QUANTEEC

Fair Video Streaming Technology

La consommation énergétique du streaming vidéo : modèles et solutions

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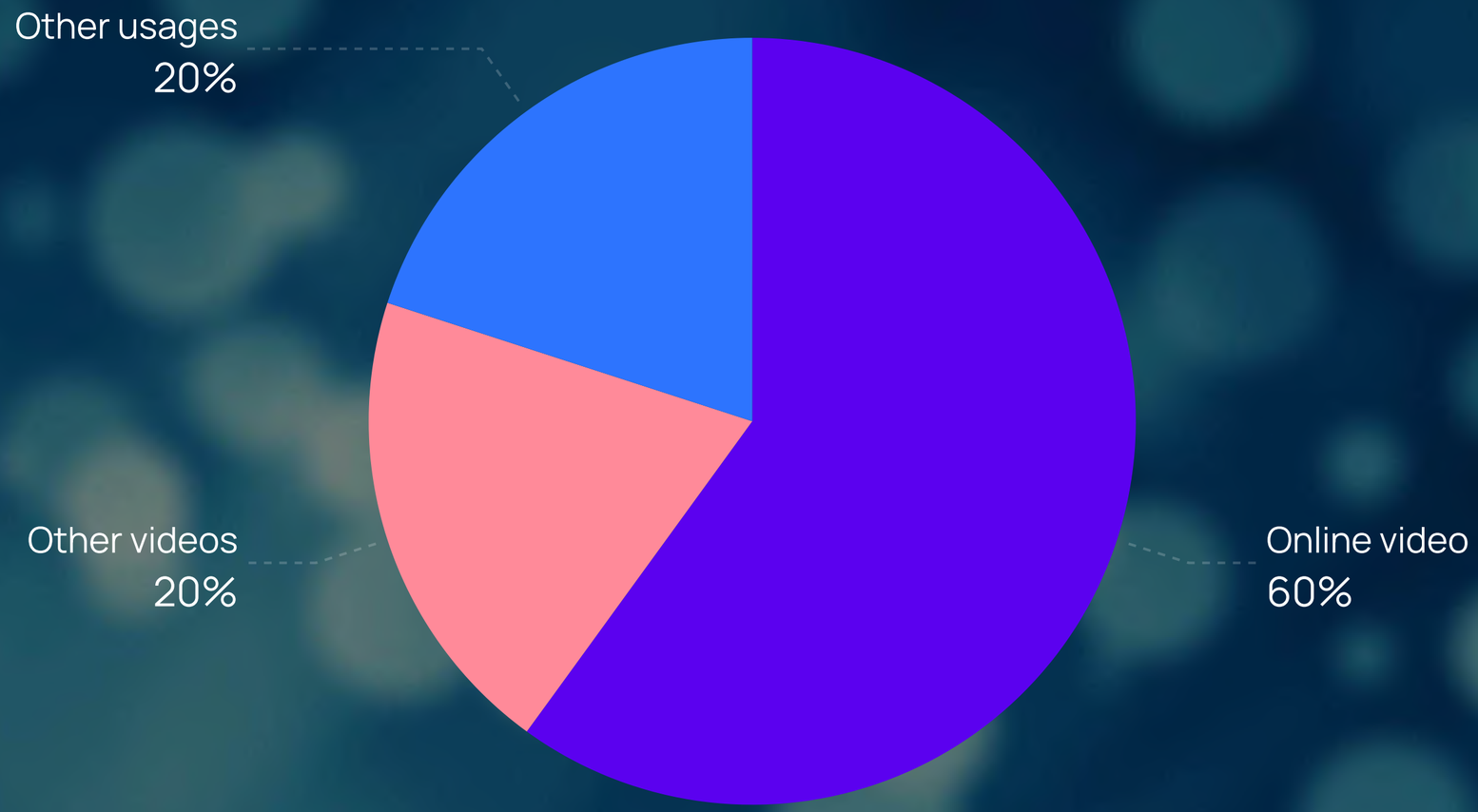
Introduction



80 % of the internet traffic comes from video

(The SHIFT Project, 2019)

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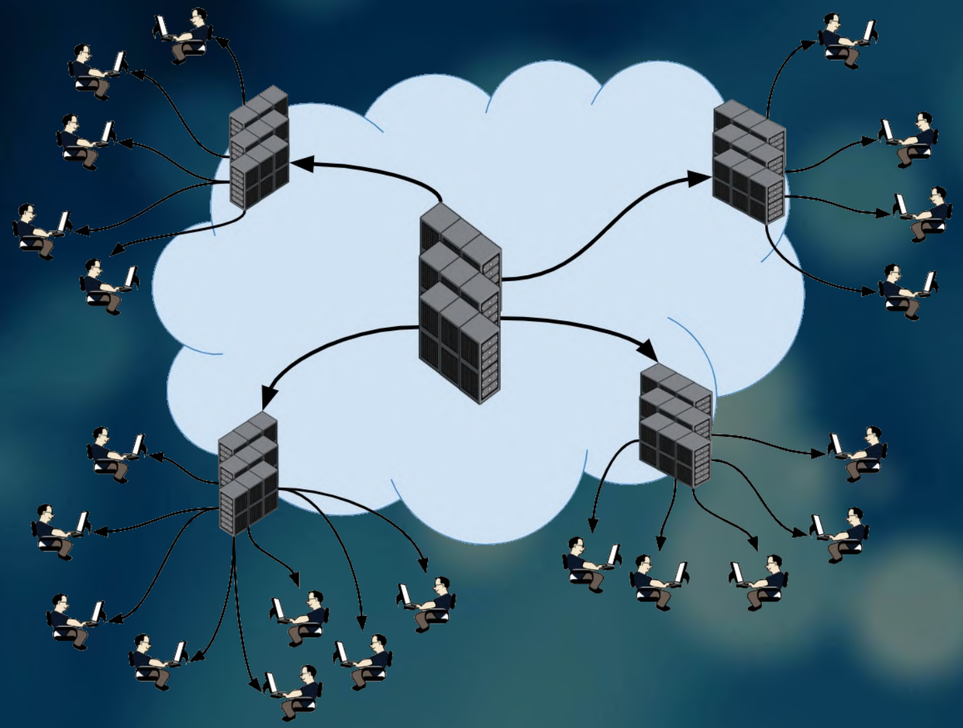

More datacenters are needed to stream such volume of video to more and more users

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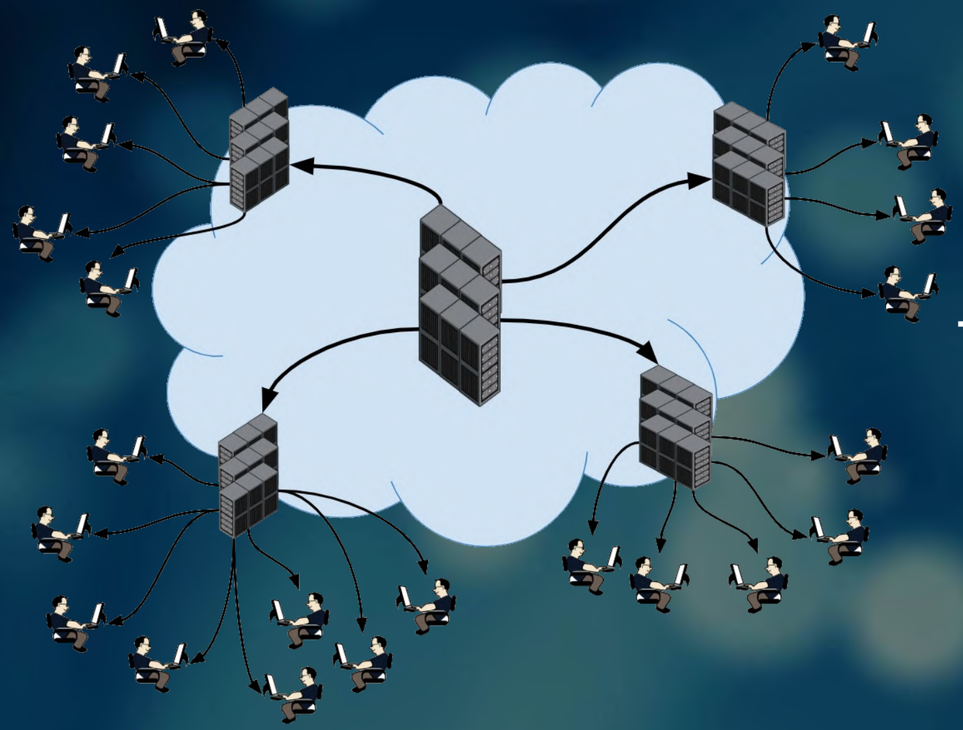
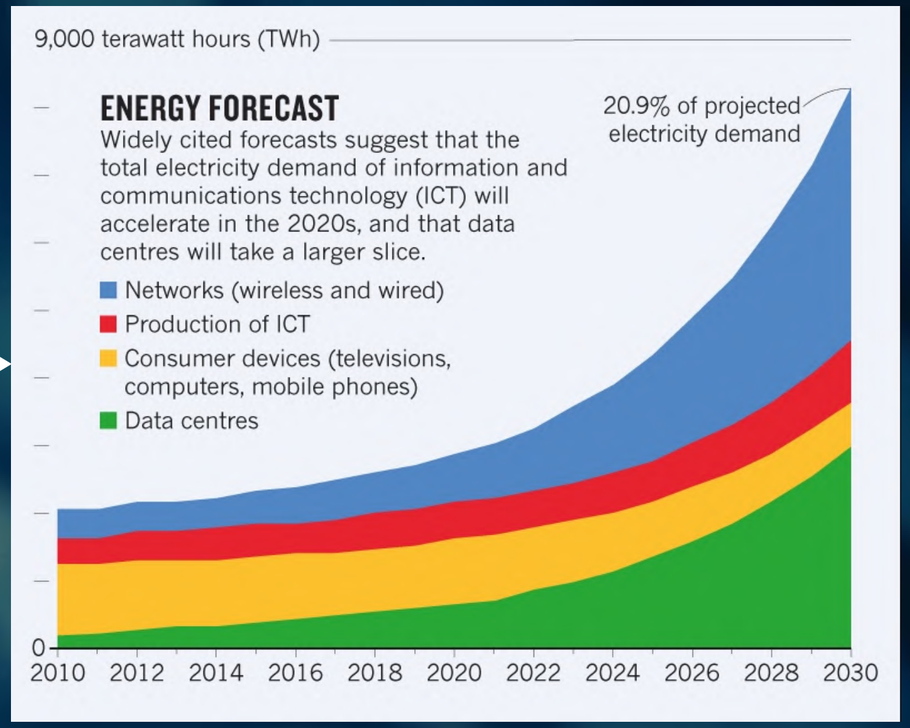




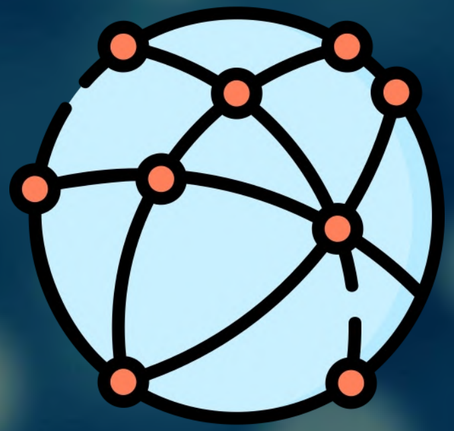
More datacenters are needed to stream such volume of video to more and more users

Significant increase in energy consumption and therefore CO2 emissions

Energy consumption models

A global consensus in the litterature : a three layers model

Datacenters (DC)



Network

Users' devices

- Marks et Przedpełski, « The Carbon Footprint of Streaming Media ».
- Makonin et al., « Calculating the Carbon Footprint of Streaming Media: Beyond the Myth of Efficiency »
- IEA (2020), *The carbon footprint of streaming video: fact-checking the headlines*, IEA, Paris https://www.iea.org/commentaries/the-carbon-footprint-of-streaming-video-fact-checking-the-headlines.

Energy consumption models

SHIFT and the 1 Byte model :

- Data-Based model : DC and network consumption depends on the amount of data transferred
- Generic model that can be used to compute consumption in various situation

Datacenter impact (kWh/byte)		7,2E-11
Network impact (kWh/byte)	FAN Wired	4,29E-10
	Fan Wifi	1,52E-10
	Mobile	8,84E-10
Device impact (kWh/h)	Smartphone	1,10E-04
	Laptop	3,20E-04

Ferreboeuf, H., Berthoud, F., Bihouix, P., Fabre, P., Kaplan, D., & Lefèvre, L. (2019). Lean ICT-towards digital sobriety. *Report for the Think Tank The Shift Project*, *6*.

IEA :

- Timebased model :
  - DC and network consumption depends on the duration of the HD/SD content viewed
  - Better results with high bitrate content
- Less generic model and more adapted to DC already optimized in terms of consumption and network (Netflix)

Datacenter impact (kW/h)	HD	9.70E-03
	SD	2.30E-03
Network impact (KW/h)	Fan Wifi	3.02E-02
	Mobile (4G)	1.90E-02
Device impact (kW/h)	Smartphone	2.00E-03
	Laptop	3.60E-02
	Tablet	5.00E-03
	SmartTV	1.94E-01

IEA (2020), *The carbon footprint of streaming video: fact-checking the headlines*, IEA, Paris https://www.iea.org/commentaries/the-carbon-footprint-of-streaming-video-fact-checking-the-headlines.

Energy consumption models

Dimpact :

- This model partially modifies the three layers to take into account the processing of videos (encoding, transcoding, deployment to CDNs.)
- Generic model as for SHIFT
- Databased to compute network consumption and timebased model to compute datacenter consumption

Data centre processes (varies by module, but examples provided below)	Internet network infrastructure	End-user devices (varies by module)
• Content ingestion & uploading • Encoding and transcoding • Storage • CDN Origin • User analytics services • Hosting services • [other module-specific processes]	• Core internet network • Metro networks • Access networks • Content Delivery Networks (CDNs) • Customer premises equipment (CPE) – modem routers, Wi-Fi repeaters, etc.	• Televisions • Laptops • Set-top boxes • Computers & monitors • Tablets • Smartphones • Smart speakers

Datacenter impact (kWh/h)		1.30E-03
Network Impact	Wired (KWh/byte)	6.00E-12
	Mobile (KWh/byte)	1.10E-01
	Customer equipment (Kwh/h)	1.10E-02
Device impact (kWh/h)	Smartphone	1.50E-03
	Laptop	2.20E-02
	Tablet	5.50E-03

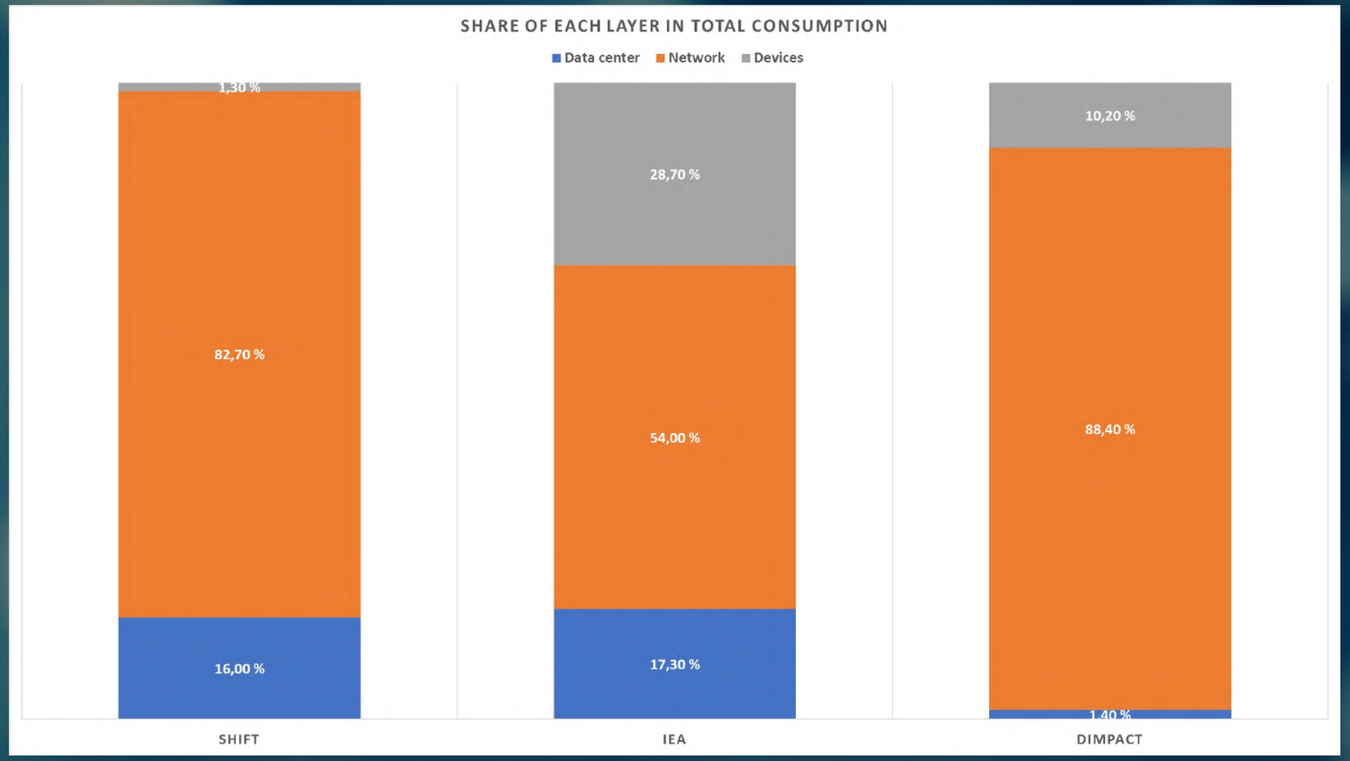
DImpact (2022), « Estimating the Carbon Impacts of Serving Digital Media and Entertainment Products », https://dimpact.org/downloadResourceFile?resource=2.
Stephens, A., Tremlett-Williams, C., Fitzpatrick, L., Acerini, L., Anderson, M., & Crabbendam, N. (2021). Carbon impact of video streaming.

Energy consumption models

Case study

- Online WebTV broadcasting 24/7
- On average 300 simultaneous users during the day
- Average stream of 2.5Mb/s for more than 95% of the users

	Data Center	Network	Device	Energy consumed
The SHIFT Project	154,4 kWh	796,7 kWh	12,0 kWh	963,0 kWh
IEA	36,6 kWh	114,5 kWh	61,1 kWh	212,2 kWh
Dimpact	1,8 kWh	119,1 kWh	13,8 kWh	134,7 kWh



QUANTEEC - Concept

Quanteec: an evolution of Mathias Lacaud's thesis work and mentored by Daniel Négru.

"How to ensure content delivery in the networks of the future?"

Mathias Lacaud. "Towards pragmatic solutions to improve the quality of video streaming in current and future networks. Networking and Internet Architecture". Université de Bordeaux, 2020. English. ⟨NNT : 2020BORD0143⟩. ⟨tel-03019507⟩

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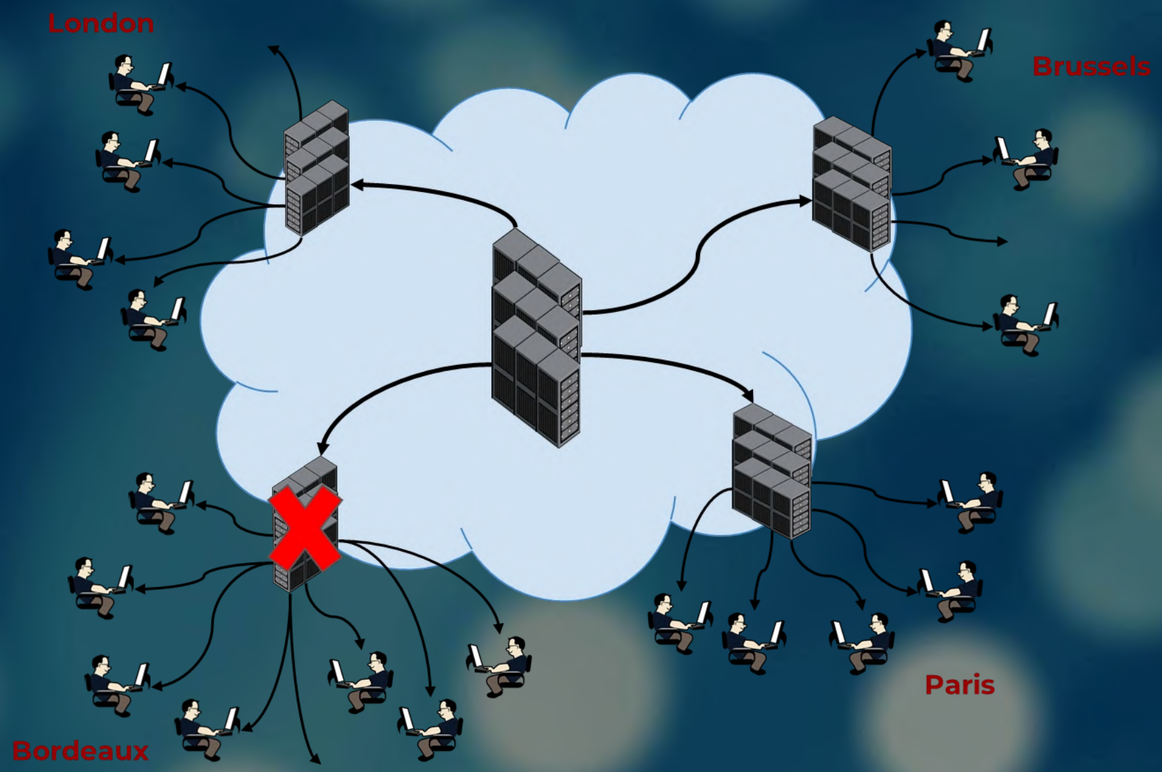


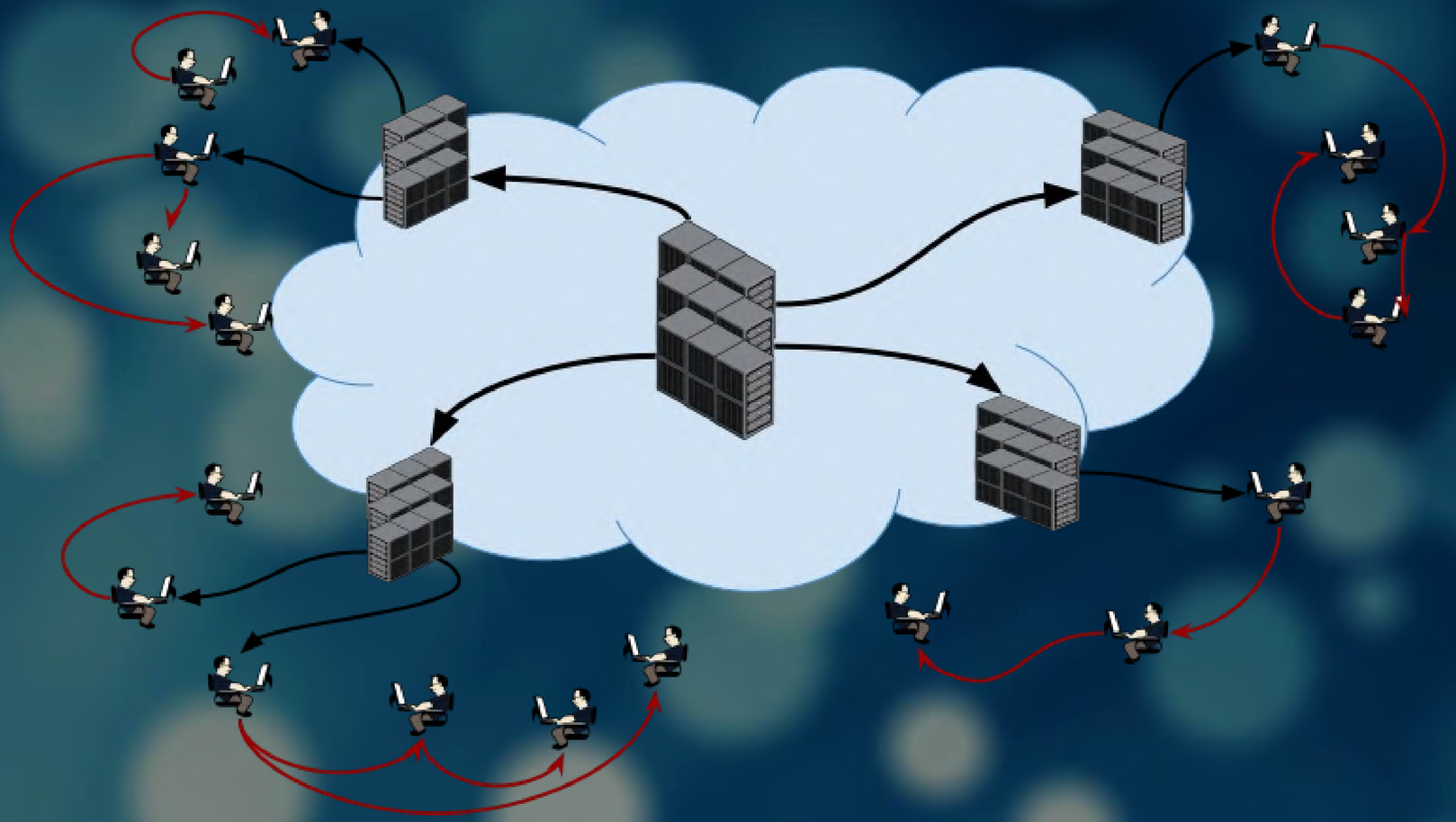
Issues :

- Risk of local outages in case of major events
- High energy, environmental and financial cost with the deployment of more and more servers to increase capacity, support peak usage and guarantee SLAs.

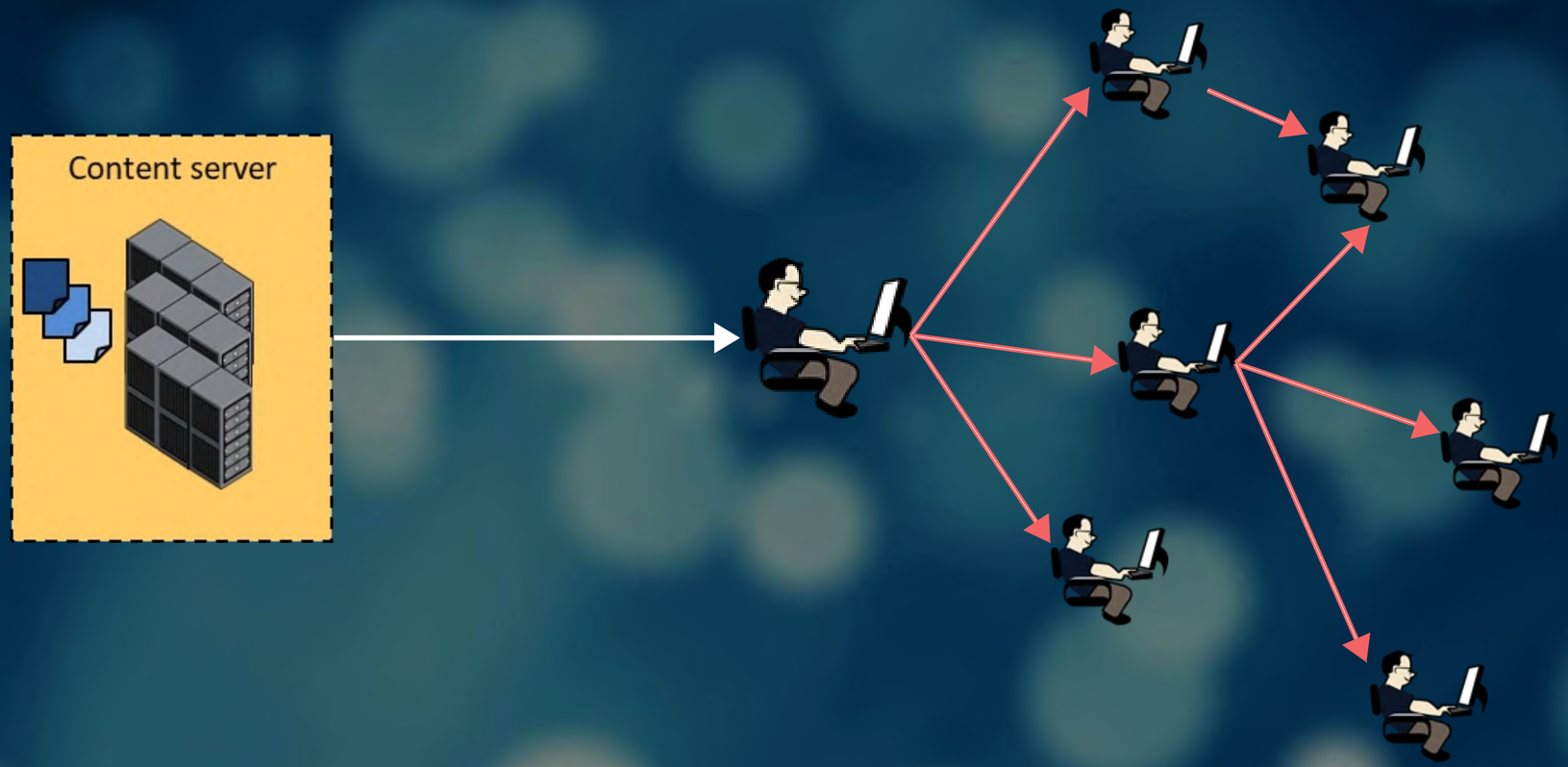
Mathias Lacaud. "Towards pragmatic solutions to improve the quality of video streaming in current and future networks. Networking and Internet Architecture". Université de Bordeaux, 2020. English. ⟨NNT : 2020BORD0143⟩. ⟨tel-03019507⟩

QUANTEEC - Concept

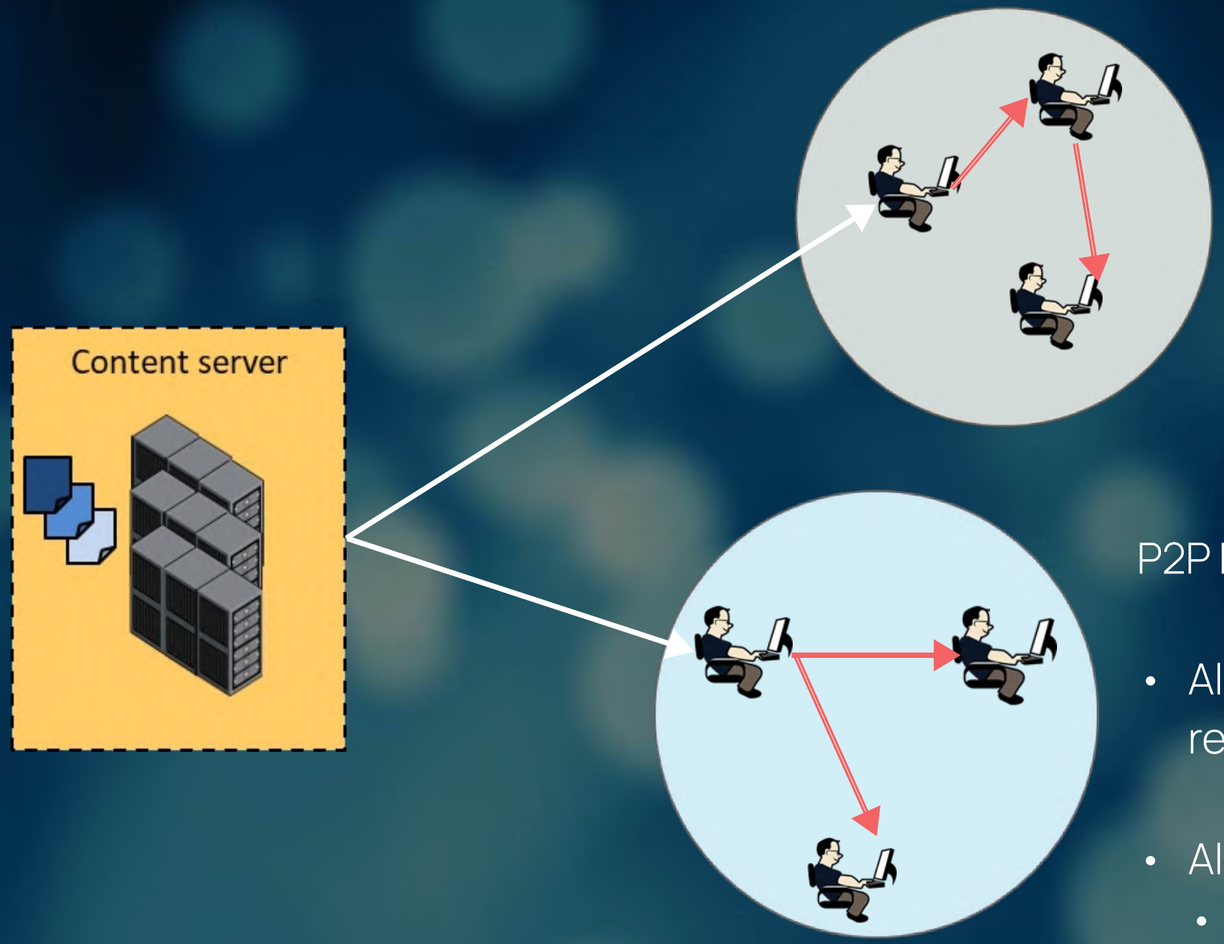
Solution: P2P-assisted streaming



QUANTEEC - Reducing data center charge



QUANTEEC - Optimizing P2P network

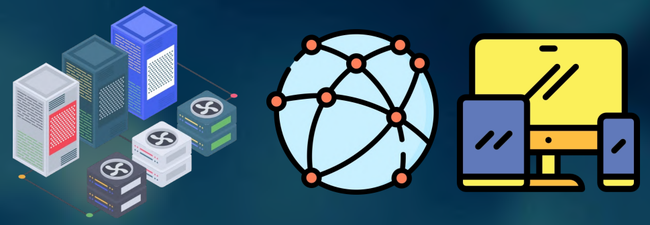


P2P Network optimisation with an algorithm and geolocalisation :

- Algorithm selects groups in which the peer will be able to send or receive data
- Algorithm estimates then best group from peers based on
  - IP Address
  - City
  - Region
  - Country

QUANTEEC - Compute consumption

Quanteec consumption model :



- Three layers model as in litterature
- Data based to compute data-center and network consumption

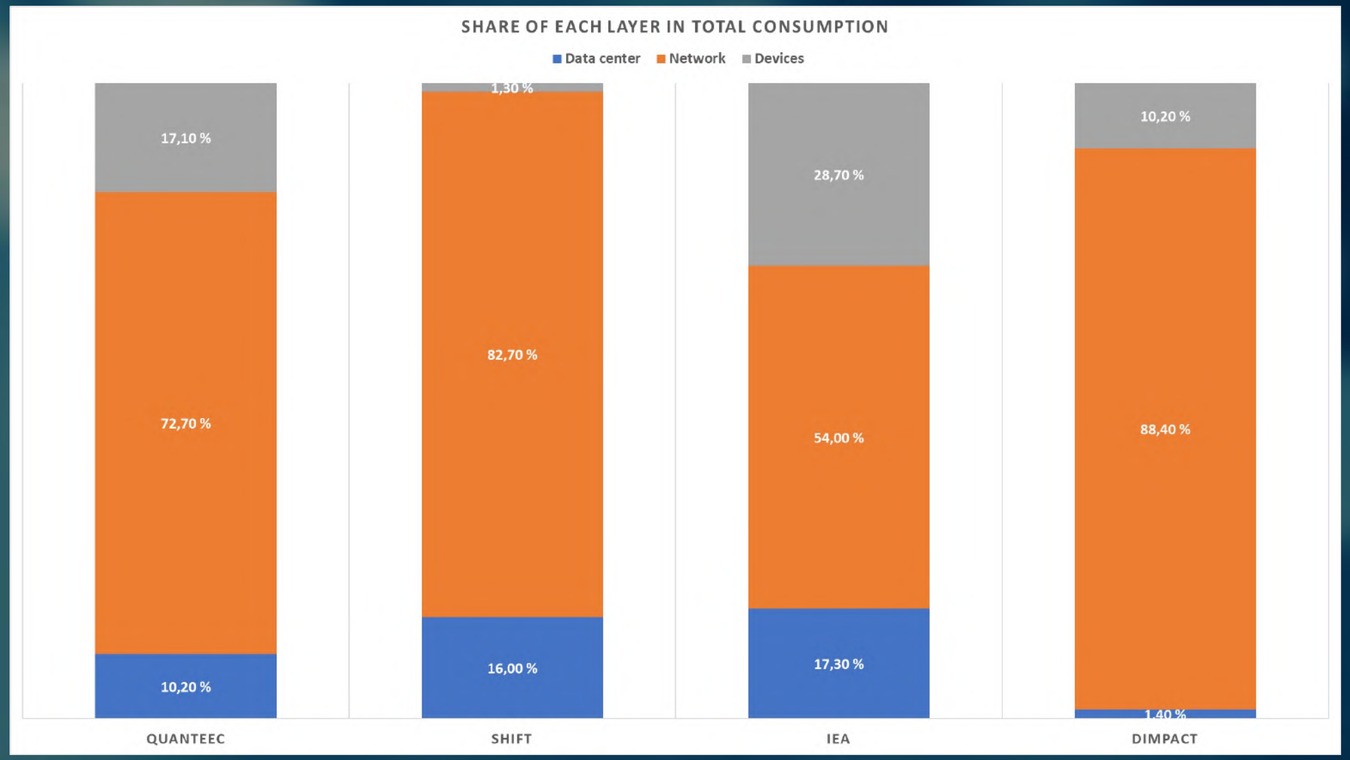
- Based on the litterature :
  - Used the project IEA model to compute data center consumption
  - Network consumption used peer geolocation to compute consumption (Makonin et al, 2022)

  - Use IEA model to compute device consumption

QUANTEEC - Compute consumption

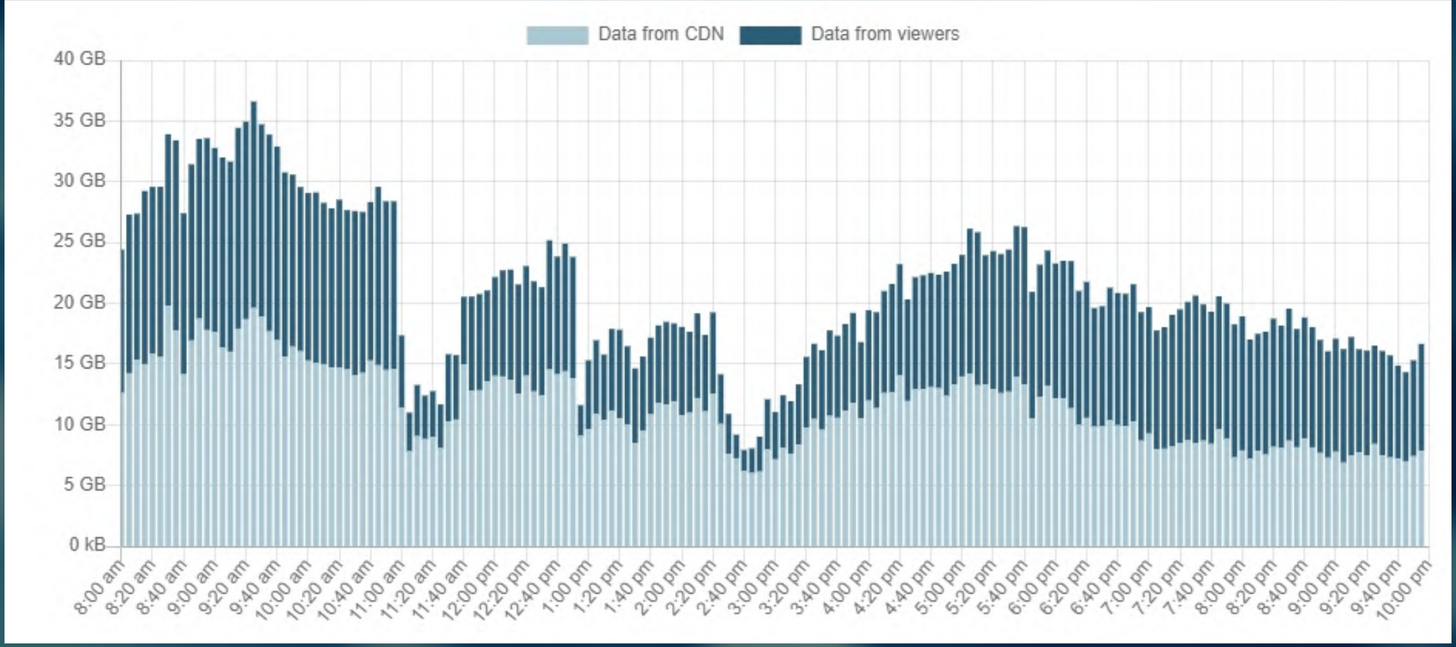
Case study with Quanteec :

	Data Center	Network	Device	Energy consumed
The SHIFT Project	154,4 kWh	796,7 kWh	12,0 kWh	963,0 kWh
IEA	36,6 kWh	114,5 kWh	61,1 kWh	212,2 kWh
Dimpact	1,8 kWh	119,1 kWh	13,8 kWh	134,7 kWh
Quanteec consumption model	36,6 kWh	260,2 kWh	61,1 kWh	357,9 kWh



QUANTEEC - Compute consumption

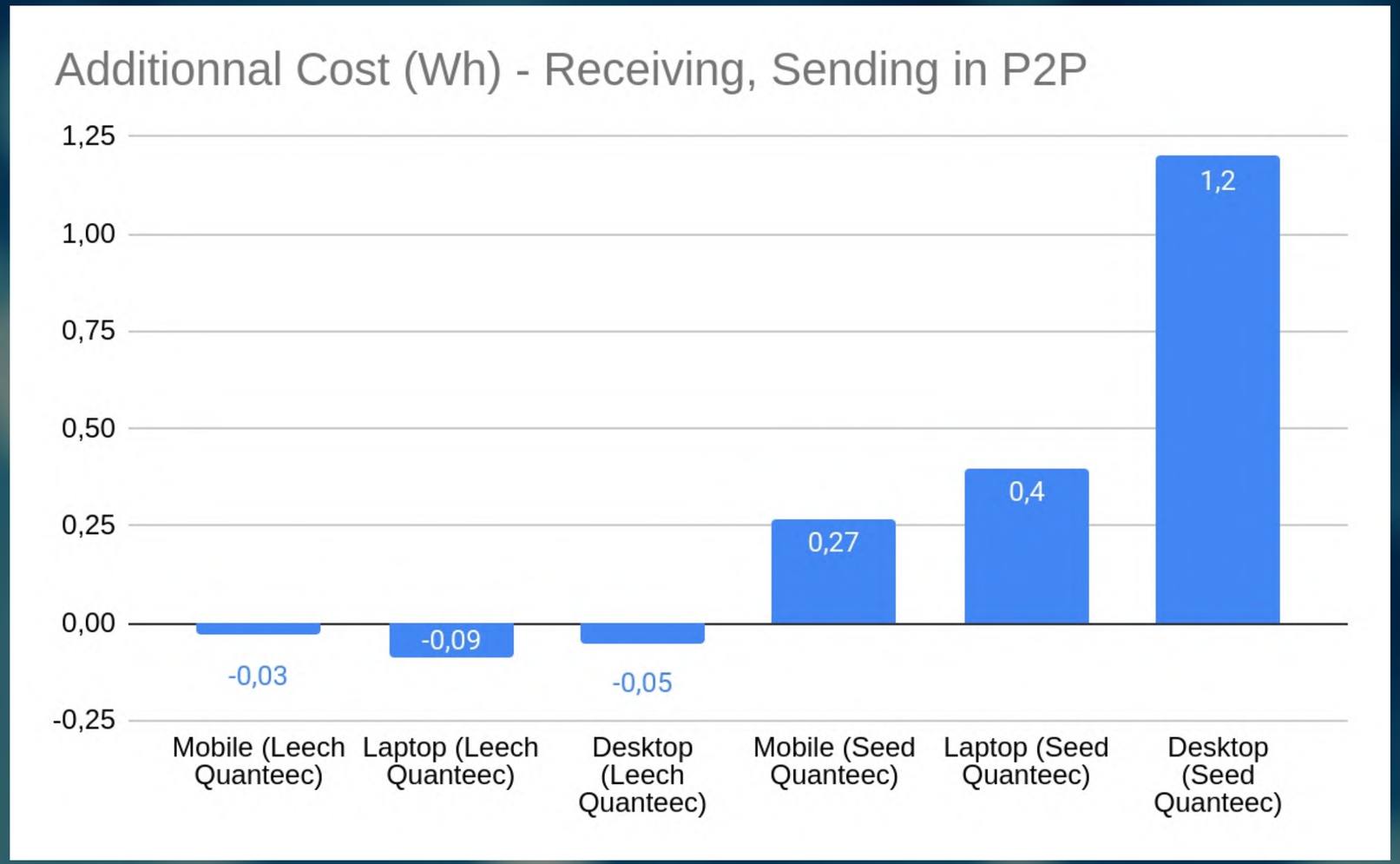
Energy saving with Quanteec :



	Consumption without Quanteec tech	Consumption with Quanteec tech	Energy saved	Percentage Energy saved
The SHIFT Project	963,0 kWh	701,6 kWh	261,4 kWh	27,1%
IEA	212,2 kWh	180,4 kWh	31,8 kWh	15,0%
Dimpact	134,7 kWh	118,8 kWh	15,9 kWh	11,8%
Quanteec consumption model	309,7 kWh	254,4 kWh	55,3 kWh	17,9%

QUANTEEC - Compute consumption

Does Quanteec tech increase device consumption ?



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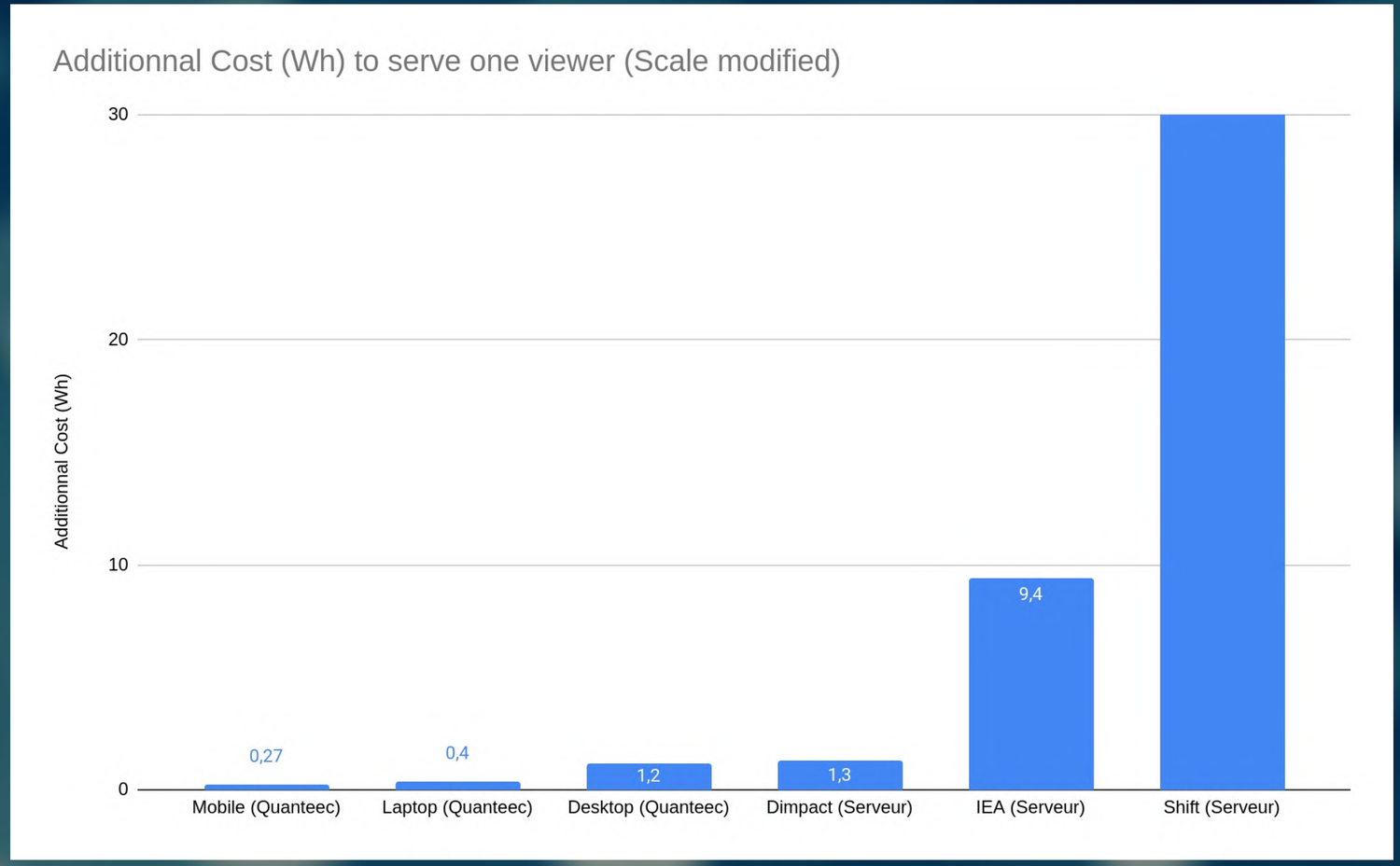

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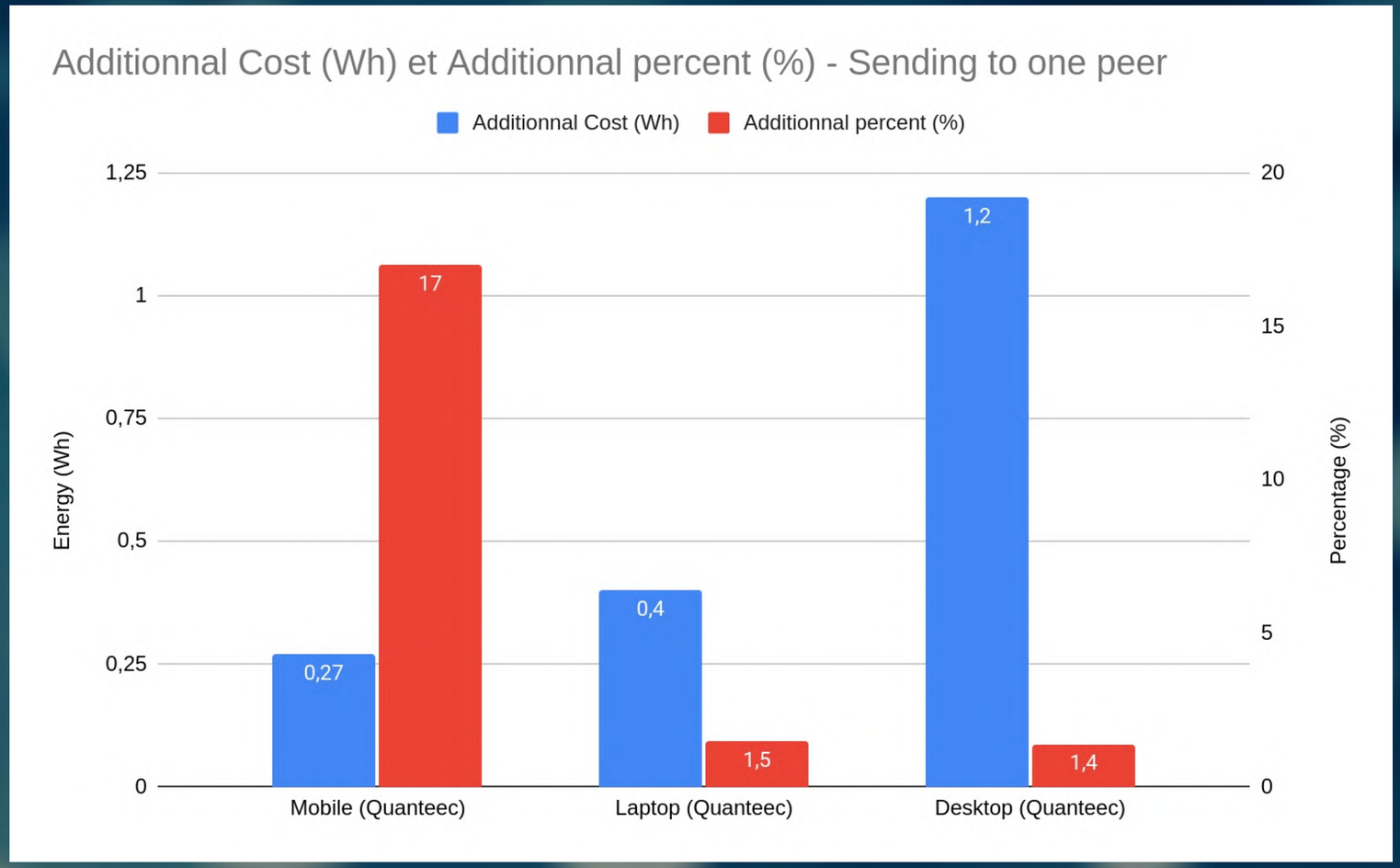
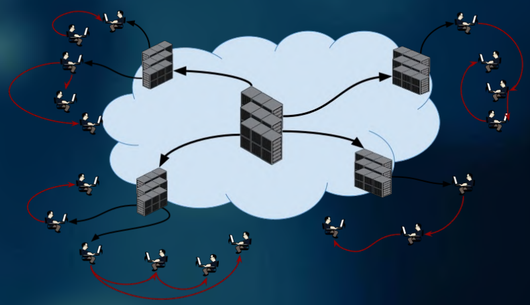


QUANTEEC - Conclusion and future works

- Estimating the energy consumption of video streaming is difficult.
- Studies converge on the consumption of viewing devices as they are the easiest to measure
- Discrepancies exist on the consumption information of the network and the server, sometimes due to a lack of access to data.

Quanteec :

- Propose a hybrid P2P-CDN solution to improve the elasticity of the broadcast resources
- Allow to reduce the energy consumption of the servers (slightly in instantaneous, a little more when considering over-provisioning) and the network.



QUANTEEC - Conclusion and future works

Future works :

- Join scientific and industrial study groups

- Obtain more accurate server data. In particular, to be able to differentiate between direct server utilization and the exact utilization lost due to over-provisioning.

- Get data with multiple use cases (VoD catalog, advertising, etc.)