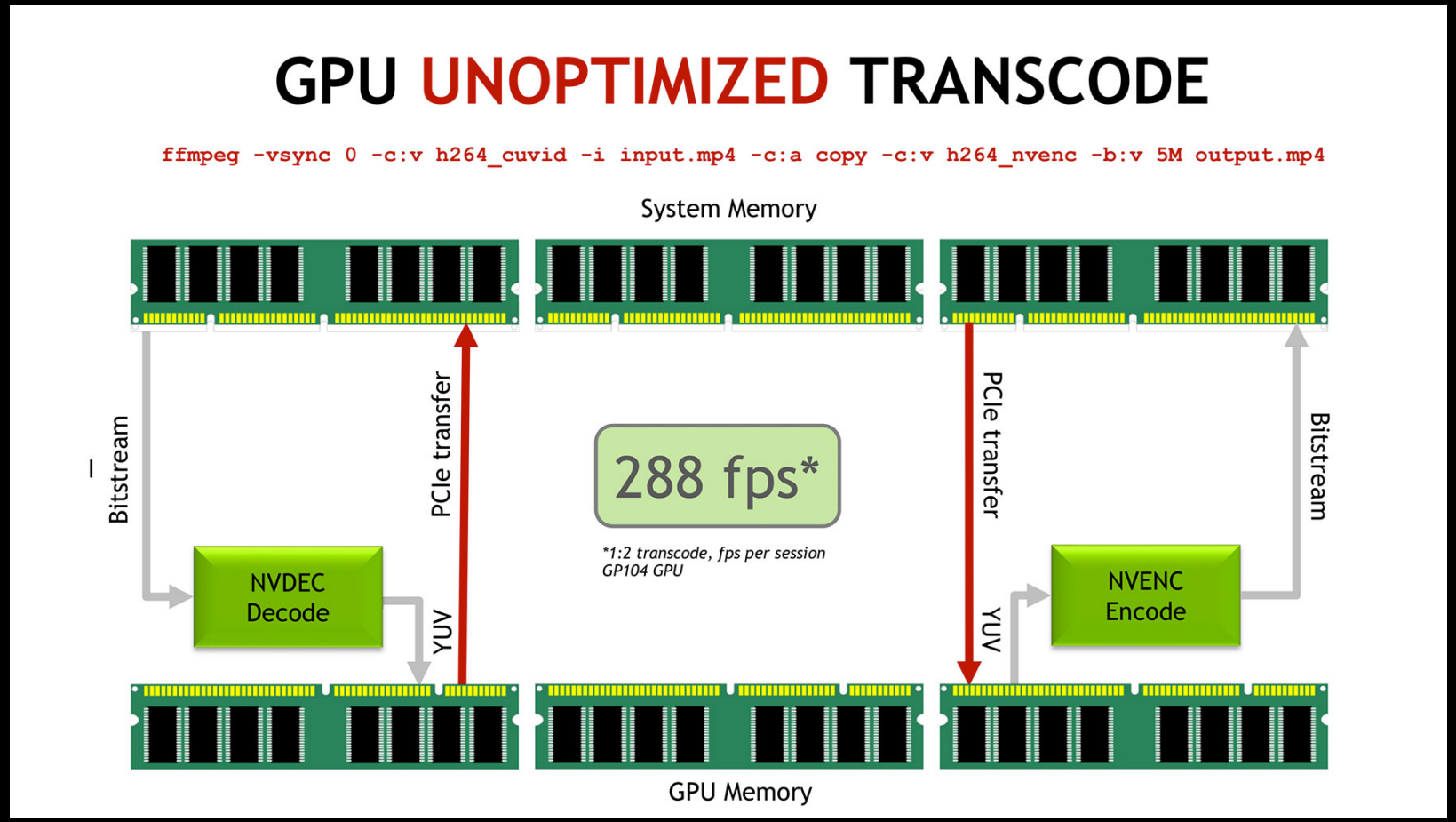


29 fps*

*1:2 transcode, fps per session
4 GHz Intel i7-6700K

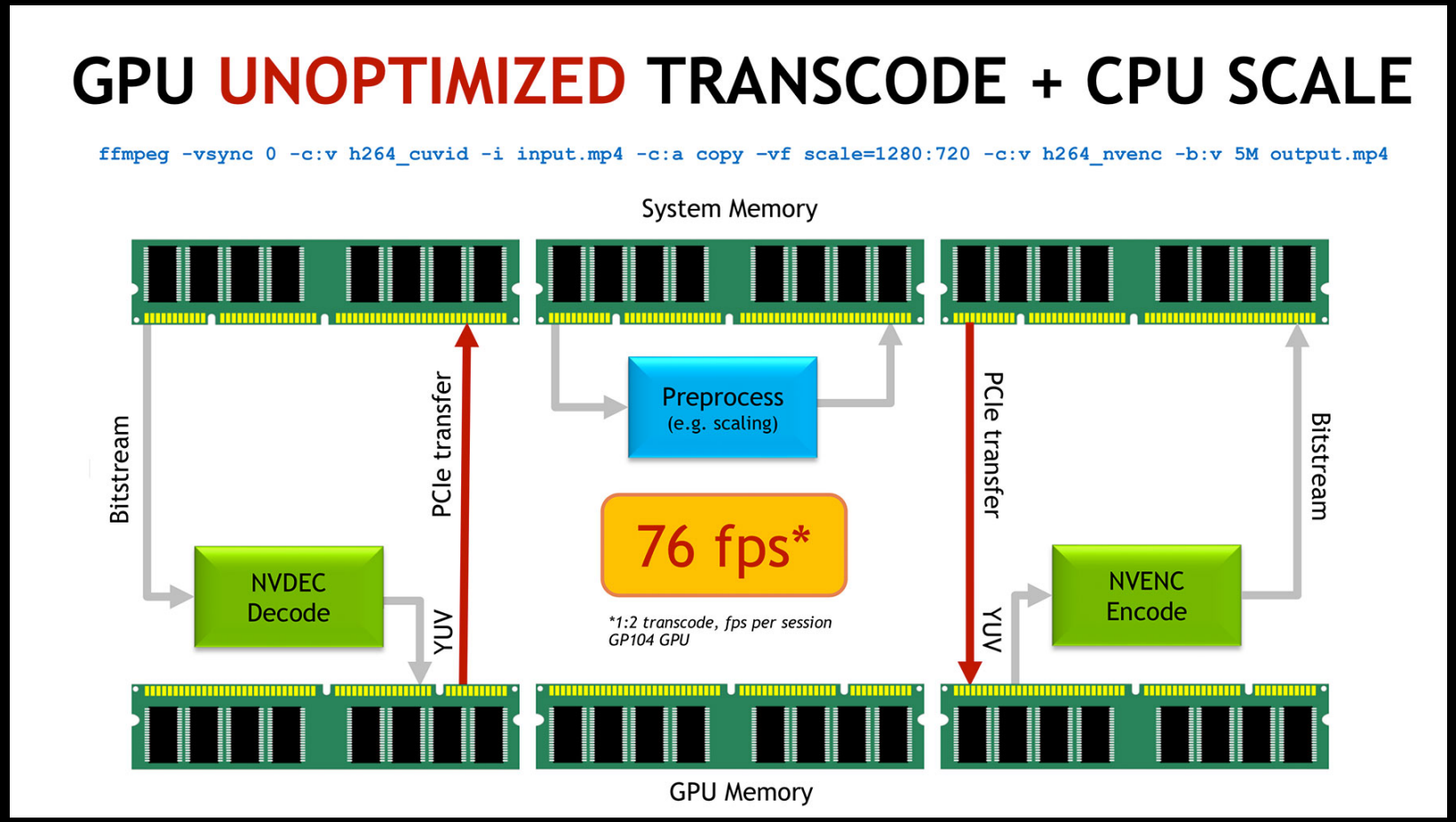
Fase III – FFmpeg optimization strategies 3/5

Goufone



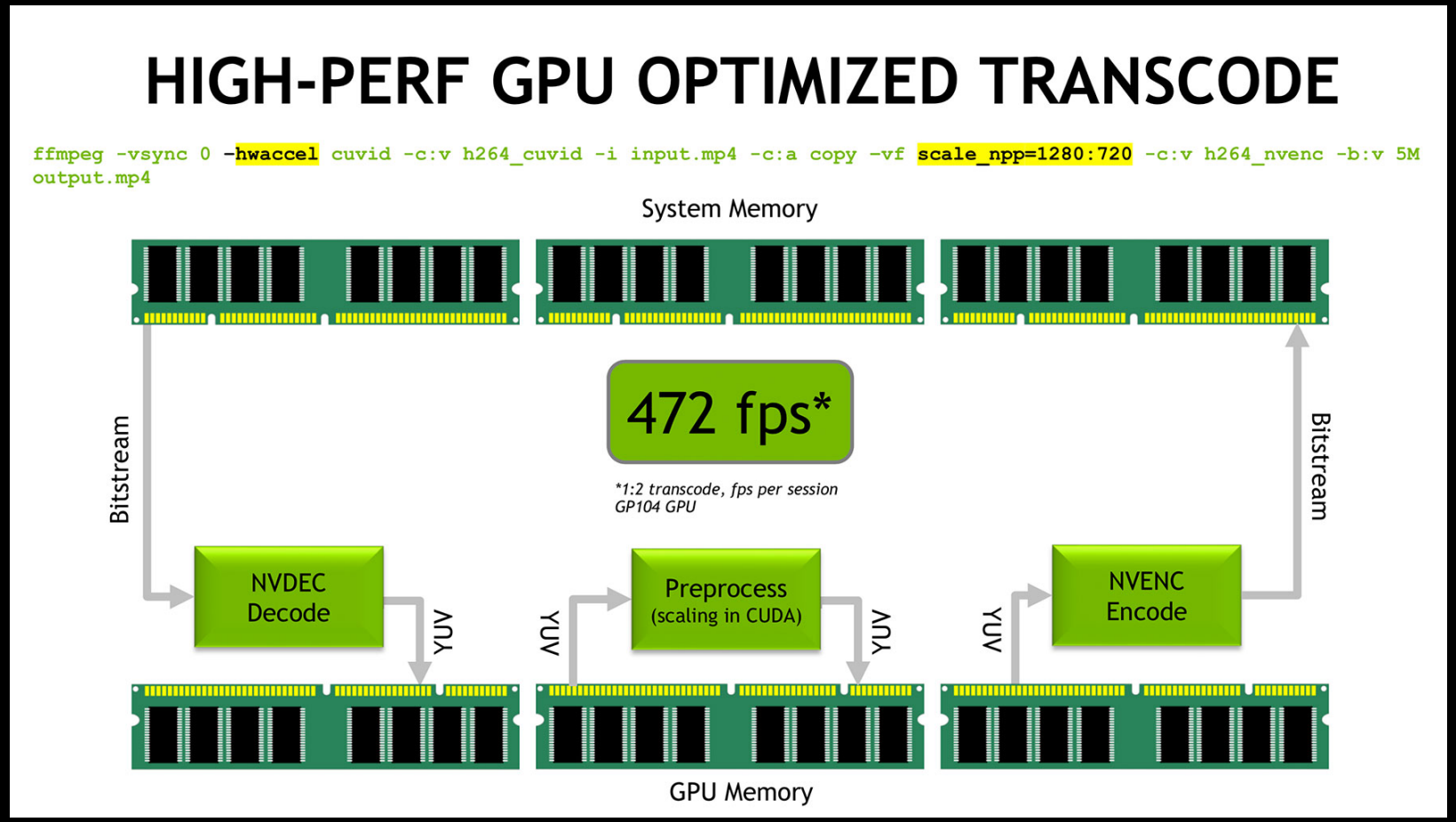
Fase III – FFmpeg optimization strategies 4/5

Goufone



Fase III – FFmpeg optimization strategies 5/5

Goufone



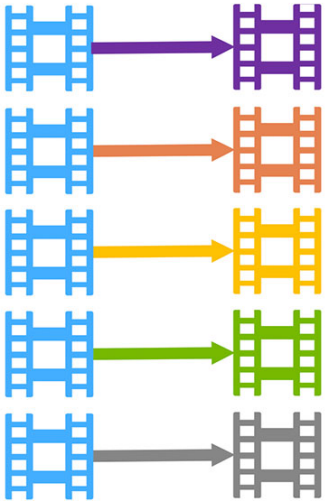
Fase III – FFmpeg parallel transcodes 1/2

Goufone

PARALLEL TRANSCODES (*1:N*)

Multiple command lines

```
ffmpeg -y -vsync 0 -hwaccel cuvid -c:v h264_cuvid -i input.mp4 -vf
scale_npp=1920:1080 -c:a copy -c:v h264_nvenc -b:v 5M output1.mp4

ffmpeg -y -vsync 0 -hwaccel cuvid -c:v h264_cuvid -i input.mp4 -vf
scale_npp=1280:720 -c:a copy -c:v h264_nvenc -b:v 5M output2.mp4

ffmpeg -y -vsync 0 -hwaccel cuvid -c:v h264_cuvid -i input.mp4 -vf
scale_npp=640:480 -c:a copy -c:v h264_nvenc -b:v 5M output3.mp4

ffmpeg -y -vsync 0 -hwaccel cuvid -c:v h264_cuvid -i input.mp4 -vf
scale_npp=320:240 -c:a copy -c:v h264_nvenc -b:v 5M output4.mp4

ffmpeg -y -vsync 0 -hwaccel cuvid -c:v h264_cuvid -i input.mp4 -vf
scale_npp=160:128 -c:a copy -c:v h264_nvenc -b:v 5M output5.mp4

...
```



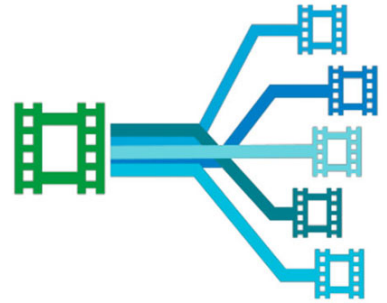
Fase III – FFmpeg parallel transcodes 2/2

Goufone

PARALLEL TRANSCODES (*1:N*)

Single command line

```
ffmpeg -y -vsync 0 -hwaccel cuvid -c:v h264_cuvid -i input.mp4
-vf scale_npp=1920:1080 -c:a copy -c:v h264_nvenc -b:v 8M output_1080p.mp4
-vf scale_npp=1280:720 -c:a copy -c:v h264_nvenc -b:v 5M output_720p.mp4
-vf scale_npp=640:480 -c:a copy -c:v h264_nvenc -b:v 3M output_480p.mp4
-vf scale_npp=320:240 -c:a copy -c:v h264_nvenc -b:v 2M output_240p.mp4
-vf scale_npp=160:128 -c:a copy -c:v h264_nvenc -b:v 1M output_128p.mp4
...
```



Fase III – Fix packet loss

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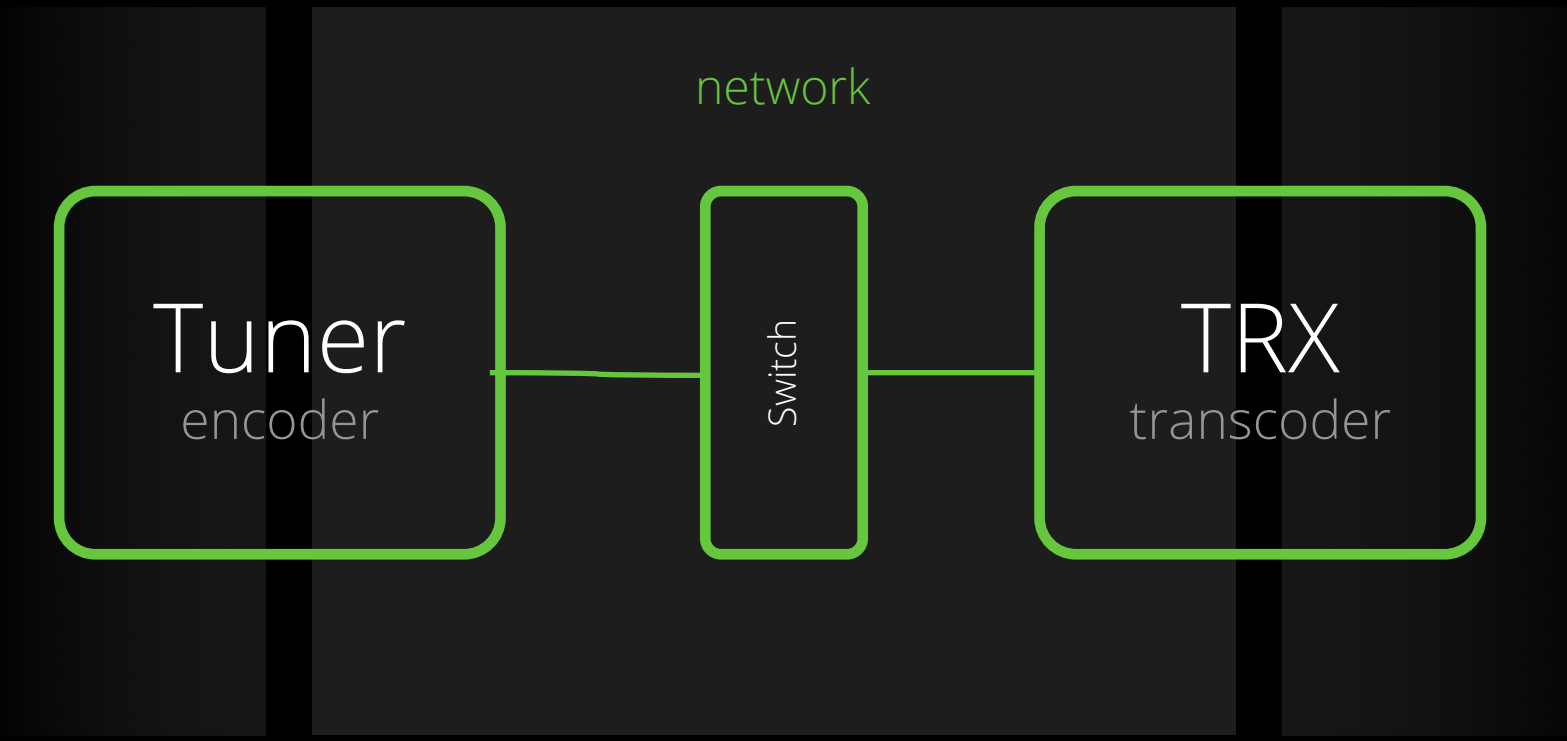

Fase III – The good, the bad, the evil

Goufone

- ✅ We have EVEN MORE live streams 🙌
- ❌ Encoder: *black box* 💵
  - High price
- ✅ Transcoder: GPU transcoding 🚀
  - high performance (x2 - x3)
  - multiprofile (1080p, 720p, 360p) ⭐
  - trxcast ⚡
- 🔆 Network: packet loss (WIP 💪)

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Fase IV

Fase IV – Goals

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- General Optimization
  FFmpeg, network, tuning...
- Get rid of the black box
  In-house solution
- Modular design
  Easy to maintain

Fase IV – New encoder

Tuner → TRX → CDN

Goufone

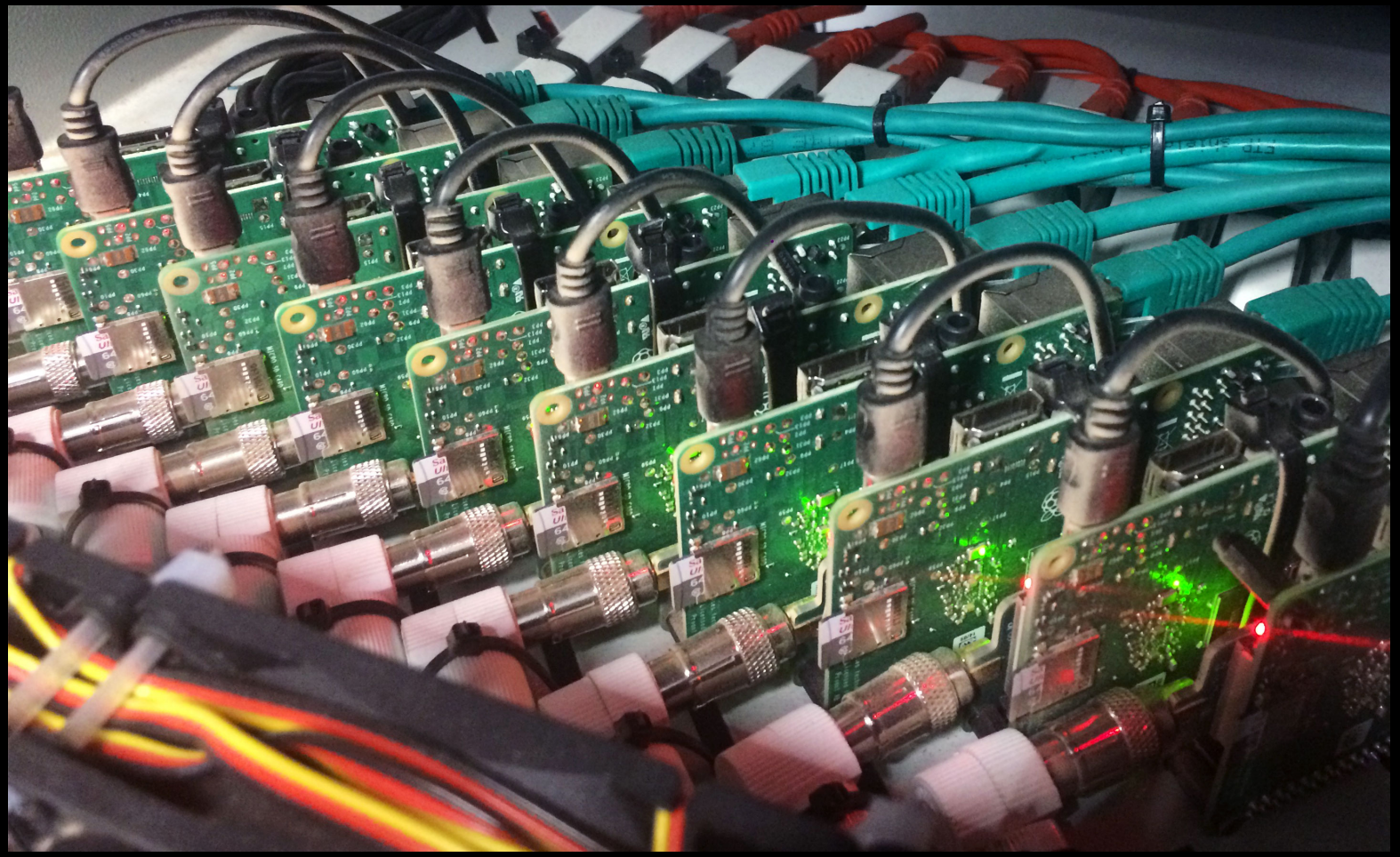
- TV tuner
  Sony CXD2880
- Standards
  DVB-T2, DVB-T
- Frequency
  VHF III, UHF IV, UHF V

Raspberry Pi – TV Hat

Fase IV – New encoder

Tuner → TRX → CDN

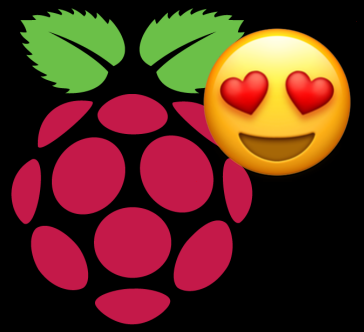
Goufone



Fase IV – New encoder advantages

Goufone

- Low CPU usage
- Low memory footprint
- Low price (35€ + 22€)
- Very modular!



Fase IV – The good, the bad, the evil

Goufone

- ✅ We have even more live streams 🙌
- ✅ Encoder: *Raspberry Pi + TV Hat* 📦
  - Low price
  - Modular
- ✅ Transcoder: GPU transcoding 🚀
  - High performance (x2 – x3)
  - Multiprofile (1080p, 720p, 360p)
  - Trxcast
- 🔆 Network: packet loss (WIP 💪)

Goufone

Fase V

Goufone

Redundancy

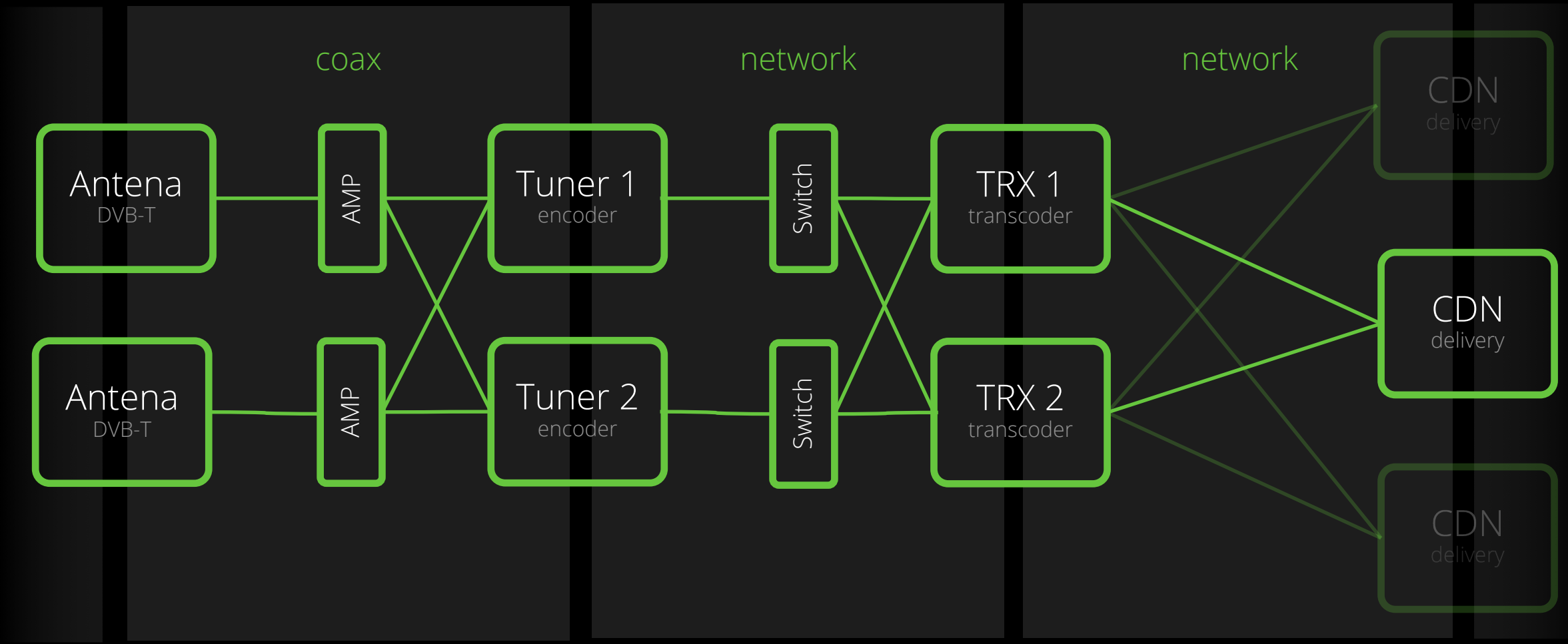
- Add more encoding servers
- Add more transcoding servers
- Add more DVB-T inputs
- Network redundancy
- Improve input signal quality

Fase V – Infraestructure

Tuner → TRX → CDN

Goufone

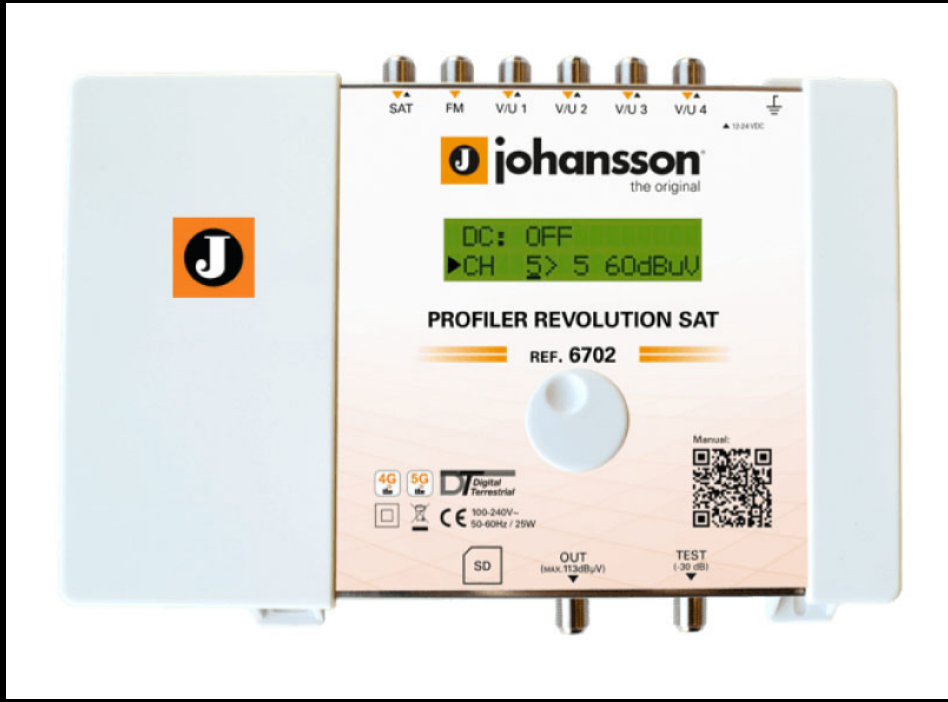
tv stack



Fase V – TV Amplificator

Goufone

- Read-out of input level strength
- Can process +50 VHF/UHF channels
- Channel converter, shift frequency
- Sharpest filters (50 dB on adjacent ch.)
- Real-time AGC on all individual multiplexes
- Complete flexibility in assigning filters



Fase IV – The good, the bad, the evil

Goufone

- ✅ We have even more live streams 🙌
- ✅ Encoder: *Raspberry Pi + TV Hat*
  - Low price
  - Modular
- ✅ Transcoder: GPU transcoding 🚀
  - High performance (x2 – x3)
  - Multiprofile (1080p, 720p, 360p)
  - Trxcast
- ✅ Network redundancy 🔀
  - no packet loss ⭐

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Fase VI

Fase VI – Goals

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Front-end

- Authentication
- Authorization
- Stream balancing
- VoD catalog
- Time shift
- UI/UX
- ...

Thanks

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Q&A

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Engineering

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