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# Efficient, intelligent, content-aware networks

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The rapid, exponential growth of internet traffic means investment in infrastructure, new technologies and paradigms for getting content to users are needed. EU-funded researchers are pushing these boundaries - changing the way content is delivered so that users can access high-definition (HD) and three-dimensional (3D) video on demand.

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Video and similar bandwidth-hungry content are forecast to be the main driver of future internet-traffic growth, with 1.2 million video minutes - equivalent to more than two years' of video - travelling around the internet every second by 2016. But today's networks handle this content inefficiently.

'Today, the vast majority of internet usage is data retrieval, data delivery and streaming, and web services access, where the user cares only about the content and is oblivious to the location where it is stored, as long as it is timely and reliably delivered,' explains Dr Theodore Zahariadis, CTO at Synelixis Solutions Ltd in Greece. 'The user knows that he or she wants news from CNN, videos from YouTube or weather information, so they use a web browser to download data from the relevant server.'

'In order to serve each user's request, billions of identical content chunks are replicated at the application server, and follow paths across the network, many of them the same. Therefore identical content is sent multiple times over the same internet segments, exponentially increasing the network traffic and the network infrastructure requirements.'

There is, however, a much more efficient alternative, one that not only reduces the load on servers

and networks, but makes it easier and faster for users to discover and access content. It could also improve the user experience with increased interactivity and content enrichment. It is achieved by focusing not only on the communications channel but on the content itself, by embedding intelligence into the network so servers, routers and end-user devices know what data is being accessed from where - so, for example, video streaming adapts to changing network conditions, ensuring high-quality video optimised for the viewing device.

This approach to developing so-called Future Content Networks (FCNs) was implemented and tested in the 'Content-aware searching, retrieval and streaming' ( COAST [2]) project, coordinated by STMicroelectronics in Italy and supported by more than EUR 3 million in funding from the European Commission.

Dr Zahariadis, the COAST technical coordinator, points out that the project's approach became possible due to the increasing processing power, memory and caching capabilities of end-user and network devices, enabling them to become content aware. This in turn enables three key developments rolled out by the project team as part of an FCN overlay architecture.

Firstly, network nodes (such as routers, home gateways and user devices) are embedded with intelligence that enables them to identify and classify content 'on the fly' as it passes through them, and identify where distributed content is located and cached - in order to optimally match users' data requests with availability and meet Service Level Agreements (SLAs) on content consumption.

Secondly, a content-aware delivery architecture was deployed, complete with solutions for efficiently and dynamically discovering the underlying network infrastructure and identifying user device types - so that content is continually optimised for the device on which it will be consumed and the means by which it will be delivered.

Thirdly, the COAST team developed technology to adapt and enrich media content so users receive content that best suits their preferences, network and device characteristics and can interact with it - selecting different viewpoints for a video, for example, or panning and zooming in or out.

Reducing redundant traffic

'By changing the content delivery paradigm, we can reduce the identical traffic that is routed over the same internet links, and consequently decrease network infrastructure investment requirements and extend the lifetime of existing network infrastructure to meet the increasing content-delivery requirements,' Dr Zahariadis explains. 'And by enhancing the internet content-searching capabilities with passive crawling and content-popularity features, we can deliver in a timely way the most appropriate content, matched to the user's preferences and context.'

The upshot for end users is easy, fast access to content - potentially at reduced cost if they are being billed by minute or volume - while also enhancing their ability to share content and become content providers themselves. Meanwhile, content providers should be able to serve a broader audience thanks to the improved indexing and search functionality, while network operators gain by being able to extend the lifetime of their existing infrastructure and putting off the costly investments that would otherwise be required to meet growing traffic demands.

Crucially, the COAST technology offers scalability by design, enabling it to keep pace with ever-growing bandwidth demands from HD video and, increasingly in the future, 3D video.

In that regard, the project has made notable contributions to the MPEG 'Dynamic Adaptive Streaming

over HTTP' (DASH) standard, which seamlessly adapts video content to changing network conditions, providing high quality playback without stalling or rebuffering issues. During the course of the project STMicroelectronics, along with other COAST partners, demonstrated the first 3D DASH-streaming client prototype running on an embedded platform and is continuing to actively promote the standard.

The team's work has also fed into other standardisation activities, among them Internet Engineering Task Force (IETF) working groups on the AVT, CDNI, ALTO and Decade standards, as well as the European Telecommunications Standards Institute's (ETSI) TISPAN working group and the Digital Living Network Alliance (DLNA).

The technology is also being considered for commercial implementation, notably by Spain's Telefónica, a project partner. Telefonica I+D, Telefonica's R&D arm, has identified concrete exploitation areas that, in collaboration with COAST partners and third party providers, could improve Telefonica's content delivery services, support content adaptation and enhance the operator's mobile broadband network.

Other partners, such as STMicroelectronics, NEC, Yahoo and Synelixis, are also exploiting the results in collaboration with their product and business divisions, the project technical coordinator notes. And their collaboration is continuing.

'Though there are no precise plans for a follow-up project, members of the consortium are already collaborating on research in COAST-related areas, including content-centric networking, distributed searching and indexing, dynamic adaptation of content and efficient content distribution,' Dr Zahariadis says.

COAST received research funding under the European Union's Seventh Framework Programme for research (FP7).

Link to project on CORDIS:

- FP7 on CORDIS [3]
- COAST project factsheet on CORDIS [4]

Link to project's website:

- 'Content-aware searching, retrieval and streaming' website [2]

**Contact:**

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