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Social-Content Revolution. A Vision for the Future Social Oriented Networking.

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Abstract: Content distribution services are booming and they will be responsible for the majority of future Internet traffic. In parallel, Online Social Networks (OSNs) have become today's most popular Internet applications. The widespread adoption of OSNs has drastically changed the way content is consumed in the Internet, as the popularity of a given content is most often dictated by its "social" success. This calls for novel social-aware network architectures that exploit these social-content interdependencies to improve the efficiency of content distribution services and the Quality of Experience for the end user. This paper presents a set of targeted use cases to introduce the underlining requirements and standardization opportunities within W3C.

Keywords: Social-aware future Internet architecture, On-net Content Dissemination, Energy Efficiency, Information-Centric Networking, Social-Content Interdependencies, Mobile Networks.

Context and Stakes

Content distribution services are booming and they will be responsible for the majority of future Internet traffic. In parallel, Online Social Networks (OSNs) have become today's most popular Internet applications. The widespread adoption of OSNs has drastically changed the way content is consumed in the Internet: users often consume content based on the information shared through OSNs. As a consequence the popularity of a given content is highly impacted and most often dictated by its “social” success. This calls for novel social-aware network architectures that exploit these social-content interdependencies to improve the efficiency of content distribution services and the Quality of Experience for the end user.

The FP7 eCOUSIN project aims to design such a novel social-aware network architecture that exploits the social-content interdependencies with built-in content dissemination functionalities to improve its efficiency.
ADSL or 3G connections represent a bottleneck for intensive users of shared contents. In addition to this, the social aspects in terms of comments and evaluations of shared contents have multiplied the "willing to share ratio" and consequent requirement of more bandwidth.
This will incentivize users to look for a radical upgrade of their Internet connection and to exploit all the potential offered by platforms as the one proposed here.
Within eCOUSIN we aim at developing a user friendly platform for social aware multimedia content management and sharing.

Illustrative use cases

Such social-aware network architectures shall provide a clear added value in use cases involving social-content interdependencies, such as the ones briefly presented in this section, namely personal content sharing clouds, social-assisted time-unconstrained content delivery, Information-Centric Networking (ICN) for social-driven content delivery, and enhanced content placement in distribution networks using users' social and coarse-grain location information.

Personal Content Sharing Clouds

The integration of social networking with peer-to-peer communication has the twofold objective of providing a higher degree of data ownership to end users while incentivizing the adoption of large bandwidth fixed connectivity provided by ISPs. The proposed solution also integrates widely used off-the-shelf Universal Plug and Play (UPnP) devices/services, taking advantage of Digital Living Network Alliance (DLNA) AV Media Controllers and Servers already available in users’ home networks.
This use case consists in enabling to locally store private content in personal devices and to share it over the Internet with remote persons linked by social relationships. A typical scenario would be as follows:

A. Alice has a DLNA-enabled Smart TV she usually uses to browse the Internet, e.g., to read news and access Facebook. Bob has a Telecom Italia’s Cubovision (or any other similar set-top box) where he stores his own pictures and music files, to be available on other remote nodes via DLNA AV Media Server. Smart TV and Telecom Italia’s Cubovision devices are deployed in Alice and Bob home networks respectively;
B. Alice and Bob meet on their summer holiday; when they come back home, they become friends on their preferred OSNs that are based on the Federated Social Networking Standard Implementations (FSN). The creation of a new social relationship triggers the automatic generation of a communication link between Alice’s and Bob’s gateways, already deployed in their home networks to provide Internet connectivity;
C. Once friends, Alice uses her Smart TV to access via DLNA the pictures, videos and music that Bob stores on his Telecom Italia’s Cubovision and has tagged as “shared with friends”. Alice accesses Bob’s Telecom Italia’s Cubovision without any specific goal, just for her own curiosity to see pictures and videos of her new friend, e.g., to view photos of his previous vacations or check his music selection;

D. After a couple of days, Bob saves his holiday pictures in the "Summer 2012" directory on the Telecom Italia's Cubovision and then notifies via FSN his friends (including Alice) of the new photo album. Alice clicks on the FSN post exploiting her Smart TV and accesses via HTTP the whole directory content;
E. Bob takes a new video with his smartphone. The FSN client automatically uploads the video on his Telecom Italia's Cubovision at home and notifies his friends of the new video location. Alice can access that specific video stored in the Bob's home private network simply clicking on the new post.
F. Finally, Bob accesses a YouTube video from his mobile and decides to share it in using one or more OSNs. Automatically, this video is downloaded and stored in his Telecom Italia's Cubovision system. While Alice is browsing her OSNs contacts she clicks on the YouTube video Bob shared, and the Content provider (i.e. YouTube) redirects Alice to Bob's Cubovision that serves the video to Alice.

The proposed solution is based on a cross-layer approach: modifications of social network entities and relationships are automatically associated with (and translated into) peer-to-peer network reconfigurations. In particular, social network information is dynamically mapped to peer-to-peer components, creating a correspondence between entities/relationships of social networks and devices/mechanisms of peer-to-peer networks. The outcome of the proposed solution is to allow resource sharing with greater data ownership retention for final users if compared with traditional social network mechanisms while pushing for the adoption of large bandwidth symmetric fixed connectivity.

The above use case individuates three different mapping layers:

- **Identity Mapping**, associating one or more social identities to one or more peer nodes. For instance, the "Alice" Facebook profile and the "@Alice" Twitter profile could be associated to the "Alice" peer node, managed by her home gateway and containing her office desktop PC and her personal Android smartphone;
- **Relationship Mapping**, associating social network relationships with peer-to-peer connections among different peer nodes. For instance, "Alice" and "Bob" identities are strictly related since respective Facebook profiles are in a friend relationship. For this reason "Alice" and "Bob" peer nodes are in mutual communication, as long as the friend relationship lasts;
- **Access Mapping**, associating identities and/or relationships with shared resources. Different identities/relationships grant differentiated access to resources available in peer nodes belonging to other users.

We expect this new paradigm to incentivize high-speed internet connection based on fiber optic or LTE. The integration of social networking with smarter content distribution mechanisms has the twofold objective of providing a higher degree of data ownership to end users while incentivizing the adoption of large bandwidth fixed connectivity provided by ISPs.

Social-Assisted Time-Unconstrained Content Delivery

This use case focuses on the possibility to reduce costs and energy consumption on the side of the mobile end user for the access to data-intensive content, such as videos that the user is interested in, thanks to social recommendations derived from the user's participation in online social networks. The main ideas are twofold:

- 1) to proactively prefetch relevant data at the user's device in time when Wi-Fi connections are available
- 2) to retrieve content from other users in proximity using device-to-device techniques, such as Wi-Fi ad hoc.

This way, the use of energy and monetary costly mobile connections can be reduced, while providing the user with the same or even better experience.

Information-Centric Networking for Social-Driven Content Delivery

In response to the needs of emergent bandwidth-consuming applications, mainly driven by the popularity of video content and social networks, several projects and initiatives for the Future Internet have started over the last years to envision a clean slate foundation of the Internet by moving away from the current endpoint-oriented approach to promote information at the center of networking design considerations. As a result, several Information-Centric Networking architectures have been proposed targeting a well-defined set of architecture invariants, which are persistent/unique naming for content objects independently on location, efficient content distribution and discovery through name-based routing, in-network caching, security and mobility.
As the ICN concept redefines interdependencies between network entities to make them depending more on naming and semantics of pieces of content, there is an opportunity to explore the benefits of using ICN as a network layer for content delivery in OSNs while also taking into account the relevant interactions inside the social graph resulting from OSNs.

Enhanced Content Placement Using Users' Social and Coarse-Grain Location Information

CDNs provide efficient mechanisms to distribute popular content by placing this content close to the end user and thus reducing the network traffic. However, the offered performance for mid and low popular content is not good enough mostly due to the difficulty to predict where this type of content is going to be consumed. Fortunately, the recent irruption of OSNs offers valuable information to predict where this mid and low popular content is going to be consumed. An important fraction of this content, in many cases User Generated Content (UGC), is nowadays distributed through OSNs. Therefore, we can leverage the information of a specific user's social relationships to predict where the content that (s)he shares is going to be consumed.

Requirements and Challenges

The novel social aware network architectures such use cases will rely on will require three special sets of functionality:

- First, tools to monitor, aggregate and collect data from OSNs and content distribution applications in a distributed manner, together with algorithms that exploit such data for modeling the social-content interdependencies;
- Second, functionalities for content look-up, placement and delivery that exploit the social-content interdependencies and the knowledge of the network infrastructure;
- Third, networking functions that need to be evolved as a consequence of the usage of social information and that support the dissemination layer and the applications.

The following table gives an overview of the specific requirements associated with these functionalities.

Functionalities	Requirements
Social and Content Information	- Collecting information associated with OSNs' users (social relationship, user interests, user usage patterns, user location, mobility pattern, etc.)

Extraction & Data Management	- Collecting information about content exchanged/shared between users (content properties, content scoping, etc.) - Data aggregation and abstraction - Data mining to highlight useful information from collected social and content data for content dissemination and delivery - Federation between heterogeneous social networks - Understanding the naming scheme in ICN while taking into account the social and content information collected in the OSN
Content Dissemination	- Social-enhanced caching and/or prefetching strategies - Social-enhanced content placement strategies - Content look-up algorithms based on users' activity in OSNs
Network Layer	- Network topology detection - Social-enhanced content delivery specific to the network architecture (CDN, ICN, mobile networks, adhoc Wi-Fi, etc.) - Adhoc Wi-Fi content exchange - Network availability detection - Load and congestion monitoring - Mobile device proximity detection

Four key challenges stand out of these requirements:

- First the framework for monitoring and modeling social-content interdependencies shall be capable of gathering up-to-date information of users' real-time interactions, and of uncovering the interdependencies between user interaction in OSNs and the resulting impact on content consumption in related content distribution services.
- Second, the techniques to replicate and place the content near the user, which are normally only based on overall content popularity and shortest paths, must be enhanced with additional information extracted from OSNs. The existing techniques for content look-up need to be extended with information about users' interest and similar search results of their social contacts.
- Third, naming of content is of great importance in OSNs. In the case where OSN traffic is delivered via an ICN, the naming must be investigated as well as how OSNs can adapt them to the ICN paradigm, and how ICN routing can benefit from the social links in the OSNs to improve its routing and forwarding strategy.
- Fourth, the target system must also represent an evolved management system for content placement and delivery to mobile users by exploiting statistical patterns derived from mobility, connectivity and social information. Thus, this will require the specification of open interfaces as well as the potential use of new interfaces with mobile network infrastructure components, aiming at advanced caching, management and delivery of content to mobile consumers.

These requirements and challenges open interesting Social Networking related standardization lines to be addressed within W3C.

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