



Distributed Adaptive Streaming™

White Paper

This document contains proprietary information of Giraffic Technologies Ltd. ("Giraffic"). The text and drawings herein are for the purpose of illustration and reference only. The concepts, specifications and forecasts on which they are based are subject to change without notice. No part of the contents hereof may be used for any other purpose, copied or altered, disclosed to persons or firms not listed as the explicit recipient in the header of this document, or reproduced by any means, without explicit prior written permission of Giraffic.



1. Preface

“Over-the-Top” (OTT) TV or Broadband TV’s phenomenal growth in the recent years has caused a major change in the media production, distribution and consumption. Internet video traffic already represents the majority of the internet traffic, delivered via billions of connected devices. The Video Distribution & Monetization market opportunity is worth over \$10Bn to be captured by OTT Video Providers and Entertainment Device Manufacturers. Strategic areas of innovation that impact viewers’ engagement are content creation and video delivery quality.

Meeting the consumer’s demands for HDTV everywhere can be very challenging, due to the internet infrastructure limitations, incurring bandwidth costs and limited monetization opportunities for content over the web. As a result the end-user often experiences viewing artefacts ranging from re-buffering pauses to suboptimal video resolutions, over wireless or fixed line connectivity, which have direct impact on user engagement and revenues of the OTT providers.

Giraffic is the enabler of Next Generation Internet TV broadcast technology for Online Video Publishers, Over the Top (OTT) Operators and Consumer Electronics Entertainment Device Manufacturers. Bridging the gap between broadcast quality TV and the boundaries of Internet and mobile video, Giraffic is the maker of the **Distributed Adaptive Streaming™ (DAS)**. DAS is a novel robust and secure UDP-based Crowd-Streaming cloud that enables OTT content providers to offer the best streaming experience to their customers by accelerating video and rich media content distribution while offloading up to 80% of their video and data traffic. The result is a smooth, buffering-free HD video streaming over any networking condition to any device for a true TV everywhere experience.

With millions of users to date, and thousands joining daily mainly in the US, UK, Hong-Kong and Israel, DAS has proven to be a secure and efficient content distribution technology since its commercial deployment in 2012.

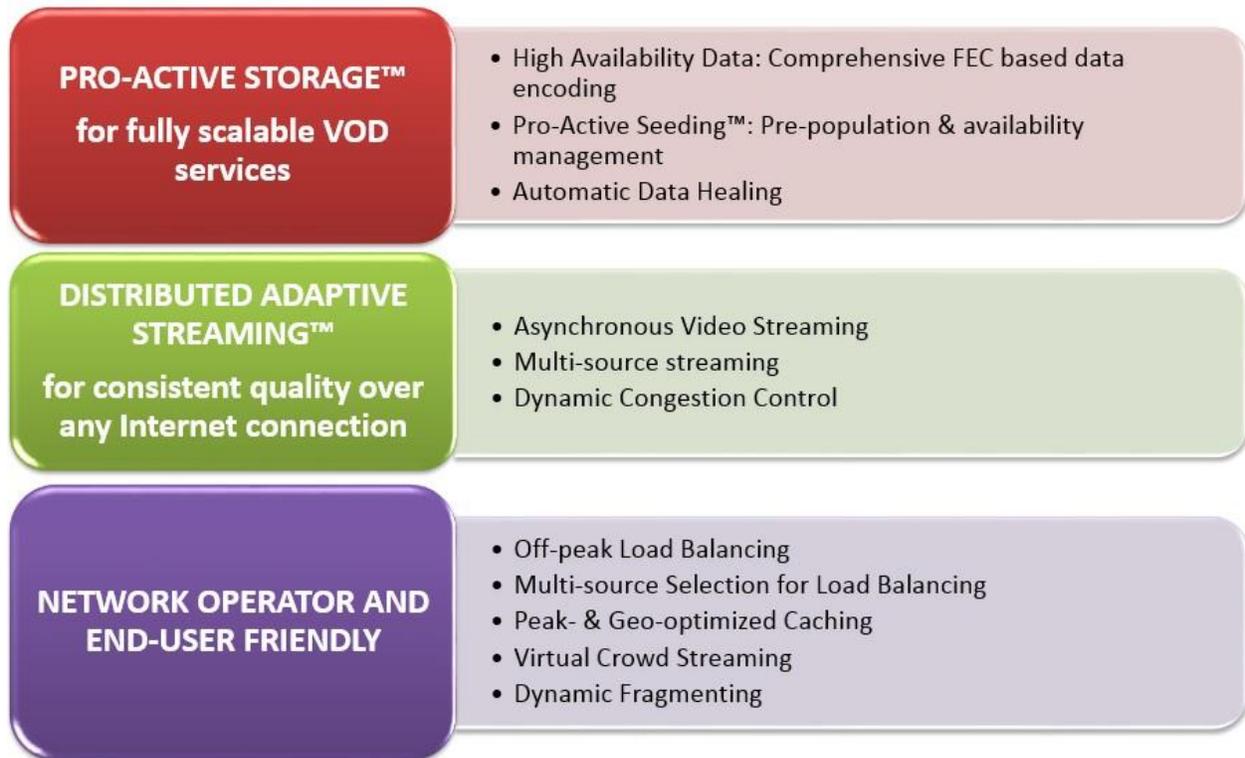
With its two flagship products, **Distributed Adaptive Streaming™ (DAS)** and **Adaptive Video Acceleration™ (AVA)** a client-only solution requiring no server integration, Giraffic’s average 3-4X performance enables the best streaming experience in any networking condition.

This paper discusses the different layers and aspects of Giraffic’s patented **Distributed Adaptive Streaming™ (DAS)** technology.

2. Introducing Distributed Adaptive Streaming™

Giraffic brings to the market a new technology for managing and distributing any online digital content, whether popular or niche “long-tail”, from premium video content via VOD or catch-up TV to games, music as well as large file download and User Generated Content.

DAS is a unique combination of **distributed robust coded storage cloud** and a **multi-source asynchronous streaming protocol** that can be integrated in any video website, apps, or video service as a simple add-on for a higher video quality, smoother streaming or downloading that substantially offloads bandwidth requirements. For the personal consumption, DAS can be used to perform personal backup or as a sharing application. **2.1 Solution at a Glance**



2.2 Technology Highlights

- **DAS is a robust and secure UDP based Crowd-Streaming**
 - a. **FEC Based Encoding** - Low-redundancy data eliminates needs for content replication and caching over the network.
 - b. **Proactive Data Seeding** - Proactive data pre-population in the Giraffic cloud enables geooptimized delivery of long-tail and popular content from other end-user devices, for an all-time availability.
 - c. **Asynchronous Coded Multi-Source Streaming/downloading** – Data can be received in random order from multiple sources simultaneously and assembled on-the-fly in asynchronous order.
 - d. **Automatic Adaptation to Popular Content** – highly popular contents are automatically cached on a large number of users' devices for immediate availability to new users.
 - e. **Automatic Data Healing** – When any device on the Giraffic network goes offline, DAS automatically creates more data inventory and new sources for potential streaming/downloading or on-the-fly restoring of corrupted fragment.
 - f. **Security and DRM** – Giraffic maintains content's existing strict copyright protection and adds extra layers of security
- **DAS is network and user-friendly**
 - a. **Minimal System Requirement** – features a low CPU usage mainly in use when device is idle, competitive memory footprint and usage
 - b. **Network Friendly.** DAS is a very polite and requires a low uplink bandwidth usage (40-60 kbps) and actually provides congestion relief to the overall network infrastructure
- **DAS benefits for content providers**
 - a. **High Performance** – 3-4X average, highest possible resolution at given networking condition

- b. **Wide support** - any device, any OS, any HTTP, HTTP/S, any DRM/encryption.
- c. **Flexibility** - Can be implemented on Application level, device level or Chipset level.
- d. **Easy integration** - No change to existing data infrastructure required - Giraffic seamlessly interoperates with customer's existing website player, origin servers/CDN, Online Video Management Platform or Application Management Platform.
- e. **Advanced Monitoring** - Comprehensive Management, control and reporting in real-time of network performance and KPIs(user consumption behavior, network efficiency, content distribution, cost effectiveness...)
- f. **Low risk** – Commercially deployed since 2011, with millions of users worldwide.

3. Benefits



Giraffic's network consists of end users' client devices and centrally managed servers.

The servers handle the secure connection and authentication of the end-users' digital rights management, and control and monitor the network. No actual streaming/downloading or heavy media delivery is done from the servers.

All bandwidth and storage resources are aggregated and utilized from end-user computers and home devices, such as IP set-top-boxes, media, and gaming consoles, Internet-enabled digital video recorders, Smart TVs, Tablets and mobile phones. Each user becomes a node on the network and communicates with other users on demand. This occurs when the user either requests to view a content, or serves content to other users.

Serving other users mostly occurs when the users' device is idle and the internet bandwidth in his area is abundant. An end-user's streaming or downloading activity has the lowest priority with respect to the bandwidth access and shall automatically yield to any other activities the user might be performing.

Giraffic's end-user software is bundled and integrated into the device's firmware, middleware software or video player or any other data management, for example play store. Alternatively, Giraffic's software may be bundled as a library within the content provider's own application or website.

3.1 Unlimited Scalability

More users => higher content availability => lower cost & higher performance!

End-users' last mile bandwidth is the only part of the Internet infrastructure which is expanding at the same rate as the growth in consumption, content bitrates and volume of data being downloaded.



Giraffic's fully distributed network is inherently scalable. The larger the audience of viewers is, the more the resources on the network, with the resulting ability to deliver more media and faster as the media is readily available from a closer location.

Here it is important to note that DAS only utilizes abundant or excess end-user resources in the network, so users with limited bandwidth or storage (such as mobile devices) will not be used as streaming sources, but can enjoy the accelerated video and data streaming/downloading from other devices in the network such as home desktop PCs and Set-top-Boxes.

3.2 Network Data Efficiency

Instead of replicating data fragments, the data is first FEC-encoded: all data fragments are **equally important** and carry redundancy necessary to recover from any corruption. As opposed to other crowd-streaming methods, DAS doesn't perform massive replication of the data: each of these coded fragments of data is distributed only once over the network.

Moreover each agent that has copy of the downloaded file via the Giraffic network, may save the file in a local cache. This provides any agent the ability to re-encode in real time, and serve any part of the file as if all the coded chunks had been distributed to it. Consequently: as a content becomes popular, its distribution becomes viral over the Giraffic network, enabling fast streaming/downloading of the content.

3.3 Data robustness and Error Recovery

DAS coding scheme is highly efficient in **correcting random packet loss** caused by congestion errors (i.e. even bursts to some extent) or packet-dropping over unreliable networks (wireless, cellular). Video streaming being highly-sensitive to real-time network fluctuations, packet losses can deteriorate the viewing experience from picture corruption to buffering pauses which are detrimental to the end-users engagement with the content, resulting in revenue losses for the OTT content provider. DAS platform eliminates the packet loss problem completely.

3.4 DAS advantage over conventional Peer-to-Peer Content Delivery Networks

DAS crowd-streaming technology enjoys some of the benefits of P2P such as virtually infinite peak-hour scalability and high bandwidth offloading, without carrying the burdens of traditional P2P solutions.

1. **Optimized for the New Media Age - Long Tail and popular content alike:** Enables real-time, on demand, streaming/downloading from its distributed-sourced network of end-users for niche "long-tail" content, and not just for highly popular content.
2. **Optimized for Video on Demand (VOD) Delivery,** beyond file downloads or Live Streaming.
3. **High Performance and Robust Streaming Experience** – the internet bandwidth utilization is maximized:
 - "Re-Buffering" Pauses are virtually eliminated (10X less re-buffering)
 - The streaming reliability is significantly improved
 - 5X faster streaming/downloading speed, enabling HD streaming
4. **Network Friendly:** Helps relieve internet congestion, "flatten" network bandwidth peaks almost entirely, and reduces the total amount of data transmitted to deliver the average video and data stream/download compared to traditional content distribution delivery.
5. **User Friendly:** Consumes only a small fraction (usually 5-10%) of end-users' uplink bandwidth, operates only when bandwidth is abundant and user's internet connection is idle.

4. Technology

4.1 File Fragmentation, Coding and Pro-Active Data Seeding

At the core of DAS technology is its highly-efficient patented One-Step file fragmentation, encoding and pro-active data seeding algorithm that handles redundancy, security and distribution for any data file.

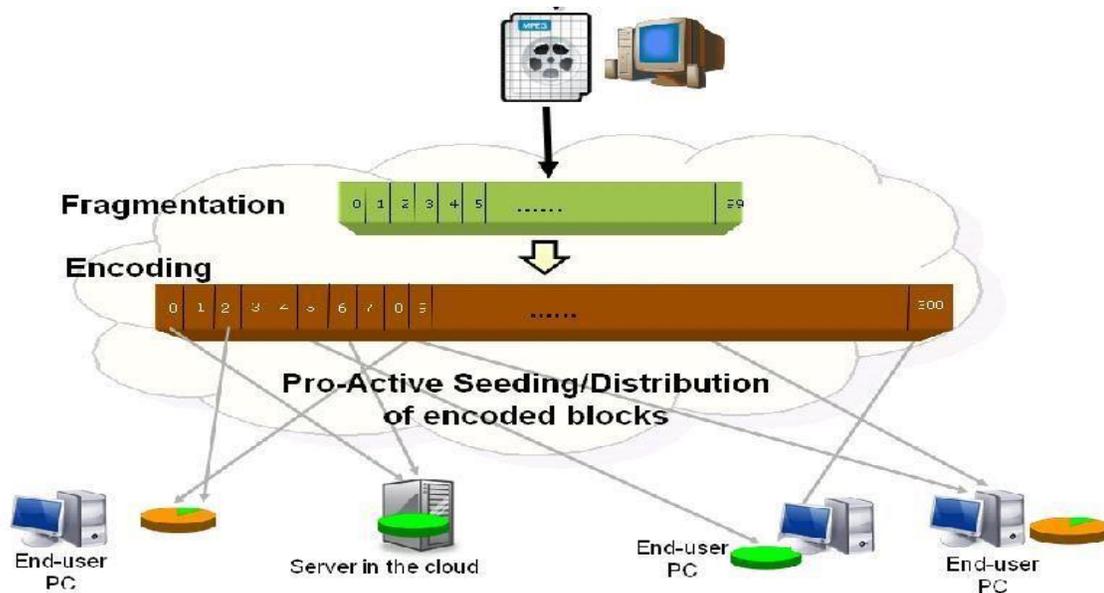


Figure 2: Giraffic's one-step segmentation, coding and encryption

Every file stored on Giraffic's Distributed-Sourced Network is split into frames. The actual length of a frame is variable and depends on the size and bitrate of the file. Each frame is then divided further into blocks. The number of blocks in a frame is in the order of one to several thousands. Each frame is then encoded on-the-fly using Eraser Correction Codes. The code is generated specifically for the particular node using **variable** block lengths in the simplest, fastest and most efficient encoding/decoding algorithms possible. Code Rate is chosen to be less than $\frac{1}{2}$. The original data, coupled with the coded redundancy, is then distributed to peers using an advanced selection algorithm that takes into account geographical factors, bandwidth abilities, availability of peers, and similar factors.

The additional redundancy is small compared to other methods (e.g. replication). Additional redundancy can be generated at each node in case the content availability decreases under a certain threshold.

Giraffic's coding technology treats all coded blocks on **equal** footing – thus **any random set of required encoded blocks retrieved can be used to regenerate the original file**. This key differentiator gives DAS a clear advantage over classic Peer-to-Peer technologies, such as BitTorrent: the issue of "the last piece" / "the rare torrent" which in many cases restricts the restoring of the full file in a timely fashion, as well as the need for an unbalanced heavier load on the "super-nodes". That allows Giraffic's technology to support the unique "long tail" characteristics of large video and data catalogues, archives and even User Generated Content.

4.2 Asynchronous Coded Multi-Source Streaming/downloading

DAS patented Asynchronous Coded Multiple-Source streaming/downloading method enables any content, whether popular or long-tail to be easily accessible and accelerates streaming for the relevant viewer

The downlink bandwidth can be maximized because multiple coded sources sends only a small portion of the content: the Giraffic agent takes care of aggregating multiple packets of data from multiple sources (up to hundreds) into one fluent stream/download in a random fashion due to its **asynchronous nature**, while the client assembles the data required for a real-time playback. Compared to a traditional download from server to client, the bandwidth utilization is split and distributed over the Giraffic cloud, this multi-source streaming is no more subject to bandwidth congestion, and is only limited by the end user's own bandwidth.

Additionally, failures resulting from the high churn rate of available devices on a network are completely avoided as DAS continuously maintains a database of active and back-up agents. A back-up agent intervenes when another agent fails sending data.

This is only possible because all agents are equivalent as long as the amount of sent data is approximately the size of a frame.

For the Giraffic Agent all fragments are equally important so there is no need to maintain a bitmap of which fragments each end user has. Furthermore, there are never duplicate packets because every data received by the Agent can be used effectively to calculate and assemble the original data file/video.

4.3 Congestion Control

Giraffic's application manages and streams/downloads content items in a distributed manner utilizing groundbreaking congestion control to overcome Internet congestion, particularly during peak hours and when streaming HD content.

Giraffic's congestion management can identify internet bottlenecks in real-time and adapt sources dynamically to guarantee a seamless delivery.

The Giraffic Streaming/downloading protocol includes a built-in comprehensive Patented Congestion Control algorithm, both on the client side (receiving data) and on the serving side (user devices sending packets of data to serve other users). The congestion control measures packet loss continuously and guarantees that data is always delivered in optimal manner on the network, automatically adapting to bottlenecks in the challenging internet environment.

Compared with traditional Peer-to-Peer replication approach where the streaming success rate of long-tail item delivery is only 30%, Giraffic's technology features a 90% success rate. DAS is a robust crowd-streaming distribution that is well-fitted for large-scale deployments, with the ability to offload up to 80% of the network traffic such as demonstrated in fig. 3. The green line represents the total bandwidth consumed by the customer, the blue line shows the traffic offloaded by the Giraffic cloud and the remaining data on the CDN/Origin is depicted by the red line. Additionally we can observe the congestion at peak-hours is almost entirely absorbed with DAS.

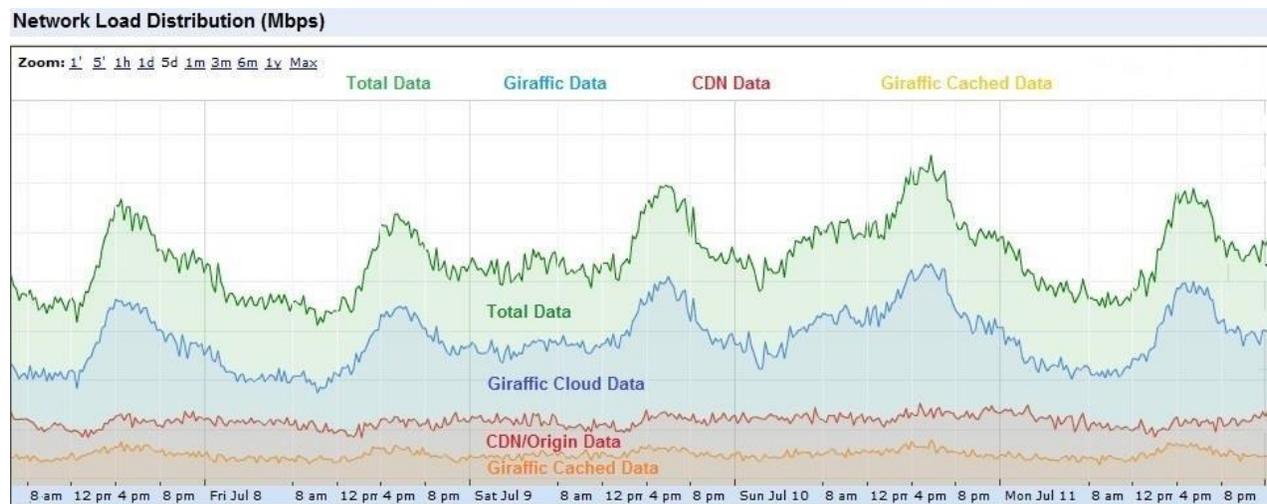


Figure 3: Screenshot of a real customer dashboard.

4.4 Giraffic's Management and Control

Giraffic Management Module is a powerful set of administration tools and reports enabling customers to get real time visibility on network performance, end-user experience, and efficiency of the content delivery network.

Giraffic's application's unique presence in the user's browser enables it to collect and aggregate valuable information which measures real user experience – such as TTFB (Time to First Byte, i.e. the amount of time it takes from the

user pressing play to the content actually starting to play), number of pauses during streaming/downloading and other data about the end-user's environment.

This information is used to automatically optimize Giraffic's network, improve user experience on the fly, adapt to congestion problems in the network, and reduce the amount of data on the network.

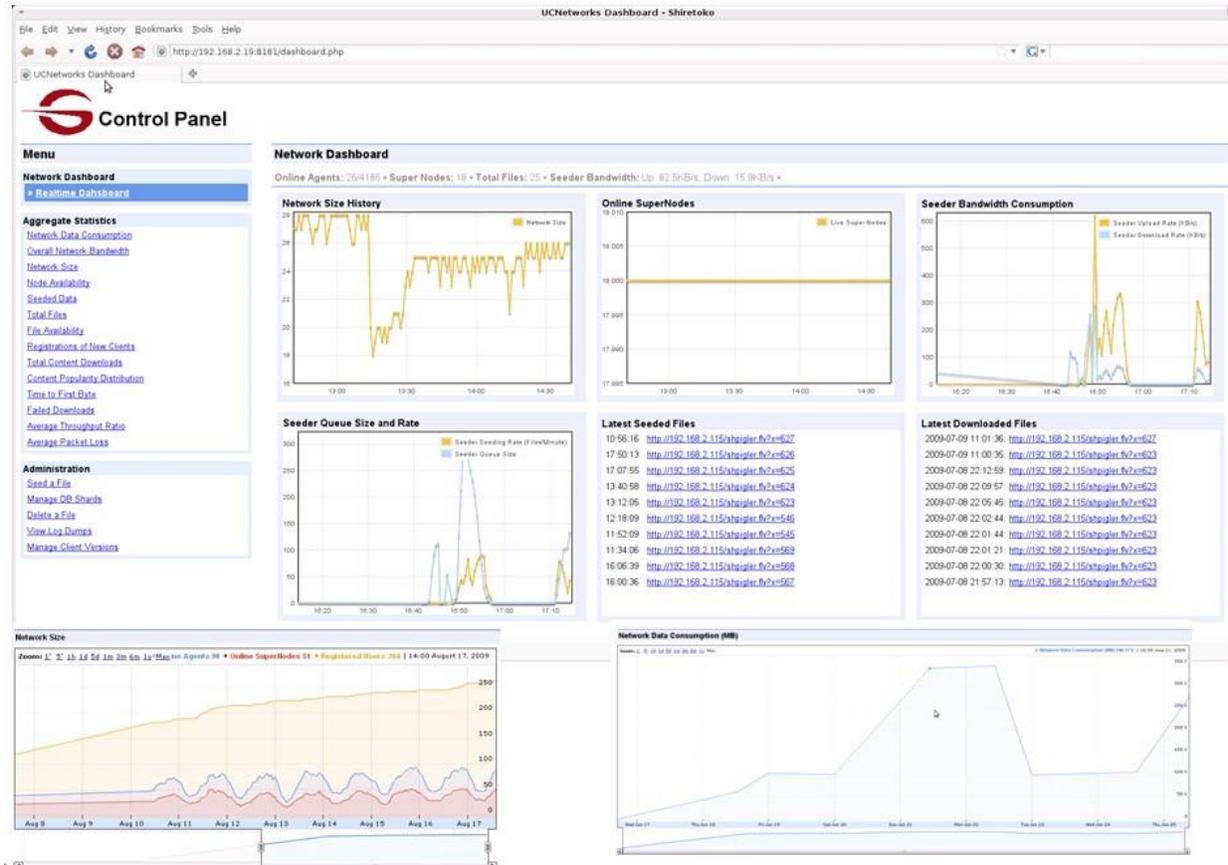


Figure 4: Sample reports from Giraffic's Administration Dashboard

Giraffic Management modules include:

- a. **Authentication and Registration** – Authenticating and Registering Agents in the network and constantly maintaining their availability in the network.
- b. **Seeding Management** – this module allocates agents to receive fragments of each file to be saved to the network. Pushing a file to the network can be done in a centralized way (faster) or in a distributed way, in which one agent gets the original file, encodes and distributes it (cheaper but slower).
- c. **Virtual file system integrity** – constantly monitoring the network for enough availability to regenerate missing data, whenever various nodes are not available beyond the required redundancy threshold.



- d. **Permission/groups** – Giraffic enables either multi-tenancy of various customers using the same global P2P network, or a complete “walled garden” network approach. Furthermore, within a particular customer’s domain, various permissions to the network reports and administration may be granted to different users.
- e. **Statistics Collection** – Giraffic collects statistics from end-users’ agents – such as user success rate, efficiency of the Giraffic network vs. the CDN fallback, user experience metrics such as TTFB (Time-toFirst-Byte) and buffer under-runs (for example: number of times a video and data buffers), and aggregates it to the customers’ central management servers via the networks’ super-nodes.
- f. **File Mapping** – The initial mapping of file chunks to agents is saved to a central scalable database – located either at Giraffic’s premises or at the customers’ own data-center. However, copies that are organically created by the peer caches are stored only on the DHT.
- g. **Billing.** This module tracks bandwidth consumption in the network, and translates it to billing transactions.

4.5 Security and Digital Rights Management

Giraffic’s software agent is a secure client side networking technology which was specifically designed to support digitally protected content and to interoperate with leading encryption and Digital Rights Management platforms. Giraffic’s technology was never utilized for P2P file sharing or other illegal content distribution and was developed from day one as a professional and protected digital content streaming/downloading platform.

As such, from inception, the company has employed worldwide security experts who have produced the comprehensive design for securing all layers of Giraffic’s platform.

Giraffic supports copyright protection and DRM.

Giraffic is configured to support customer’s existing DRM and integrates with customer’s existing licensing and encryption schemes, such as Microsoft PlayReady or Widevine.

Only requests that are authorized and decrypted on the customer’s video player or software downloading by the customer’s DRM system will be redirected to the Giraffic agent.

Transmissions and coded data are encrypted, and file based DRM is possible as the system does manipulate the content itself. Any DRM-encoded content will be distributed to the network and playable under the same restrictions as it would via any other distribution system.

Additionally, data which is encoded, encrypted and seeded pro-actively by the Giraffic distribution system is always delivered in fragments so that an end-user never holds a full copy of a file, unless that particular end user had specific access rights to that particular file/content.

Only the content owner has access to the full encrypted files, and is the only one that can upload new content into the network. End-users cannot upload any content into the Giraffic network, unless they are granted those permission by content distributors.

For further information about Giraffic’s comprehensive content and communications security features please contact us and we will send you [Giraffic’s Security White Paper](#).

5. Integration

5.1 Client Side

Client side integration with Giraffic requires two components:

- The Giraffic Agent
- The Giraffic API

The Giraffic Agent can be part of a content providers' application (as a shared/static library within the App) or an additional component that is bundled and integrated into the device's firmware, middleware software or video player.

Giraffic's code is cross platform – Windows, MAC, Linux, IOS, Android, etc...- and can be implemented on the middleware level, device OS level or part of the firmware on a chip level solution.

The API can be implemented as a Flash/Silverlight plugin or as JavaScript (e.g. if HTML5 is used) or on the device or chipset level. In addition the integrating entity (apps or website) must supply a unique content ID (similar to asset ID) to each clip. This is a unique identifier used by the Giraffic Network to retrieve the file.

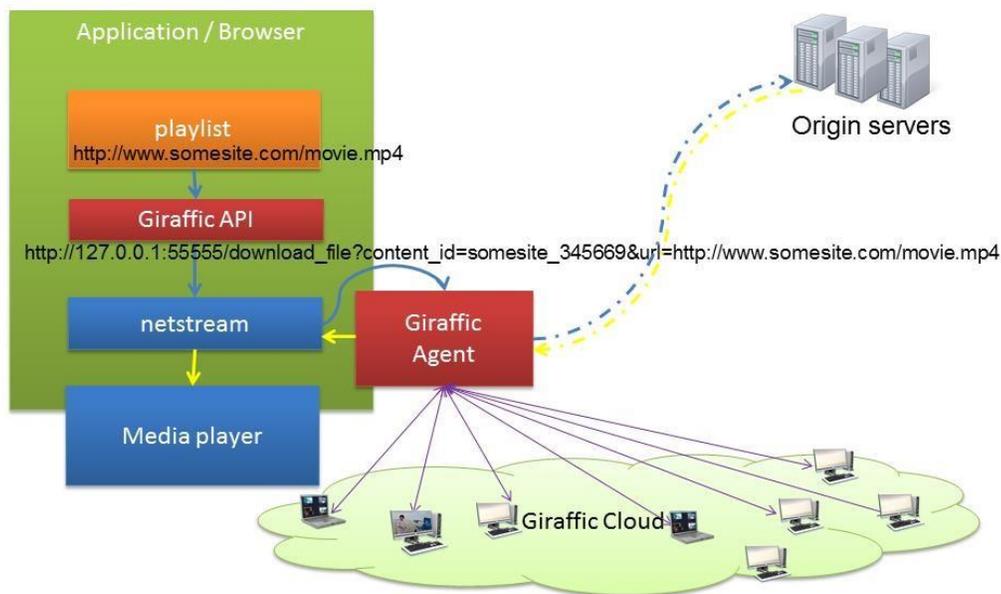


Figure 5: client side integration

The above message shows the typical message flow. The application / browser page usually contains a URL or more generally a playlist.

Without Giraffic integration: when the user clicks on one of the videos or Data the URL of this video or data is ordinarily passed to a netstream that opens a connection to one of the CDN servers and streams/downloads the file to the media player or the file system.

With Giraffic integration, there are several scenarios:

- **Giraffic Agent is running and connected.**
The original URL is replaced by the Giraffic API GetPlayURL function to a URL that is directed to the local host and contains other parameters such as content ID and fallback URL. The Giraffic Agent then requests

agents that have pieces of that file to send them to it. The data is streamed/downloaded back to the local Giraffic Agent (using UDP) that reassembles the pieces frame by frame and streams/pushes them to the media player or the file system.

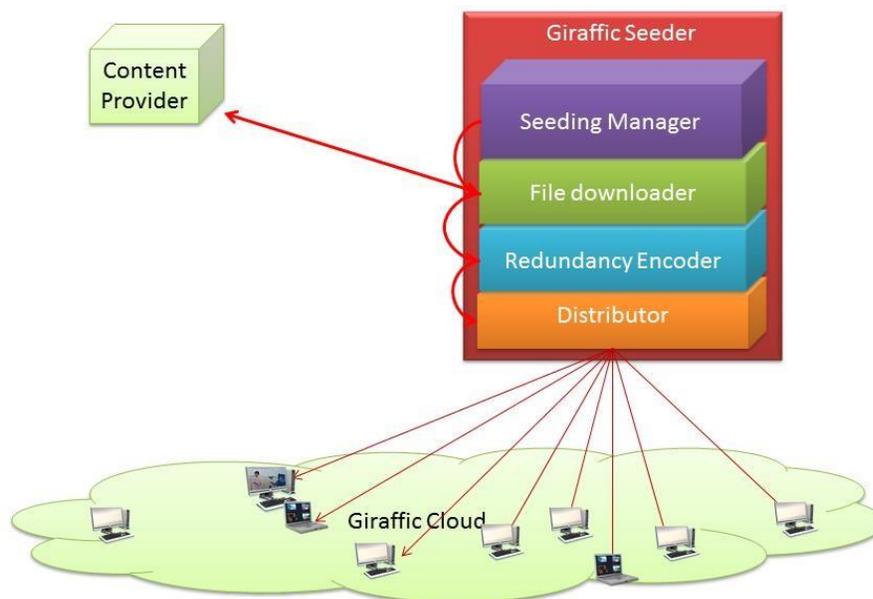
- **The Giraffic Agent is present but is UDP blocked** (or the distributed sourcing cannot support the requested bitrate for some reason).
The Giraffic Agent will contact the CDN / origin servers, retrieve the data from them and stream/push it to the application/browser or file system.
- **If the Giraffic Agent is not present at all.**
The Giraffic API will not change the URL and the streaming will ensue as if Giraffic is not there at all.

5.2 Server Side

Similar to any CDN, Giraffic requires access to the data that the content provider intends to distribute through the Giraffic Network.

[Optional] For personal backup and sharing application the data seeding will be done from client side only (Distributed Seeding).

The figure below is given in order to complete the picture and explain how files are cached in the Giraffic Network.



The seeding manager decides whether a given file needs to be “seeded” (distributed) into the Giraffic Network according to some policy (for example according to the number of hits). Once it decides the content should be seeded it instructs the File downloader to download a single copy of the content directly from the content provider. Afterwards it hands the file to a redundancy encoder which adds redundant data to the content in order to increase its availability, and then hands it to the distributor that distributes pieces of the contents to computers/laptops/devices on the Giraffic networks according to a locality optimization algorithm.



6. Summary

Giraffic DAS technology and architecture overcomes the main hurdles of storing and delivering any rich media or data over the internet – whether extremely popular or extremely niche/“long-tail” and supports any type of file or format - video, images, music, other software or files, and on any device.

It bypasses backbone bottlenecks and bandwidth constraints, compensates efficiently for low reliability of end user devices, offers an unmatched user experience for streaming/downloading content in real time, regardless of the data popularity, or the end user geographical location.

It provides the content provider huge bandwidth reductions over all type of content, while ensuring great benefits for the end-users such as a high video playback quality (less buffering, better resolutions) or fast and reliable file downloading.

Commercially deployed worldwide since 2011 by world class content providers and consumer electronics manufacturers, Giraffic’s Distributed Adaptive Streaming is a market proven solution.
