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The Evolution of Content Delivery Network: How it Enhances Video Services, Streaming, Games, e-commerce, and Advertising

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ABSTRACT:The explosive development of digital media has been creating opportunities for enterprises to change their business strategies and incorporate new-world applications. Businesses use networks for exchanging information from a centralized location as a strategic method of communication. As enterprises move forward with the next-generation network, they can share not only content, but also applications, rich media, and live events. The advancement will affect business functions including e-learning, e-communications, and e-commerce. The CDN is a revolutionary technology that enables enterprises to distribute a new generation of scalable, accelerated, rich Web-based content, including Television -quality streaming media, for e-business as well as knowledge-sharing solutions. Delivering content locally minimizes the distance between the point where a request is placed and the point where it is served because the content is replicated to the edge of the network. Web sites with higher performance are the result. In the delivery of content, inherent Internet congestion issues are simply overcome, bandwidth utilization is controlled and optimized, and applications and rich media content are delivered to the desktop. Benefits of content delivery involve central content control, efficient distribution to servers that are at the edge of a network, and automated routing of the content requests that are made to a local edge server. Furthermore, it provides web content developers with a simple way to manage data and accelerates the speed of web access for users. Therefore, content providers can place their content at the closest node from the end-user. As a result, a high-performance and adaptable solution have been developed. Researchers have widely considered content delivery networks to be a powerful solution to lowering these drawbacks. CDNs act as trusted overlay networks that offer high-performance delivery of common Web objects, static data, and rich multimedia content by distributing the load among servers that are close to clients. The benefits of CDNs include reduced origin server load, reduced latency for the end-users, as well as increased throughput. Furthermore, CDNs can improve Web scalability as well as disperse flash-crowd events. In this paper, we provide an overview of CDN development and how it enhances video services, streaming, games, e-commerce, and advertising.

KEYWORDS: Content Delivery, Content Delivery Networks, CDN, e-learning, e-commerce, e-communication, Streaming Media, Advertising.

I.INTRODUCTION

With the rapid advancement of the Internet over the past decade, it has connected over 4.66 billion people in nearly every aspect of their lives, as rapidly as the CDN has evolved, it is behind the scenes as well. It is essential for CDNs to continue their work as fundamental enablers of the Internet by optimizing and securing transactions, as well as helping organizations harness the power of the Internet. Websites have evolved from simple static pages to rich, interactive, multi-functional applications accessible from a wide variety of devices. Taking into account the increasing complexity of the Internet landscape, delivering secure, high-quality experiences to every user, anywhere, has become more of a challenge than ever. In the future, we anticipate a greater level of change for the Internet, from its devices to its software to its fundamental technologies and protocols. The fast pace of change will offer many opportunities to businesses that can leverage them, but it will also introduce new challenges. These obstacles must be overcome, especially by organizations. Architects and platform operators face unique challenges when delivering content over the internet at scale. Customers expect high-quality service with reliable delivery, low startup latency, and a wide range of content choices. In live streaming, providers have an increasingly difficult time maintaining consistently low latencies and reliable delivery, as popular content is watched at the height of its popularity. Operators should also ensure that their content is secure to protect rights holders and their own revenue and reputation. The best possible CDN enhances the user experience, adapting optimization features to real-time context and the conditions, whether it be for a rich website to a smartphone over a mobile network or a 4K stream to UHD displays at a broadcast scale. It will also need to eliminate complexity, secure websites as well as applications hosted into the cloud, and allow the agile enterprise.

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Much more importantly, it should always be looking ahead to the future, always evolving. CDN enables its customers to thrive in this environment by understanding and anticipating the constantly changing needs of the Internet and its users. It is the CDN for today and tomorrow. In order to ensure the best possible performance, CDNs have always delivered content to users from nearby servers. Due to its close physical location and topological proximity to the end-user, close proximity minimizes long-distance network latency and helps eliminate congested global peering points, Internet routing difficulties, and other middle-mile bottlenecks. As a result, having a highly distributed platform has always been the single most important architectural attribute of CDN performance, scale, and reliability [11]. A CDN platform securely delivers video, data, applications, and APIs to customers around the world with low latency, high transfer rates, and a developer-friendly environment. A guide to effectively use a CDN to deliver high-quality experiences at scale is presented in this research paper. We explained CDN technology in detail in this paper. At the end of this paper, the reader will have a robust understanding of CDN and real-world scenarios that they can use right away to assist in any future work. We write this paper to help architects, streaming architects, network architects, and CDN operation teams.

II.A BRIEF HISTORY OF CONTENT DELIVERY NETWORKS

CDNs have been created nearly twenty years ago to address the challenge of pushing huge amounts of data quickly to end-users over the internet. They are the driving force behind website content delivery today, and academics and commercial developers continue to research and improve them. In the late 90s, the world's first Content Delivery Networks were created and are still responsible for 15% to 30% of all internet traffic worldwide. Furthermore, with the growth of broadband content and the streaming of audio, video, and associated data over the internet, more CDNs have been developed. In general, the evolution of CDNs can be broken down into four generations [4,9,10]:

Pre-formation Period: Prior to the actual innovation of CDNs, the technology, and the necessary infrastructure were being built. An important characteristic of this time period was the rise of server farms, hierarchical caching, improvements made to web servers, and the deployment of caching proxy servers. CDNs were also created and grew by technologies such as mirroring, caching, and multihoming [4,10].

1st generation: In the beginning, CDNs mainly dealt with dynamic and static content delivery, as those were the only two types of content on the web. The basic principle mechanism was the innovation as well as the implementation of replicas, intelligent routing as well as edge computing techniques. Apps and the information were divided across the servers [4,9,10].

2nd generation: As a next step, CDNs focused on streaming video and audio content or VOD services like Netflix for users and news services. In addition, this generation saw the development of P2P and cloud computing technologies as well as the delivery of website content to mobile users.

3rd generation: At present, we are in the third generation of CDNs, which have been evolving in response to new research and development. As Content Delivery Networks become more community-focused in the future, we can expect this model to continue. Therefore, the systems will be driven by average users and regular individuals. The new technology mechanism will be self-configuring as well as self-managing and autonomic content delivery. In the future, the quality of the end-user experience should be the deciding factor [4,9,10].

Content Delivery Networks originally arose to deal with extreme bandwidth pressures, as video streaming became more popular, along with Content Delivery Network providers. With the advancement of connectivity and new consumer trends in every generation, the pricing of Content Delivery Network services decreased, allowing it to become a mass-market technology. As cloud computing became widely adopted, CDNs have played an increasingly important role in all layers of business operations [9,10].

III. THE DEFINITION OF CDN

The Content Delivery Network (CDN) is a highly distributed platform of servers that reduces the physical distance between a server and a user and thereby minimizes delays when loading web pages [6]. Using this technology, users in all parts of the world will be able to view high-quality content without experiencing slowed loading times [7]. If there is no CDN, content origin servers must answer every request from the end user. As a result, there will be significant traffic to the origin and subsequent loading, which will increase the chances of an origin failure if the traffic spikes are too high or if the load is persistent. The CDN offloads traffic from content servers and improves the web experience for both content providers and their end users by responding to end user requests in place of the origin and closer to the end user physically and geographically [8].

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IV. THE EVOLUTION OF CONTENT DELIVERY NETWORK

Internet and Cloud Service Providers provide Content Delivery Network to provide static or dynamic content and webpages. CDNs allow clients to access the nearest servers instead of the main ones or central ones to avoid any bottlenecks created at the location of the servers. Even at high traffic times, CDNs make it easier to deliver similar content to a large number of users efficiently and reliably. CDNs can reduce the physical distance between the user and web hosting servers to provide faster rendering of web pages and improve performance [4,12].

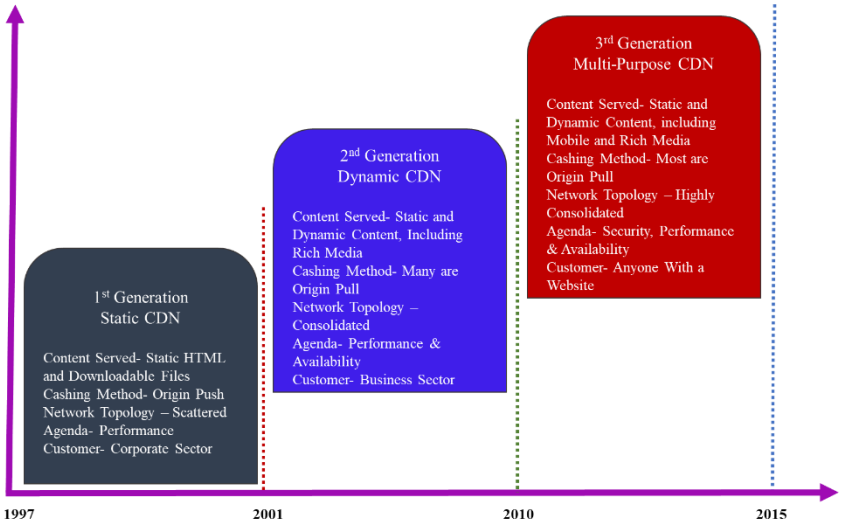

Fig. 1 Evolution of CDN

V. OVERVIEW OF CDN FEATURES

ENHANCING CUSTOMER EXPERIENCE

Due to the rapid development of the Internet, the website's content has been developed from text and graphics until the current form comprising of a huge number of High-Definition pictures as well as streaming media files. The total resource utilization of the website will be an increase, whilst requirements for network quality additionally increase. Furthermore, Internet users do not just request the more varied website content, as well as quick access. This creates an unavoidable challenge for the website operators.

REDUCING THE COST OF ORIGIN SERVERS

At present, the video industry has entered a period of stability and homogeneous competition. Many websites use video and text content to improve customer retention and also collaborate with content providers to develop in-house content, which translates to higher customer acquisition costs. Furthermore, with enhanced network bandwidth as well as the popularity of smart devices, customers have greater requirements necessary for display as well as video playback quality. If the website provides inadequate service quality, it could lose customers in spite of original investment. Since the site's content keeps expanding, the burden on the origin server additionally increases. Scaling up the originating server or executing a distributed implementation for user access frequently results in increased costs. There is no doubt that CDN represents the most cost-effective option in this scenario.

KEEPING YOUR NETWORK SECURE

There has been an increase in attacks on the Internet as a result of numerous security risks present on nearly all websites. As an example, DDoS and web attacks are very complex and attackers often use multiple protocols, making network defense even more challenging. Furthermore, content security poses a problem. In order to attract users, some websites and companies purchase rights to movies and TV shows. There has been an increasing hype over the value of the intellectual property (IP) since 2016. In cases where websites lack the financial backing to purchase copyrights, they may plagiarize content by using hotlinks. In spite of repeated lawsuits against copyright infringements, these illegal activities persist. By collaborating with content providers, CDN providers hope to resolve this issue.

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VI. THE IMPORTANT FUNCTIONS AND OBJECTIVES OF CDN INFRASTRUCTURE

• **Availability:** In the presence of several remote caching servers or POP, the availability of streaming services can be ensured. Whenever one of the servers gets down, the burden is directed to the closest POP to avoid downtime. The worst-case scenario involves the source server gets down, most of the service can be operated by the source shield as well as POP server for a good amount of time-based upon the available cache.
• **Scalability:** Building a highly scalable CDN is the essence of the media OTT service. Scalability, as well as performance, are the parameters for measuring the achievement of a video streaming service. With the option of adding on-demand servers, modern-day cloud-based CDN is built to manage the peaks and lows of inbound traffic. There is no extra cost paid since cloud services can be configured to cost depending upon the number of bytes delivered. In the instance of privately built CDN, this benefit will not be included, and then there is a possibility that servers could be seated idle in the low traffic circumstances.
• **Performance:** A CDN's primary objective is to deliver performance. Having POPs situated in the required locations will decrease the number of hops in the path, which reduces the latency for end-user cached content.
• **Security:** In each CDN, security is a top priority. In connection with this, security features such as application firewalls, bot identification and mitigation, and requests restricting are being added. The threat can never enter an origin as by the design just the origin shield will be able to access it. Additionally, higher numbers of nodes (i.e POP) are less vulnerable to D-DOS attacks.

VII. AN OVERVIEW OF HOW A CONTENT DELIVERY NETWORK CAN IMPROVE YOUR VIDEO STREAMING SERVICE

The growth of video streaming over the past few years has been spectacular. As a result of the COVID-19 outbreak, online streaming has become even more popular. People are now stuck at home for both work and entertainment, which has changed streaming from a convenience to a necessity [1]. As a result of these increases, streaming providers have also had to deal with more demand on their infrastructure considering peak hours are less predictable. Increasing numbers of remote workers and kids at home are resulting in exponential increases in video streaming for both professional and entertainment services during the day [2]. Customers hate sluggish streams more than anything, which is why streaming providers should ensure that their infrastructure is capable. As business models change, having a content delivery network (CDN) is increasingly essential [3].
There are many ways in which CDNs can help in meeting increased streaming demands. It improves latency, increases reliability, and brings data closer to users. Now we will take a look at how CDN can improve the quality of service.

a) Decrease the distance between data and users
When optimizing CDN streaming, there are many factors to consider. The location of your users is one factor to consider. By strategically adding resources to regions with the highest streaming needs, you can make sure that your CDN provides the best value for each dollar spent. Furthermore, it improves customer satisfaction by enabling users to access content more quickly.

b) Service can be made faster by reducing latency
By using advanced technology, live streaming CDNs further improve the speed of your video streaming. CDNs must have high-quality hardware and be able to handle existing traffic needs while scaling easily. Securing your servers so they can scale up easily is also key. Finding a reliable partner who provides the hardware you need for CDN updates and can manage the hardware supply chain efficiently is key to ensuring a smooth deployment.

c) Improve the reliability of your streaming
Content not being served up when a user requests it is a data center engineer's nightmare. Large organizations can avoid this problem by utilizing techniques and infrastructure that enable load balancing, intelligent failover, and the transfer of traffic to a functioning data center in the event of a total outage.
The seamless delivery of data to customers is more important than ever because even a two-second delay in service can result in a loss of revenue [1,2,4].

The importance of video quality
Today's audiences expect increasingly high-quality video from their televisions, computers, and smartphones since high-speed internet access and high-resolution media are ubiquitous. In the entertainment industry, application developers, and video streaming services, the bar for speed and audio-visual quality of media delivery continue to be

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raised, and consumers are simply no longer willing to tolerate delays, poor images, or unpleasant audio. Online video streaming is one of the most effective marketing and communication tools available today but keeping up with the technology is challenging. It may be easy to learn how to stream video but providing consumers with the quality and access they demand from online streaming media is challenging businesses are now facing. A web video is a fast, high-impact way to grab the attention of an audience, especially for advertising purposes. However, the poor video quality will not only distract from your message but can also damage your brand. Whether a video that takes a long time to start playing or stutter during playback will cause viewers to abandon the page and look somewhere else [5].

Delivering a high-quality video experience to the audience

When streaming video-on-demand or live, video quality is significantly impacted by network congestion, latency, and packet loss, all of which increases as the distance and number of networks between a media server and the user increase. Spikes in network usage and internet bottlenecks are inevitable. Enterprises can manage their streaming media storage and delivery better with a properly configured online video platform and contribute to shortening the distance their video streams need to travel before reaching consumers. Publishing companies are taking advantage of adaptive bitrate (ABR) streaming technology and content distribution networks (CDN) to address network limitations and to give consumers a smooth viewing experience. The ABR streaming solution allows video players to switch between different stream bitrates depending on the current network conditions. This allows for faster startup times, reduces buffering delays, and provides the best video quality. CDNs allow content providers to connect to a large network of servers that distributes the content globally, ensuring that a media stream will originate from a server located closer to the user [4,5].

VIII.CONTENT DELIVERY NETWORKS - HOW THEY CAN IMPROVE YOUR GAMING SERVICE

Today's gamers would like to play their preferred games anywhere, anytime, as well as on any device. The rising popularity of free-to-play games has led to the players frequently switching games as soon as they have completed the content or whether the game does not engage enough. Therefore, game developers and publishers remain under pressure to keep pace with a continuous demand for new content as frequently as possible in order to maintain more players and generate revenue effectively to maintain their business [14,15].

Depending on what type of game, as well as the destination device platform: console, mobile, or PC, content assets for games might vary and include a varied mix of textures, images, models, videos, audio, and much more. These assets can also vary in size from hundreds of megabytes for mobile games to tens of gigabytes for PC or console games. Because of those reasons, CDNs are frequently used to efficiently cache those assets on the edge near to the players and deliver these as required.

Following are some aspects of such a solution that can improve gaming service:

i) Efficient assets layout in the source to improve cost and performance. ii) Content will be updated and serving multiple assets versions to their clients. iii) Uploading content and integrate with build pipelines. iv) Spreading load between multiple CDNs to optimize the performance, cost, and increase the availability. v) Collecting download performance metrics from clients and CDNs, real-time performance monitoring, and batch reporting [13,14].

Requirements

The following are the most important requirements for static game assets distribution:

• Adequate download capacity to manage the workload spikes: CDN capacity will have a direct impact on game success due to the fact that player experience incorporates pre-and post-installation downloads. An unsuccessful content delivery strategy might lead to failed downloads and churn before players even begin to play the game.

• Cost efficiency: In the case of popular games, IT infrastructure costs for content delivery can amount to a significant amount. Due to this, it is vital to develop a cost-effective architecture in order to improve game economics.

• Constant download performance: Players can originate from all over the world and will be expecting a comparable experience irrespective of where they are living or how much further they are from the source of the download assets.

• Conformity with the requirements of data localization: It is important to take into account how your game download strategy would address local data compliance regulations in particular parts of the world [14,15].

• Content versioning: The capacity to serve various versions of the assets at exactly the same time to support older clients or for A and B testing.

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IX.IN ORDER TO IMPROVE YOUR GAMING SERVICE, THE FOLLOWING POINTS MUST BE CONSIDERED

Performance and error-rate

Available bandwidth to the client is the main metric used to measure performance. In most cases, bandwidth is more important than latency. As long as the bandwidth is adequate, it is often okay to serve, for example, clients in Europe from the US. The only exception to this is games played via a browser or Facebook Messenger, where games request assets as they run, and players effectively play from CDNs. Lower latency improves the user experience in those games. A low error rate is another important requirement. In the event of an unsuccessful download, retries and redundant CDN downloads will be attempted. As a result, players will have to wait longer, and churn will increase [13,14].

Local Coverage

Customers frequently need to pay attention to local specifics and still use multiple CDNs for reasons which contain the following:

• Regulations: For instance, a separate CDN by origin as well as points of presence situated in the country is normally required to serve up users in Mainland China.

• Improve performance in countries with a substantial user base: Local points of existence and good quality peering along with last-mile providers are essential to provide a good user experience for the users in countries with sub-optimal network connectivity alternatives.

Functionality

Although serving static game assets are not the most complex use-case for CDN, several advanced CDN features might come in handy [16]. A CDN solution must offer support management via APIs to combine with upload tools, CI and CD the pipes, and infrastructure-as-code solutions. It would also offer monitoring capabilities and will be able to deliver access logs used for centralized analysis. Access logs data can be used together with performance data from clients to develop reports on CDN usage and performance [15,16]. A Few CDNs also support real-time logs as well as metrics streaming. Compute on the edge functionality can assist in some instances. For instance, it can be used to create unique installer names for each user for PC games to monitor the pre-launch user experience, or to create personalized content depending upon the customer or user-specific attributes in the request.

Ability to handle spikes

Once a new game is released or an existing game launches new content, the enthusiasm from the players frequently leads to sharp traffic flow increases within CDN providers. Although customers can often execute gradual rollout methods to minimize the traffic spike, popular games even commonly experience traffic volume rises that can have a negative effect on CDN performance if not efficiently manage. It is essential to test a CDN's ability to deal with traffic spikes in advance and coordinate together with CDN providers to provide early notice of planned large-scale download use. A multi-CDN setup enables the spillover traffic to the secondary CDN providers if the main provider doesn't provide enough performance or capacity.

Security

Normally, a user's validation and authorization to download the content is not an important concern, because the majority of content distributed through a game is probable public content anyway. Though, you may want to consider limiting access to betas or previews. The capability to serve private content with signed URLs as well as the signed cookies to enhance security. Furthermore, want to offer Origin Access Identity, a feature that enables developers to restrict access to their content only to their Distribution, thereby forcing content that will be downloaded through the CDN provider that further improves the security posture. Other security features to consider include DDoS protection, Shield, web application firewalls WAF, and ensuring that appropriate permissions are set up and configured. Also, version control can give away to avoid unwanted object removal [13,14,15].

X.IMPROVE YOUR E-COMMERCE SERVICE WITH A CONTENT DELIVERY NETWORK

Currently, e-commerce is operating in a highly competitive and overcrowded environment. So far though every online store can possess a competitive advantage associated with its ranking, quality, exclusivity, price, etc., there is one transversal method that irrespective of positioning and sector, is now important to the overall quality of the user's experience. Retailers can ensure their web and mobile sites are available and provide great customer experiences by

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following the best practices and implementing new technologies. Retailers and brands face new problems as a result of each of these developments. New technologies are helping them find new ways to deal with these problems. Some of the top retailers do this by caching content on content delivery networks, or CDNs, that maintain servers around the world. Using a CDN, a website can be delivered much faster than if it had to make a journey through several internet nodes, grab the data, and make the return trip to the consumer. In this case, it doesn't matter whether the web content is stored on a retailer's server or a cloud provider [17,18].

Reduced Load Times as well as the Latency: As the CDN network receives and distributes traffic loads to the closest servers, the geographical location of the download plays a key role in download speed and latency. CDN networks effectively reduce page load times and increase data transmission at the same time. Whether it's video streaming, gaming, or the e-commerce platform, CDNs can provide visitors with faster connections. Additionally, it is possible to ensure fast data transmission through other methods. A few CDN providers use machine learning or artificial intelligence to manage cache servers. In order to keep cached content readily available, it is distributed according to demand. CDN providers can speed up user requests further by delivering cashing web content closer to the client.
Manage traffic peaks easily: In certain sectors such as e-commerce, client traffic tends to keep up with temporary or periodic peaks. In these times, CDN providers will be distributing user requests amongst accessible CDN servers to decrease the load. Load balancing helps to prevent crashes as well as server overloads [16,17,18].

New Data Transmission Technologies: Similar to the SSL encryption referred to above, data transmission technologies also modify and upgrade over time. For example, Brotli, BBR, and HTTP2 CDN a service provider will incorporate these new technologies into a website, and that means there will always be access to the most recent data transmission updates [17].

Safer Encryption: Encryption techniques change and develop over time as their weaknesses surface via real-world use. CDN providers are quick at adopting and implementing these new technologies as they arise. An excellent CDN provider will be applied to new SSL certificates as well as encryption methods without affecting the usual operation of their customers. Often, customers will not even notice the change [17,18].

Improved Insights About Traffic: CDN providers hand over the hard labor through the internet ecosystem. They process almost half of all the information traffic over the internet. This implies that they produce vast amounts of analytics data. This information can be shared with their clients, which provides them actionable insights, as well as intelligence into their customer base. Also, an Information analysis they can provide indicates everything a developer needs to understand to additionally optimize the website. Extensive reporting eventually leads to a performance increase, which leads to greater user experience and subsequently further reflects on selling and conversion rates [17,18].

To prevent any possible slowing down from demanding data such a request incurs retailers will be able to offload static content like images, JavaScript, Cascading Style Sheets (CSS), and videos to a CDN, which can then deliver the content to the website visitors. They will also be able to offload the HTML that gives the logic to assemble a web page. The following steps will speed website performance. There is another significant value to a CDN. E-retailers pushing content will need to find a CDN that can locate the best route to that provider. The main services all have several data centers, therefore try to find a CDN with multiple servers that can route requests to multiple data centers in the most effective manner. And if operated internationally, a CDN with a global reach is required [17,18].

XI.CONCLUSION

Because of the rapid development of the Internet, individuals have more and more high expectations for information services, as well as a desire for faster response times and better product experiences. Because of its extensive experience in the Internet industry, CDN has acquired a strong knowledge base and strong capabilities over the years. With a CDN, a website can load more quickly, strain can be reduced on servers and bandwidth resources, and website security, as well as business continuity, can be improved. A CDN would be an ideal choice for improving end users' experience and ensuring their satisfaction. Additionally, it will be able to save on deployments of hardware and bandwidth when using a CDN, not only by increasing security, stability, and worldwide presence. Furthermore, it has a positive impact on user experience and quality of service, with the ability to deliver content as needed from thousands of servers around the world.The Internet functions today cannot exist without content delivery networks based on everything that has been said so far. Users are increasingly demanding better data traffic both in quality and quantity. CDNs provide a multitude of benefits on the Internet and with the rising demands for better service, CDNs are in high

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demand. The CDN industry needs to take more steps today to make it better and more secure. The CDN has become an integral part of the Internet content delivery chain. They enable content providers to deliver content closer to consumers, and they minimize the risk of dealing with bursty traffic caused by a standalone content delivery system by aggregating variable traffic across a variety of sources. Almost one-third of the most popular content sites on the Internet use CDN services to ensure their content is delivered on time and reliably.

Based on the successful implementation, the CDN is anticipated to significantly reduce packet loss and modestly increase throughput for video, streaming, games, and e-commerce services. This technology requires high bandwidth in order to maintain a reasonable Quality of Service (QoS). There will be packet loss when there is insufficient bandwidth. As a result, content delivery quality can be compromised. This problem can be solved by using cache technology. The Content Delivery Network (CDN) is one of these technologies. As a result, CDNs must be positioned close to the user area, which makes access times faster than without CDNs. Another contributing factor, such as choosing the right video format, can have a significant impact. Streaming large formats of video requires a content delivery network that can maintain the broadcast's quality. Speed is an essential component of any successful e-commerce website. In addition, speed is what leads to a good user experience, a fast-loading time, and by extension, what impacts your turnover. This article should have helped to understand some of the key features of CDNs for live streaming. There has been an increase in the demand for video content, streaming, games, and e-commerce, which will most likely continue in the near future. Video streaming in mobile is so popular in today's digital world because the audience responds better to products and services that are promoted through the use of it. Leveraging web based CDNs to ensure that the target audience receives high-quality performance in high speed and quality with minimal lags, no matter where they are located.

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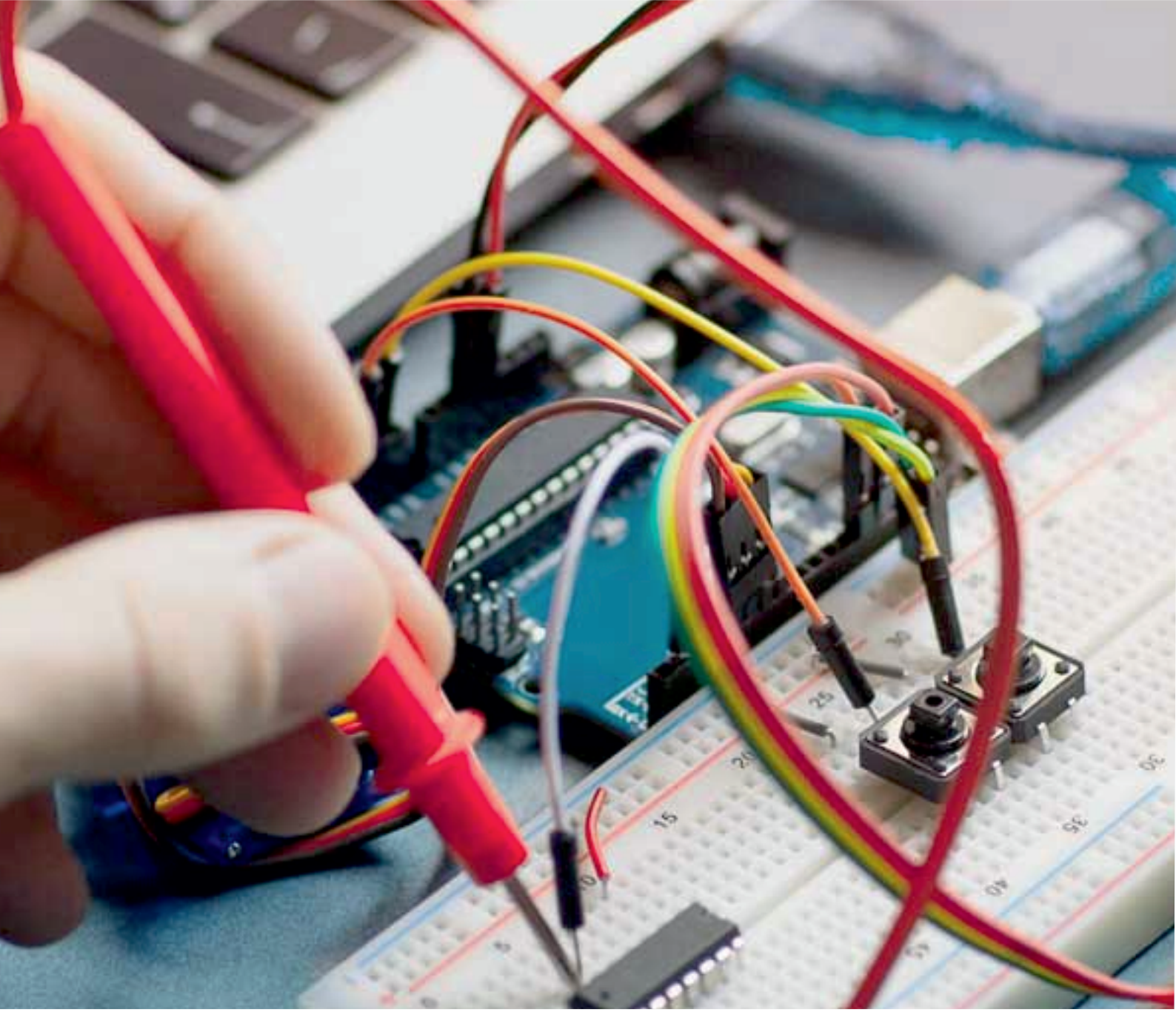

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