Mobile Multimedia Portal

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Abstract

We are considering the dissemination of multimedia content to mobile users with wireless devices with possibly long disconnection times, but can support high peak bandwidths. We take advantage of the support for bursty traffic of available technologies and design a system to effectively overcome the disconnection times, allowing various levels of Quality-of-Service guarantees, depending on assumptions about the statistics of the connection characteristics and mobility patterns. Enabling techniques are based on prefetching objects and media segments of relatively more importance to other parts of the data and dynamically selecting the appropriate medium representation and quality for the various objects and components. Scenes, media objects and streams are described by XML documents specifying their characteristics and functionality (similarly to the MPEG-4 BIFS) and objects are weighted according to their importance in the scene (through author specification) and user preferences (through dynamic profiles). Based on this information, the user device can prefetch, or the portal can push, objects in the order of their significance, when bandwidth is plentiful, anticipating congestion or disconnection periods.

Introduction

Various wireless and mobile data technologies, such as PDAs connected to Wireless LANs (IEEE 802.11b or Hiperlan), Qualcomm's HDR and the latest version of the UMTS specification, provide high peak data rates in bursts. We are considering dissemination of multimedia content, including digital continuous media, e.g., video, to mobile users with wireless devices that can handle very bursty traffic, have possibly long disconnection times and can support high peak bandwidths (e.g., in the range of Mb/s).

The key issue is how we can take advantage of the support for bursty traffic of the technologies and design a system to effectively overcome the disconnection times, allowing various levels of Quality-of-Service guarantees [1], depending on assumptions about the statistics of the connection characteristics and mobility patterns. Enabling techniques are based on prefetching objects and media segments which are relatively more important than other parts of the data and dynamically selecting the appropriate medium representation and quality for the various objects and components (e.g., resolution). Content adaptation [2, 3], including exploitation of hierarchical coding [4, 5] of media and transcoding [6, 3], are key technologies. Multimedia multicasting [4] and broadcasting are exploited where and when possible, for example for *pushing* content and refreshing caches.

To have a concrete framework we assume that each media object or stream can be seen as a collection of objects (just as the MPEG-4 video scene structure) and has an XML document describing these objects, their characteristics and their functionality (similarly to the MPEG-4 BIFS [7]). Furthermore, we assume that each object can be given a weight (or a vector of weights for various qualities of the same object) according to its importance in the scene (author specified) and the user preferences (e.g., using a utility function on stream components and their presentation quality). With this information, the user device could decide to prefetch, or the portal could decide to transmit ahead of requests, a number of objects in the order of their significance, when bandwidth is plentiful, anticipating congestion or disconnection periods.

We assume that users employ devices which have significant, but limited storage capabilities (in the range of MBs, quite feasible today with flash RAM) and relatively high peak data rates (in the Mb/s or tens of Mb/s range, quite easily available with today's WLANs and soon through 3G systems such as UMTS). We also assume that the content to be accessed or distributed is multimedia data available on various Web and media servers and channeled through our *Mobile Multimedia Portal*. A particular case we consider is video encoded in MPEG-4 format.

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* This research has been funded in part by the Greek General Secretariat of Research and Technology and the European Social Fund, through PENED’99 grant No. 99ED-193.

Issues

Key desirable properties of such an architecture are: minimum response time (or actually, response time within user prespecified limits), smoothness in presentation of continuous media, ease of integration into systems, support for service personalization and localization, and low development, deployment and maintenance cost.

Many issues arise in this context. Where should such a system be "located"? Is one or a centralized system enough or should we design a distributed environment? What would its parameters and attributes be? Is LDAP [8] a good choice for (dynamic) personalization? How exactly would a mobile device exploit such a system or service? Is there enough bandwidth for such a service? The problem becomes more complex if one considers the wide variety of mobile devices, differences in the networking infrastructure, in particular those supporting mobility, and the diversity of Web content.

Additional technical questions include deciding on the method of caching and or prefetching to be used. As presented in [9], the technique of on demand prefetching gives the best solution as it does not abuse network resources and has higher statistical probability of reusing the cached material. This probability is expected to have a strong impact on system performance since we expect reasonable information and prediction about what the user has requested, what will need next, where s/he is located and where s/he is going next, as well as current estimates of the available system resources.

Our Approach

Our approach uses various techniques such as prefetching, content and quality personalization, user profile synchronization, user movement prediction and dynamic bandwidth estimation. The main idea is to be able to describe the multimedia content using attributes and properties, combined with user preferences as well as to deal with localization and network specific issues in a hierarchical way. In such a model we can store information regarding the description of content, e.g., an MPEG-4 file or a Web site, in a way similar to BIFS. BIFS stands for Binary Format for Scenes, the mapping of the scene description into a parametric form, suitable for low-overhead transmission [7]. This representation format associates each node with a node type. Nodes are then represented by their node type and set of attribute value specifications.

In particular, we want to capture the objects comprising a multimedia scene, such as its background image, moving sprite and its associated sound stream, background music, synchronization information etc., the attributes of each object and the demands each of these objects poses on the network at different qualities. We will then be able to retrieve the user preferences, such as the user’s objects priorities (e.g., preference in listening rather than viewing) and determine information about the current user location, content that s/he has already downloaded and projections about what kind of content the user might ask for next. Then, if bandwidth availability permits and the device has the necessary capabilities we can prefetch the content to the user device or cache it to the nearest network access point.

The key system components are:

- **Mobile devices** with: limited storage capabilities, mobile IP awareness and high data rate wireless interface(s).
- **Leaf nodes** with: (relatively large) storage capabilities for content caching, mobile IP support, LDAP enabled, bandwidth estimation services provided to mobiles served by them, mobile station tracking and movement prediction capabilities, etc. Leaf nodes can be selected access points or basestation controllers or even basestation transceivers, depending on the technologies chosen.
- **Root node(s)**: which are similar to *leaf nodes*, but higher up in the hierarchy, supporting caching and content filtering, but most importantly enabling a hierarchical LDAP structure. Root nodes are typically selected servers in the core network.

A possible scenario is as follows. As proposed in [10] we probabilistically predict user movement and prefetch the personalized content to the (next) access point (that the user will most probably visit). The difference between our approach and the one outlined in [10] is that the agent deciding what objects to retrieve is not operating on the mobile device and with mobile device only information. The mobile device is mobile IP enabled (so that location changes do not affect established sessions), thus hand-offs between access points work seamlessly.

We chose to use an LDAP schema as the means of retrieving content attributes, user preferences and network parameters. Using such an approach we have the ability to easily adapt to a wide combination of content, user characteristics and network performance. In general, we will be able to know what has already been transmitted, the parameters of transmission, the user's next location (with an attached probability), what users like and how much bandwidth we have available. For example, if a user has requested an MPEG-2 video and has declared, according to his/her preferences, to retrieve only the I frames of the video, then algorithms like those described in [11] can be used.

Problems we are focusing on are how the profiling system should be organized, what prefetching algorithms should be used and how can such a system extend the LDAP schema based on user requests. An important question that arises is whether we should have a central organization or follow a distributed approach. We tend to support the distributed system approach with location-aware characteristics. The user profile will travel with the user as s/he changes locations. The combination of the user profile mechanism with the location aware profile of the server, the knowledge of what has already been transmitted and the knowledge of what is already cached, gives a good combination and a potentially high gain.

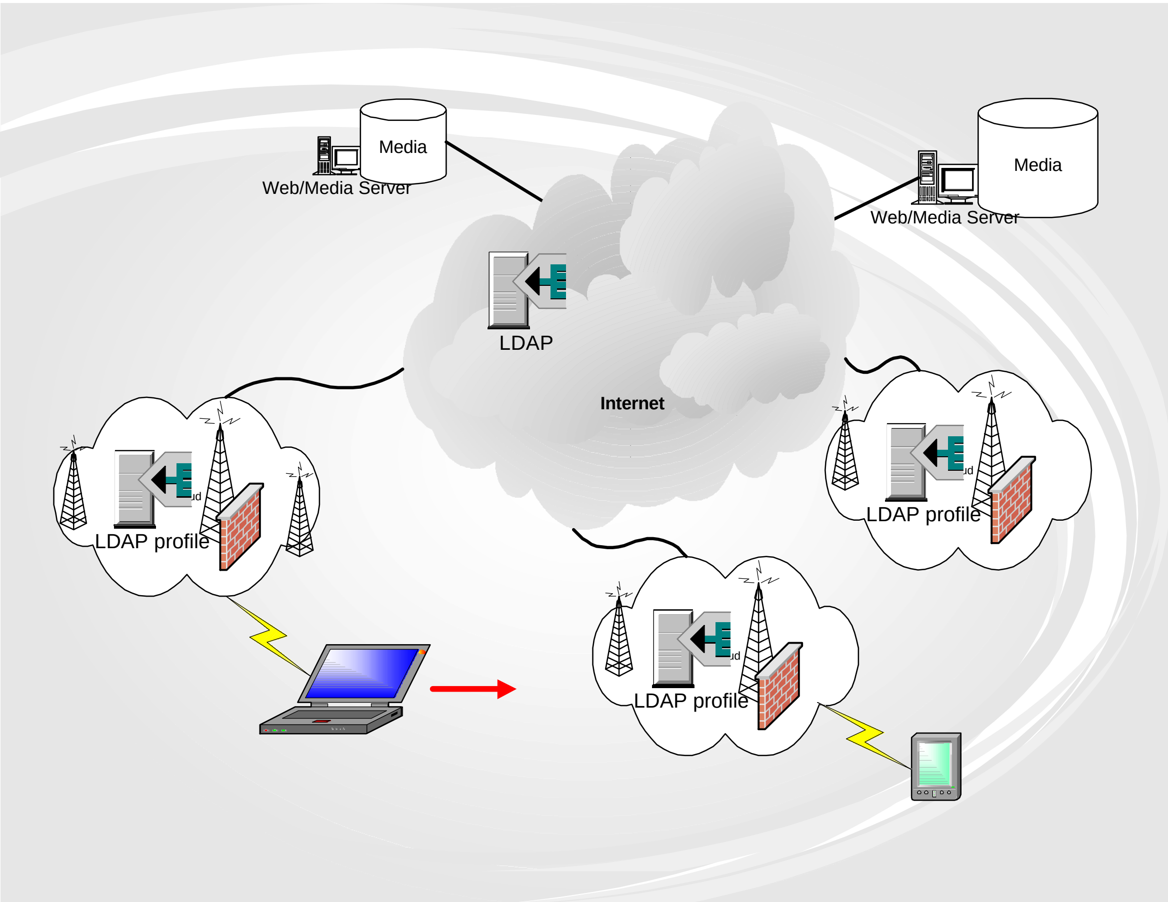

Figure 1: System depiction; LDAP hierarchy, networks with access points behind firewalls and with storage capabilities, mobile devices, and content servers.

The result is that, as we can predict where the user is going [10], we can prefetch the content that the user will most probably try to access to the next access point. The user's mobile device knows what has already been retrieved by the user, what s/he will probably need next and how much bandwidth is currently available. This knowledge can be advantageous when there is available bandwidth and the device can instruct the access point to prefetch the content that the user will probably need next.

Aiming towards a total solution, apart from the network infrastructure, we also need to implement a client-side application able to support the aforementioned requirements. Our aim is to design and implement an adaptive multimedia application that will be able to realize the features of our architectural framework. This application should have the following characteristics:

- Allow users to define and store their preferences by means of an interface to an LDAP server. This solution enables the automatic retrieval of personalized multimedia content.

- Allow users to dynamically interact with the content metadata and retrieve multimedia objects on-demand. This solution presents an alternative way of retrieving personalized multimedia content based on an interactive approach.
- Allow for a degree of interactivity between the user and the quality of multimedia content. Users should be able to dynamically pause, resume or even discard certain portions of the multimedia information (in terms of media objects and/or degradation of quality - transcoding).
- Allow for a degree of interactivity in terms of multimedia content presentation. Our goal is to enable users to interact with the content they have chosen to see by means of layering media objects in a structured and hierarchical way. Content metadata should be such that it will enable the spatiotemporal transformation of the whole multimedia scene. Users will then have the ability to move objects around the scene and change their layer precedence.

Conclusion

We described an adaptive, user-centric framework for multimedia access and dissemination that exploits features such as content characterization and adaptation, user profiles, and dynamic network estimation and blends them all together into an infrastructure for the provision of adaptive multimedia content over wireless networks to mobile devices. We specified a system capable of organizing user profiles in a hierarchical or distributed way based on LDAP, and the method for transferring profile information between agents in different cells or networks to be visited by the users. This enables prefetching of the multimedia metadata and also possibly the content itself based on the user preferences (available in the profile) and projected network conditions.

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