

Seven Years of ATHENA
Achievements and Impact

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Motivation

Video streaming is dominating today's Internet traffic

- **January 2024**: **68% (fixed)** and **64% (mobile)**
  - Video on-demand: 54% / 57%
  - Live: 14% / 7%

- **Main applications**: **YouTube**, **Netflix (>10%)**, Tik Tok, Amazon Prime, Disney+ (<10%)

Top Content Categories by Downstream Volume – Fixed

	Downstream Volume		
	Content Category	% DS Vol	Sub. Volume
1	On-Demand Streaming	54%	7.9 GB
2	Live Streaming	14%	2.0 GB
3	File Delivery	13%	2.0 GB
4	Browsing	3%	441 MB
5	Game Play	3%	398 MB
6	Video Call	2%	300 MB
7	Messaging	0.6%	81 MB
8	Voice Call	0.5%	74 MB
9	Machine to Machine	0.01%	2 MB
10	AR/VR	0.00%	18 KB
11	Other	10%	1.4 GB

Top Content Categories by Downstream Volume – Mobile

	Downstream Volume		
	Content Category	% DS Vol	Sub. Volume
1	On-Demand Streaming	57%	900 MB
2	File Delivery	11%	173 MB
3	Live Streaming	7%	107 MB
4	Game Play	5%	75 MB
5	Video Call	5%	73 MB
6	Browsing	2%	38 MB
7	Messaging	2%	29 MB
8	Voice Call	1%	19 MB
9	Machine to Machine	0.00%	68 KB
10	AR/VR	0.00%	1 KB
11	Other	10%	160 MB

Top Apps by Downstream Volume – Fixed

	Downstream Volume		
	Application	% DS Vol	Sub. Volume
1	YouTube	16%	1.9 GB
2	Netflix	12%	1.4 GB
3	Facebook	9%	1.0 GB
4	Tik Tok	7%	859 MB
5	Operator Content	7%	850 MB
6	Amazon Prime	6%	722 MB
7	Disney+	5%	610 MB
8	Xbox Live	5%	573 MB
9	Instagram	3%	370 MB
10	Snapchat	2%	231 MB

Top Apps by Downstream Volume – Mobile

	Downstream Volume		
	Application	% DS Vol	Sub. Volume
1	YouTube	21%	233 MB
2	Facebook	18%	199 MB
3	Tik Tok	15%	175 MB
4	Instagram	7%	82 MB
5	Snapchat	7%	76 MB
6	Netflix	6%	73 MB
7	Disney+	2%	25 MB
8	WhatsApp	2%	24 MB
9	Telegram	1%	15 MB
10	X (Twitter)	1%	14 MB

Source: Sandvine Global Internet Phenomena (Jan 2024).

ATHENA - Adaptive Streaming over HTTP and Emerging Networked Multimedia Services



ATHENA

Christian Doppler (CD) Laboratory

https://athena.itec.aau.at/

"Application-oriented basic research" to address current and future research and deployment challenges of **HTTP Adaptive Streaming (HAS)** and emerging streaming methods

- Application/transport layer enhancements
- Quality of Experience (QoE) models
- Low-latency HAS
- Learning-based HAS

Funding:



Christian Doppler Forschungsgesellschaft



End-to-End Aspects

Content Provisioning

- Video encoding for HAS
- Quality-aware encoding
- Learning-based encoding
- Multi-codec HAS

Content Delivery

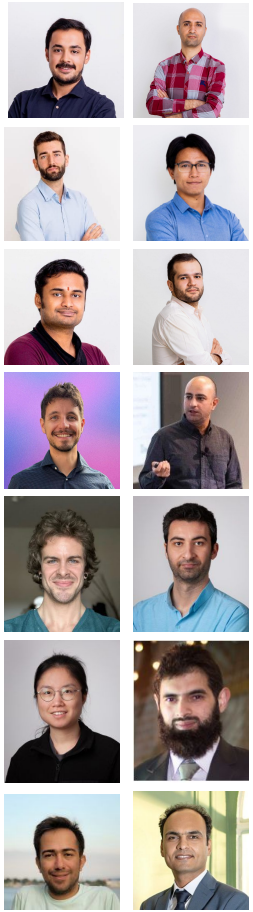
- Edge computing
- Information CDN/SDN ↔ clients
- Netw. assistance for/by clients
- Utility evaluation

Content Consumption

- Bitrate adaptation schemes
- Playback improvements
- Context and user awareness
- Quality of Experience (QoE) studies

ATHENA Major Results (1/2)

- **Successful defended PhD theses**
  - Dr. Alireza **Erfanian**: "**Optimizing QoE and Latency of Video Streaming using Edge Computing and In-Network Intelligence**", May 25, 2023
  - Dr. Ekrem **Çetinkaya**: "**Video Coding Enhancements for HTTP Adaptive Streaming using Machine Learning**", June 7, 2023
  - Dr. Minh **Nguyen**: "**Policy-driven Dynamic HTTP Adaptive Streaming Player Environment**", June 30, 2023
  - Dr. Jesús **Aguilar Armijo**: "**Multi-access Edge Computing for Adaptive Video Streaming**", July 10, 2023
  - Dr. Reza **Farahani**: "**Network-Assisted Delivery of Adaptive Video Streaming Services through CDN, SDN, and MEC**", August 22, 2023
  - Dr. Vignesh V **Menon**: "**Content-adaptive Video Coding for HTTP Adaptive Streaming**", January 15, 2024
  - Dr. Babak **Taraghi**, "**End-to-end Quality of Experience Evaluation for HTTP Adaptive Streaming**", July 10, 2024
  - Dr. Daniele **Lorenzi**, "**QoE- and Energy-Aware Content Consumption for HTTP Adaptive Streaming**", July 31, 2025
- **PhD theses near submission**
  - Emanuele **Artioli**: "**From Pixels to Semantics: Compute-Bandwidth Tradeoff in Next-Generation Video Streaming**"
  - Mohammad **Ghasempour**: "**Content-Adaptive Multimedia Coding and Processing for Energy-Efficient Adaptive Streaming**"
  - Yiying **Wei**: "**Neural Adaptive Video Representation and Generative Reconstruction for HTTP Adaptive Streaming**"
  - Kamran **Qureshi**: "**Video compression and immersive media delivery**"
- **Two successful habilitation defenses**
  - Dr. Hadi **Amirpour**, "**Beyond One-Size-Fits-All: Adaptive and Computationally Efficient Video Streaming**", June 25, 2026
  - Dr. Farzad **Tashtarian**, "**Network-Assisted Adaptive Streaming: Toward Optimal Quality of Experience through System Collaboration**", November 14, 2025
- **Numerous master's and bachelor's theses, alongside CDG/FFG-supported internships**



ATHENA Major Results (2/2)

- **Publications in prestigious academic journals & conferences**
  - E.g., **IEEE Communications Surveys & Tutorials** (impact factor: 50.6), ACM Computing Surveys (30.4) **IEEE Transactions on Image Processing** (15.3), IEEE Transactions on Circuits and Systems for Video Technology (11.1), IEEE Transactions on Multimedia (9.9), IEEE Internet of Things Journal (8.9)
- **Patent applications**
  - 20 published patents, **11 granted** (so far)
- **Spin-off projects**
  - FFG APOLLO, GAIA, DORBINE; EU IA SPIRIT; HoloSense; ForestScope
- Organization of **workshops**, **special sessions**, **special issues**
  - **VCIP**, IEEE **ICME**, ACM **MM**, ACM **MMSys**, ACM **CoNEXT**, IEEE **ICIP**, **PCS**
- Contribution to **reproducibility in research**
  - **Open source tools** (*e.g.,* Video Complexity Analyzer and LLL-CAdViSE)
  - **Datasets** (*e.g.,* , VCD, VEED, COCONUT, Nature-1k, LMM-10K)

Categories > Engineering & Computer Science > **Multimedia**

	Publication	h5-index	h5-median
1.	Multimedia Tools and Applications	120	165
2.	ACM International Conference on Multimedia	119	163
3.	IEEE Transactions on Circuits and Systems for Video Technology	112	157
4.	IEEE Transactions on Multimedia	110	159
5.	ACM Transactions on Multimedia Computing, Communications and Applications	60	96
6.	IEEE International Conference on Image Processing (ICIP)	55	89
7.	IET Image Processing	52	73
8.	Signal Processing: Image Communication	51	76
9.	Multimedia Systems	50	98
10.	IEEE International Conference on Multimedia and Expo	50	68
11.	Journal of Visual Communication and Image Representation	45	71
12.	International Society for Music Information Retrieval Conference	42	70
13.	Computational Visual Media	33	80
14.	ACM International Conference on Multimedia Retrieval	33	53
15.	International Journal of Multimedia Information Retrieval	29	45
16.	ACM Multimedia Systems Conference (MMSys)	27	45
17.	IEEE MultiMedia	27	37
18.	Conference on Multimedia Modeling	26	39
19.	IEEE Workshop on Multimedia Signal Processing	26	33
20.	IEEE International Conference on Multimedia and Expo Workshops (ICMEW)	24	51

Categories > Engineering & Computer Science > **Signal Processing**

	Publication	h5-index	h5-median
1.	IEEE Transactions on Image Processing	165	217
2.	IEEE Transactions on Wireless Communications	161	220
3.	IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)	137	203
4.	Conference of the International Speech Communication Association (INTERSPEECH)	112	160
5.	IEEE Transactions on Circuits and Systems for Video Technology	112	157

Categories > Engineering & Computer Science > **Computer Networks & Wireless Communication**

	Publication	h5-index	h5-median
1.	IEEE Transactions on Wireless Communications	161	220
2.	IEEE Communications Surveys & Tutorials	155	305

Categories > Engineering & Computer Science > **Computing Systems**

	Publication	h5-index	h5-median
1.	IEEE Internet of Things Journal	197	273



ATHENA



BITMOVIN

Video Complexity Analyzer

An Open Foundation for Live Per-Title Encoding

How do you optimize encoding for content you haven't seen yet?

Industry Challenge	Open Research Foundation	Scientific and Industrial Impact
Bitmovin identified **live streaming** as an opportunity for impact	VCA — **Video Complexity Analyzer**	ATHENA's **most-cited** publication and **most-starred** Github repository
Bring **content-adaptive encoding** to **live workflows**	• **Real-time video complexity analysis** • **Open source** • **No patents on the core technology**	Foundation for **further publications** and **patents** enabling **live per-title encoding**

Conclusions

- **University-industry collaboration** through an public-private-partnership **turns research questions into opportunities for impact**
  - **ATHENA** connected **advances in adaptive streaming** with **practical industry challenges**

- **Open research** can support **industrial innovation**
  - **VCA** illustrates how an **open foundation** can enable **further publications** and **patentable applications**

- **ATHENA's legacy** continues beyond the laboratory
  - Through its **researchers**, **reusable tools** and **datasets**, and **follow-on projects**

Acknowledgments

ATHENA team & ITEC support

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Thank you for your attention
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