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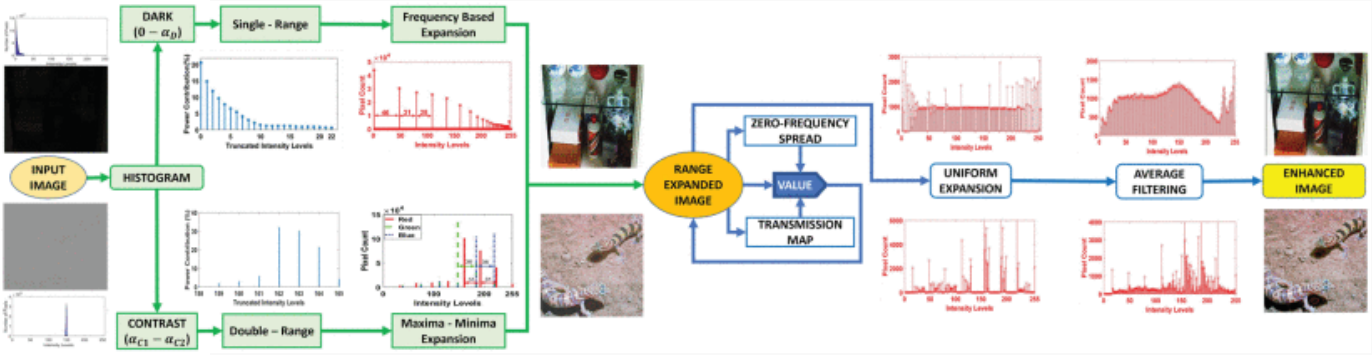

A schematic diagram of the proposed energy router system for improving the renewable energy consumption and power supply flexibility.

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EDITOR'S NOTE

On behalf of the Editorial Board of IEEE CTSoc News on Consumer Technology (NCT) editor-in-chief Wen- Huang Cheng and editors Yafei Hou, Luca Romeo, Yuen Peng Loh, Jianlong Fu, and I am delighted to introduce the January issue of the News on Consumer Technology (NCT).

For this issue, we begin with a cover story regarding the enhancement of visual data quality published by IEEE Transactions on Consumer Electronics. This work explores the unsupervised approach to image enhancement in order to unravel hidden visual details in perceptually invisible images.

Following the cover story, there is a feature interview with Dr. Francesco Epifania, the CEO and Co-Founder of Social Thingum. He has extensive experience in the field of AI and HCI, both in academia and industry and has taken part in various startup training programs such as the MIP Start-up program, London Startupbootcamp, and Accelerate in Israel.

Finally, the issue ends with a featured article from Dr. Shuen-Huei Guan and his colleague Feng-Hsu Tsai. Dr. Guan is the Executive Vice President at KKCompany Technologies Group, where he leads the long-term research program and has built teams and technologies in video encoding and recommender systems. The article discusses the history, current state, and future of OTT video streaming and highlights the technologies and challenges involved in the field.

Have a nice read!

Chuan-Ju Wang, Ph.D.
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ARTICLE TITLE
Unsupervised Enhancement and Web Tool for Perceptually Invisible Type Degraded Image

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JOURNAL TITLE
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Visual data quality enhancement has been a growing interest in recent technology to support consumer electronic devices to handle severe contrast degradations in images that causes substantial loss of visual information. Due to the various limitations such as small computation power, there is a significant constraint in deploying heavy algorithms to solve this problem. This work explores the unsupervised approach for image enhancement in order to unravel hidden visual details in perceptually invisible images. The proposed approach is a two-path approach based on the type of degradation, specifically, dark or low contrast. Starting with identification of degradation using histogram intensity range, dark images will undergo single-range truncation and frequency-based expansion, whereas low contrast images will have double-range truncation and then maxima-minima expansion. Both cases will then go through spatial-distribution based uniform expansion subject to a transmission map and spread of zero-frequency intensity levels and finally, average filtering smoothens the image histogram for a more visually pleasant enhancement. Assessments on image quality and computation time shows the feasibility of such an algorithm as support for visual systems in consumer devices. Furthermore, a consumer-focused, platform-independent app was also created and made available to the general public for additional study. This research work demonstrates the potential and points the direction of future advancements to improve the visual systems in consumer electronic devices.

INTERVIEW WITH THE CEO OF SOCIAL THINGUM FRANCESCO EPIFANIA

Social Thingum is an innovative SME founded by Francesco Epifania in 2015.

Francesco Epifania, PhD – CEO, Socio & Co-founder

Since 2015 he is CEO & Co-Founder of Social Thingum, growing innovative SME in the Italian AI and Human-Computer Interaction (HCI) landscape. He has many-year experience in AI, HCI both in the academic and industrial fields, and he attended several training opportunities for startups such as MIP Start-up program,London Startupbootcamp and Accelerate in Israle. He was a research fellow at the Department of Computer Science of the University of Milan and helds a PhD in Computer Science from the University of Milano-Bicocca, together with three degrees in the Computer Science field: a bachelor degree in Digital Communication, a master degree in Information Technology and a master degree in Computer Science. He produced numerous publications for national and international conferences and journals. His research interests are in the field of Human Computer Interaction and particularly in the creation of intelligent, multi-channel interactive systems for knowledge enrichment. His work is also related to the evaluation of Recommender Systems in heterogeneous domains.

Who is Social Thingum ?

Social Thingum is a innovative SME founded on a high-profile team, combining skills and experience in academia and industry. We develop innovative ICT technologies and algorithms to connect people and objects through Smart Social Networks. Our Social & Smart paradigm combines potential for learning and interaction through the synergy between Artificial Intelligence and Social Networks. We exploit a young and dynamic work team, consisting of resources largely from academia, and numerous strategic contacts with several universities in Milan. In particular, the start-up main product is a Social Intelligent

Learning Management System (WhoTeach) capable of fostering the development of skills of students, professionals and managers by aggregating and disseminating knowledge created by experts. In addition, we are currently developing the EaSY 4.0 project, with the aim of creating a technological infrastructure that revolutionizes human-machine interaction in the use of household appliances, through an intelligent social network that learns their usage habits and provides recommendations for optimizing them in a totally personalized and user-centered manner. We work in some cutting-edge computing fields, proposing original and tailored technological solutions, especially through the use of approaches such as cognitive knowledge representation systems and artificial and computational intelligence. The team is particularly involved in R&D and consulting projects in the areas of Machine Learning, Big Data Analytics, Internet of Things, Smart Living, Recommender System and WEB 4.0. The startup also carries out exploitation of 3 European projects: NETT, which is the case study in which the realized platform was tested, and SandS and Elliot, in the area of IoT.

What is Social Thingum's Mission?

Social Thingum develops innovative ICT technologies and algorithms to connect people and objects through intelligent Social Networks. The company proposes an innovative paradigm of integration between Artificial Intelligence techniques and Social Networks: this synergy between cognitive and social aspects proves to be a distinctive and characterizing element of the company's value proposition. In particular, the specific objectives are:

- The realization and commercialization of innovative technological solutions and advanced consulting in the IT field, in particular Internet, web and mobile applications, Social Network, Recommendation System, E-learning, User Experience, Advanced Analytics, Internet of Things, Big Data and Cloud Computing;
- The continuous improvement of the WhoTeach platform, our "Social Intelligent Learning Management System" and its application in multiple organizations, entities and institutions in the educational field;
- The development of an intelligent and social infrastructure for applications in Internet of Things and Smart Living (EaSy 4.0).
- The maintenance of the NETT platform generated by the European project EE-74- NETT; exploitation of the European projects NETT, SandS and Elliot;
- Research, development and innovation in the ICT field and all related fields including human-computer interaction, "Internet of things," advanced analytics, "Big Data," and in the evaluation, design and development of multimedia and multichannel intelligent interactive systems for knowledge enrichment.

What is Social Thingum's Vision?

Nowadays, the technological and social scenario faces a crossroads: you have to choose whether to ride the long wave of new paradigms of innovation or whether to create them yourself. It is necessary to merge networks and communities of practice in all the innovative fields, to share experiences and ideas, to make visible the methodologies that can be successful and especially to connect technology and society with a holistic and international perspective.

The ambition of Social Thingum is to contribute to this process through our wide structured offer of advanced technological activities, in which a fundamental aspect stands out: a computational intelligence, enhanced and completed by social network, which uses cognitive algorithms and the knowledge base and behaviors provided by users to produce optimal and customized suggestions and insights.

Through this paradigm Social Thingum aims at providing advanced architectures and services that represent instances of WEB 4.0, thus reviewing and improving the usual scenarios of human-machine interaction and providing effective tools for knowledge enrichment.

THE PAST, PRESENT AND FUTURE OF OTT VIDEO STREAMING

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Imagine a world where technologies and infrastructures were not ready for video streaming: efficient video codecs were not widespread; the global fiber optic network was still in early development; video content protection had not yet been designed; and even mobile devices were not that powerful enough. In this world, there would be no Netflix, Crunchyroll, or even YouTube. That is an unimaginable scenario for modern people, but fortunately, it is just a product of the imagination. Today, we have a wide variety of video streaming services available in our daily lives, particularly in the realm of over-the-top (OTT) media services [1].

The history of OTT video streaming can be traced back to the early days of the internet, when streaming audio and video first became possible. In 1995, Macromedia released Shockwave Player for Netscape Navigator, which became the primary tool of streaming media on the Internet for the late 1990s and 2000s. In 1997, RealNetworks launched RealPlayer, the first streaming media player, which allowed users to stream video and audio content over the internet [2].

Akamai Technologies began delivering streaming video and audio content over the internet in 1999, using its global network of servers to improve the quality and reliability of streaming [3].

In 2005, YouTube was launched, offering a platform for users to upload and share their own video content. This platform became a major player in the OTT video streaming market. In 2007, Netflix began offering streaming video to its subscribers in addition to its DVD rental service. In 2008, Hulu, a joint venture between several major TV networks, launched its OTT video streaming service [2]. In 2013, Netflix became the first OTT video streaming service to be nominated for an Emmy award, marking the growing mainstream acceptance of streaming video [4].

The COVID-19 pandemic has also had a significant impact on the Video on demand (VOD) and OTT video streaming industry, as lockdowns and social distancing measures led to a surge in the use of these services [5]. These milestones and technological advancements demonstrate the rapid evolution of OTT, VOD and even live video streaming industry, which has transformed the way that we consume video content.

Technologies in Video Streaming

Overview

OTT, VOD, and live video streaming all rely on the transmission of video data over the internet. There are several technologies that are commonly used to facilitate this transmission, including H.264/AVC, HTTP, RTMP, and HLS.

H.264/AVC is a video compression standard based on block-oriented, motion-compensated coding [6][7][8]. It is by far the most commonly used format for the recording, compression, and distribution of video content. HTTP [9] is a widely-supported protocol that allows for the transfer of data between a client (such as a web browser) and a server (such as a web server). RTMP is a proprietary protocol developed by Adobe Systems that is optimized for streaming video [10]. HLS is a protocol developed by Apple that works by dividing the video stream into segments, which are then delivered to the client using HTTP. HLS is one of the widespread protocols to achieve adaptive bitrate streaming [11].

In addition to these technologies, there are also a range of alternative technologies, tools and services that are used in the production and delivery of OTT, VOD, and live video streaming in consideration of business requirements. These may include other audio/video codecs, MPEG-DASH, DRM, CDNs, streaming servers, and video players.

Video Codecs

If we have to name some key technologies which make video streaming feasible and possible, H.264/AVC video codec is definitely the first one coming out.

The Advanced Video Coding (H.264/AVC) video codec has dominated the industry for over 20 years, but its successor, High Efficiency Video Coding (H.265/HEVC) [12][13][14], has faced patent issues that have prevented it from fully replacing H.264. Despite this, the demand for better video compression technology has increased in recent years due to the growth of the internet and streaming industry. As a result, newer codecs such as AOMedia Video 1 (AV1) [15][16] and Versatile Video Coding (H.266/VVC) [17] have emerged, offering improved compression efficiency and lower encoding bitrates compared to H.265, referring to Figure 1.

However, the advancement of codec technology and device compatibility are often trade-offs. For example, while H.264 has the best device compatibility, it has a higher bitrate than other advanced codecs. Therefore, it's important for technology firms to consider the deployment of multi-codec strategies, such as delivering H.264 for all devices and H.265 or AV1 for specific ones, in order to balance compatibility and bitrate savings.

In summary, H.264 is the most used video codec in video streaming. And there are new emerging challengers, e.g. H.265, AV1, and H.266, to deal with higher video resolutions, higher video quality, and even higher video bitrate consumption.

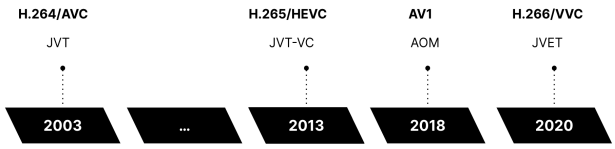

Figure 1. The history of some selected video codecs.

Video Streaming Protocols

In addition to the H.264 video codec, there are two other technologies that are essential for video streaming: HLS and MPEG-DASH [18].

Real-Time Messaging Protocol (RTMP) was one of the first streaming protocols used for video streaming, but it has largely been replaced by more modern protocols such as HTTP Live Streaming (HLS) and Dynamic Adaptive Streaming over HTTP (MPEG-DASH). Both HLS and MPEG-DASH are widely used for delivering video streams over the internet, and they both use a technique called adaptive bitrate streaming. This means that the video stream is divided into segments and multiple versions of each segment are encoded at different bitrates, as in

Figure 2. The client (such as a video player) can then adapt to the available network conditions by selecting the appropriate version of each segment to play. This allows for a smooth viewing experience, even when there are fluctuations in the network connection.

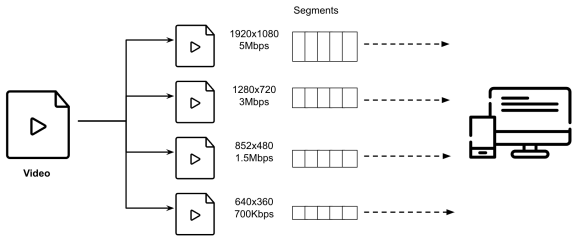

Figure 2. Adaptive bitrate streaming.

Common Media Application Format (CMAF) is a newer protocol that is gaining traction in the industry [19]. It is designed to be a common format for delivering both video and audio content, and it is supported by a wide range of devices and platforms. CMAF aims to simplify the process of delivering video streams by allowing content to be delivered using a single format, rather than multiple formats for different devices and platforms, which are caused by HLS and MPEG-DASH currently.

In summary, HLS, MPEG-DASH, and CMAF are all widely used streaming protocols in the video streaming industry, and they all use adaptive bitrate streaming to deliver smooth and consistent viewing experiences to users.

Adaptive Video Encoding

A subtle challenge in video streaming is the design of bitrate ladders, which determine the bitrates at which different versions of a video are encoded. Traditionally, a "one size fits all" approach has been used, with a single set of bitrates applied to all videos [20]. However, this approach can be inefficient, as different videos may have different characteristics that require different bitrates for optimal quality. Furthermore, even different viewers can perceive different qualities given a video with a single set of bitrates, as in Figure 3.

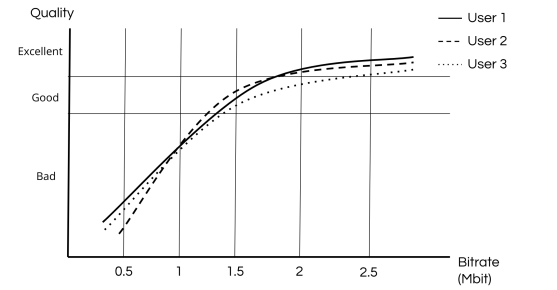

Figure 3. Plot of perceived video quality based on bitrates x users.

To address this challenge, Netflix introduced the concept of Per-Title Encoding (PTE) [21], as in Figure 4. PTE is a technique that involves analyzing the characteristics of each individual video and selecting the optimal set of bitrates based on those characteristics. This allows for a more efficient use of bitrates, resulting in smaller file sizes and faster streaming speeds. PTE can be applied to various adaptive bitrate formats, such as HLS and MPEG-DASH, and it has become an increasingly popular approach in the video streaming industry.

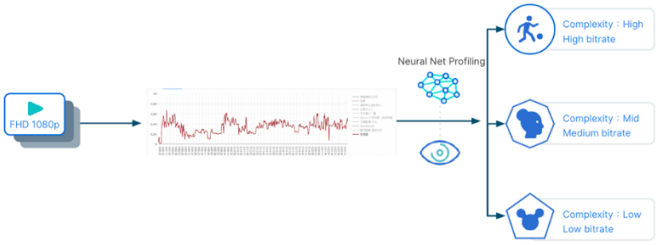

Figure 4. Videos with different characteristics require different bitrates for optimal quality.

In summary, PTE is a powerful tool for optimizing the design of bitrate ladders in video streaming. By analyzing the characteristics of each individual video and selecting the optimal set of bitrates, PTE allows for more efficient use of bitrates, resulting in smaller file sizes and faster streaming speeds.

Video Content Protection

The protection of video content and the management of rights is critical for the OTT video streaming industry. Digital Rights Management (DRM) is a technology that is used to protect content from unauthorized access and distribution. DRM solutions typically work by encrypting the content and requiring users to authenticate themselves before they can access the content, as in Figure 5. This helps to prevent piracy and ensure that content owners are able to monetize their content appropriately.

There are several major DRM solutions available, including PlayReady by Microsoft [22], Widevine by Google [23], and FairPlay by Apple [24]. These solutions are supported by a wide range of devices and platforms, but they may not be compatible with all devices or platforms. Alternative technologies for content protection, such as ClearKey, are also available [25].

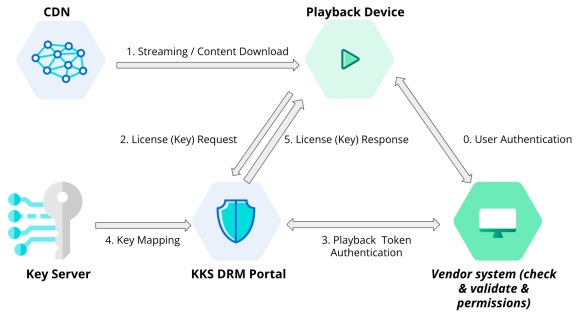

Figure 5. A system flow of DRM authentication.

To ensure that content is protected on a wide range of devices and platforms, many OTT video streaming companies use multi-DRM solutions [26]. This involves using multiple DRM solutions in parallel to cover different devices and platforms. This approach can provide a higher level of protection, but it can also be more complex to implement.

In conclusion, DRM is a critical technology for protecting video content and managing rights in the OTT video streaming industry. While major DRM solutions such as PlayReady, Widevine, and FairPlay are widely used, multi-DRM solutions may be necessary to cover a broader range of devices and platforms. Alternative technologies, such as ClearKey, may also be used to protect content.

Challenges for Video Streaming

At KKCompany Technologies, we design, build, and operate end-to-end video streaming platforms for our clients. The end-to-end process includes all of the technologies mentioned above, as well as cloud services, applications and players on various platforms, such as web, iOS, Android, smart TV, set-top box (STB). As Pixar's John Lasseter once said, “Art challenges technology, and technology inspires art” [27]. Through our work with clients, we have observed some new challenges in the video streaming industry, and we would like to share some of them here.

Quality & Bitrate

There is always a trade-off between video quality and video bitrate. The higher the quality demanded, the higher the bitrate required, which can lead to the worse streaming experience.

According to some reports, the world is entering the 5G era, which could potentially lead to stronger networking infrastructure and a better streaming environment [28]. However, it is important to note that 5G is still in its early stages and many 5G services have not yet reached their full potential. Access to 5G is currently limited to a few specific regions, with much of the world still relying on 4G or even 3G networks. Additionally, even when 5G becomes more widely available, it is likely that new services will be developed that will continue to put strain on networking bandwidth, such as 4K multi-view streaming, 8K streaming, real-time high-frame-rate game streaming, or 360 VR streaming.

This is why new video codecs, like H.265, AV1, and H.266, have been developed. These codecs allow us to handle higher video resolutions, higher video quality, and even higher video bitrate consumption. These new codecs are designed to cover potential future usage scenarios.

Protection & Penetration

In the visual effects and animation industry, the saying "every pixel counts" is a reminder of the effort that goes into creating high-quality movies or episodes. This process involves rendering pixels, frames, shots, and sequences, all of which contribute to the final video. To make the streaming of such high-budget premium content feasible and robust, technology companies often partner with software and hardware firms to incorporate digital rights management (DRM).

DRM functions quite well, or at least, well enough to some extent, except one drawback: it raises the difficulty of a video streaming's playback. That is, DRM generates playback issues when there is something wrong during the overall trust-building process. So there is always an argument with video protection and video penetration.

Solution

At KKCompany, we understand the above challenges faced by the video streaming industry, particularly the conflict between video quality and bitrate, as well as the need for effective content protection without impacting video penetration. That's why we offer a range of solutions designed to address these challenges head-on.

Our multi-codec and multi-streaming protocol, combined with multi-codecs technology, approach allows us to deliver high-quality video at optimal bitrates, while our tailor-made design of Per-Title Encoding (PTE) enables us to fine-tune our bitrate ladders for each individual video. Additionally, we offer multi-DRM protection and customized players to ensure that authorized content is only accessible to authorized users on all platforms. By leveraging these advanced technologies, we are able to deliver a seamless and secure streaming experience to our clients.

Future of Video Streaming

When considering the future of video streaming services and technologies, it is impossible to ignore the potential impact of new technologies from other fields. While video technologies themselves will continue to advance and deliver new value, the rapid pace of technological change means that the integration of these technologies with those from other fields could lead to even more opportunities in the future.

Artificial Intelligence

Artificial intelligence (AI) is expected to play a significant role in shaping the future of video streaming. AI technologies, such as machine learning and natural language processing, can be used to improve the efficiency and effectiveness of video streaming services. For example, AI can be used to optimize the delivery of video streams based on network conditions, to recommend content to users based on their preferences, and to personalize the viewing experience. AI can also be used to analyze viewer behavior and provide insights to content creators and distributors, helping them to understand and engage their audience more effectively.

Extracting knowledge and information from videos has been a long-standing research area, with numerous studies and approaches developed over the years. For example, Schwenzow et al. [29] discusses the challenges and approaches for extracting knowledge from videos, including the use of natural language processing and machine learning techniques. Bai et al. [30] presents a survey of techniques for extracting information from videos, including the use of text and speech recognition, visual analysis, and multimodal approaches. These studies demonstrate the ongoing research efforts in this area, and highlight the potential for extracting knowledge and information from videos to deliver additional side-information.

Virtual Reality & Augmented Reality

Virtual reality (VR) and augmented reality (AR) technologies are also expected to have a significant impact on the future of video streaming. VR and AR allow users to immerse themselves in immersive, interactive experiences, and they have the potential to revolutionize the way that we consume video content. For example, VR and AR could be used to create interactive, multi-dimensional video experiences that go beyond traditional 2D video. They could also be used to enhance live events, such

as sports or concerts, by allowing users to experience them from different angles or perspectives.

Blockchain

Blockchain technology has the potential to transform the way that video content is distributed and monetized. By using blockchain, content creators and distributors can create a decentralized system for distributing and tracking content, allowing for more efficient and transparent distribution and payment processes. For example, blockchain could be used to create a decentralized platform for distributing video content, where content creators and consumers can interact directly without the need for intermediaries. This could help to create a more equitable and efficient video streaming ecosystem, and it could potentially enable new business models for content creators and distributors.

Conclusion

As we have explored in this article, the world of video streaming has come a long way since the early days of dial-up internet and grainy, low-resolution video. Today, we have access to a wide range of technologies that allow us to stream high-quality video in real time, regardless of where we are or what device we are using. However, the world of video streaming is constantly evolving, and new challenges and opportunities are always on the horizon.

As we look to the future, it is not hard to imagine a world where video streaming is even more integral to our daily lives. With the continued development of new technologies, such as artificial intelligence and virtual reality, we may be able to fully immerse ourselves in the video content we watch, experiencing it as if we were right there in the scene. Additionally, the integration of blockchain technologies could revolutionize the way we pay for and access video content, allowing for more flexibility and control over what we watch.

Overall, the future of video streaming looks bright, and we can't wait to see what new technologies and innovations will shape the industry in the years to come.

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