

University of Wollongong
Research Online

Faculty of Informatics - Papers (Archive)

Faculty of Engineering and Information
Sciences

December 2006

**Facilitating Universal Multimedia Adaptation (UMA) in a Heterogeneous
Peer-to-Peer Network**

L. Rong
University of Wollongong

I. Burnett
University of Wollongong, ianb@uow.edu.au

Follow this and additional works at: <https://ro.uow.edu.au/infopapers>

 Part of the [Physical Sciences and Mathematics Commons](#)

Recommended Citation

Rong, L. and Burnett, I.: Facilitating Universal Multimedia Adaptation (UMA) in a Heterogeneous Peer-to-Peer Network 2006.
<https://ro.uow.edu.au/infopapers/484>

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library: research-pubs@uow.edu.au

Facilitating Universal Multimedia Adaptation (UMA) in a Heterogeneous Peer-to-Peer Network

Abstract

This paper proposes a P2P architecture which uses MPEG-21 as a standard based technique to dynamically adapt resources according to various usage environment attributes such as terminal capabilities and user preferences. In the architecture, a super peer based approach is used to cluster peers, store peer information, perform searches and instruct peers to adapt/send resources. Pull and push-based adaptation methods are introduced to adapt search results and resources in an intelligent manner based on the usage environment attributes. Simulation results show that the proposed architecture reduces download time while increasing resource availabilities and download speed in the network when compared to traditional P2P systems.

Disciplines

Physical Sciences and Mathematics

Publication Details

This paper was originally published as: Rong, L & Burnett, I, Facilitating Universal Multimedia Adaptation (UMA) in a Heterogeneous Peer-to-Peer Network, Second International Conference on Automated Production of Cross Media Content for Multi-Channel Distribution (AXMEDIS '06), Leeds, UK, December 2006, 105-109. Copyright IEEE 2006.

Facilitating Universal Multimedia Adaptation (UMA) in a heterogeneous Peer-to-Peer Network

Letian Rong, Ian Burnett
University of Wollongong and CRC SIT, Australia
lr98@uow.edu.au, i.burnett@elec.uow.edu.au

Abstract

This paper proposes a P2P architecture which uses MPEG-21 as a standard based technique to dynamically adapt resources according to various usage environment attributes such as terminal capabilities and user preferences. In the architecture, a super peer based approach is used to cluster peers, store peer information, perform searches and instruct peers to adapt/send resources. Pull and push-based adaptation methods are introduced to adapt search results and resources in an intelligent manner based on the usage environment attributes. Simulation results show that the proposed architecture reduces download time while increasing resource availabilities and download speed in the network when compared to traditional P2P systems.

1. Introduction

Universal Multimedia Access (UMA) allows users to access a full array of multimedia content in various formats using many devices [2]. While several papers discuss UMA in broadcast and communication systems, UMA in a P2P environment has remained largely unexplored.

This paper is structured in the following way: in section 2 the multimedia framework MPEG-21 is explained to provide readers with a general understanding of the standard which is used in the proposed architecture. The P2P architecture is then considered in section 3 with section 4 detailing the simulation. In section 5 we draw conclusions.

2. MPEG-21

MPEG-21 is a 'multimedia framework standard' from the Moving Pictures Expert Group (MPEG); it supports multimedia access and delivery using heterogeneous networks and terminals in an

interoperable and highly automated manner [4]. The proposed P2P architecture predominantly uses two key components of MPEG-21 to facilitate dynamic resource adaptations, namely, Digital Items and Digital Item Adaptation.

2.1. Digital Item (DI)

The fundamental unit of distribution and transaction in the MPEG-21 framework is the Digital Item (DI). It can be considered as a structured digital object which consists of resource(s) (e.g., a photo album, a web page) and related information on the manipulation of the resource(s) (e.g., terminal capabilities, intellectual property management requirements). A DI is generally declared using the Digital Item Declaration Language (DIDL) [5] which is expressed in XML Schema. A typical DI consists of resource(s), a list of Choices that correspond to the various adaptation aspects of those resources and Digital Item Adaptation (DIA) information which steers the adaptation process.

2.2. Digital Item Adaptation (DIA)

One of the main goals of MPEG-21 is to provide solutions for universal multimedia access (UMA). This led to the creation of a distinct part in MPEG-21: Digital Item Adaptation (DIA) [6]. This is one of the largest parts in MPEG-21 and contains tools for adapting resources on the basis of descriptions to produce a modified Digital Item.

The DIA Tools represent a collection of descriptions and format-independent mechanisms providing support for Digital Item Adaptation. The descriptors are represented in XML and can be either wrapped in a DI or used independently. The DIA Tools are further clustered into eight major categories, but, in our work, we use just two of those tools: Usage Environment Description and DIA Configuration.

The Usage Environment Description tools include descriptors that describe various dimensions of the

usage environment, namely, user characteristics, terminal capabilities, network characteristics and natural environment characteristics. The DIA Configuration tools specify how and where the related usage environment information can be used for the adaptation of DIs. Also, these identify whether a Choice in a DI should be configured manually or automatically according to the Usage Environment Descriptors associated with the Choice. The usage of these related tools is explained in the following section.

3. P2P Architecture

3.1. Resource, usage environment and adaptation process presentation

The Digital Item concept is adopted to represent resources in the proposed architecture with the advantage that the DI broadens the concept of a media resource from that of a single file to a complete user experience. For example, a DI representing the movie trailers for the movie “Lord of the Rings” could include movie trailers and sample sound track sections. Choices such as the language option for displaying the movie subtitles could also be included explicitly in the DI. Furthermore, DIs could contain DIA descriptor information such as DIAConfiguration to specify where each adaptation operation should occur (e.g., on the receiver side, sender side etc.). In addition, the Usage Environment Descriptions tools are used to describe the usage environment attributes in the architecture.

3.2. P2P architecture design

We take a super peer based approach [7] in building the P2P system architecture. The motivation and advantages behind using a super peer based approach are: 1. super peers can be used to store peer and resource related information and, 2. super peers can use that information to make important decisions in a dynamic P2P system; examples might be searching for resources and assigning peers to perform resource adaptations and sending. This is more scalable than a pure P2P system which requires peer and resource related information to be broadcast to surrounding peers [3]; such broadcasts are costly (in bandwidth terms) and have limited coverage in a large P2P network.

Based on the super peer design, peers are grouped into clusters and super peers are nominated to be in

charge of one or more clusters. Two types of super peers are defined in the architecture: category super peers (C_SP) and locality super peers (L_SP). A C_SP or a number of C_SPs govern peers which share content that belongs to a particular category, while each L_SP is in charge of peers within a certain locality range. Metrics such as IP address, RTT and physical distance can be used as locality attributes and their feasibility and performance in our system is currently under investigation.

When new peers join the network, they must first register with a corresponding L_SP based on their locality attributes and then submit related usage environment attributes (i.e., user preferences) to that L_SP. Peers can then register information of their shared content (described as DIs) with one or more C_SPs; this includes submitting related usage environment attributes (i.e., terminal capabilities). The usage of the registered usage environment attributes is explained in the adaptation approaches in the following section.

3.3. Pull-based and push-based adaptation approaches

Two different, two-stage adaptation approaches are proposed in the architecture to accommodate varying user needs: a pull-based and a push-based adaptation approach. The two approaches can be used together to complement each other or individually, based on user settings. The aim is to guide users through the search and consumption cycle of adapted resources without exposing them to unnecessary technical details. With the pull-based approach, a request peer initiates the search of a resource and submits the request to the corresponding C_SP, while in the push-based approach, C_SPs use registered DIA descriptors (i.e., user preferences) to send information of new shared content to potentially interested peers. Both approaches consist of the following stages: 1. the adaptation of the initial search results, and 2. the adaptation of the requested multimedia resource. The two approaches are only different in the first two steps. The full set of steps is shown in Figure 1 and will be explained here in greater detail:

Step 1 pull_a (pull-based approach): The initial search function is performed by submitting a request with the search keyword to the corresponding C_SP based on the cluster for which the user would like to search in. The request also includes DIA descriptors (i.e. user preferences) that relates to the search.

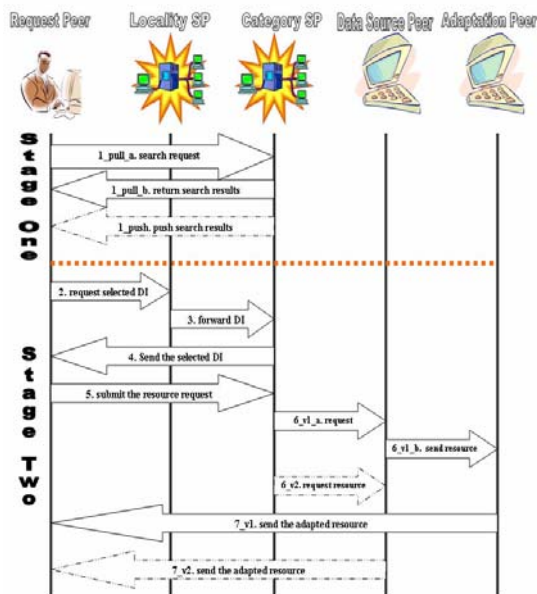


Figure 1. two-stages adaptation approaches

Step 1_pull_b (pull-based approach): Once the C_SP receives the request, it searches for DIs according to the search keyword and DIA descriptors of the user. This filtering process is considered to be the first adaptation phase in the approach as it uses the usage environment knowledge from the user to adapt the search result to that user's requirements. An example of this mechanism in operation would be a user in Japan who is only interested in receiving information about the movie "The Ring" in Japanese.

Step 1_push (push-based approach): Alternatively, in the push-based approach, C_SPs periodically "pushes" new content to potentially interested peers in a category based on their registered DIA descriptors.

Step 2: The second adaptation stage starts once the request peer receives the result which contains descriptions of the DIs that meet the search criteria. This stage consists of a content negotiation approach which was initially proposed in our previous work [8], adapted and modified to accommodate dynamic resource adaptations in the P2P architecture. The approach is initiated by the user selecting a DI from the search result list and forwards the request to its L_SP.

Step 3: The L_SP then retrieves the peer IDs of all the peers in the locality cluster and forwards the ID list, together with the request, to the corresponding C_SP (note: based on [1], we define the size of locality clusters to be within the range of 75-150 and therefore the peer ID list would not be too large). In addition, the L_SP searches registered usage environment attributes of peers in its cluster for idling high-end peers with the

ability to perform adaptations that are related to the request and forwards the idling peer list to the C_SP.

Step 4: The C_SP sends the requested DI to the request peer and puts both the peer IDs list and the idling peer list to the local cache. The C_SP could also perform some adaptations on the requested DI before sending it according to the DIA descriptors it has received in *step 1_pull_a* before forwarding it to the request peer. For the push-based approach, the DIA descriptors are received previously during the registration stage. An example of possible adaptations on the requested DI would be the short-listing of the Choices in the DI. The result might be to remove Choices in a DI which are not related to the user's preferences.

Step 5: After the request peer receives the modified DI, it performs certain adaptation and Choice selections based on its DIA descriptors (e.g., select the video format on the basis of available decoders). This is followed by transmission of a resource request to the C_SP. The request can include further DIA descriptors to be used by the adaptation peer during the resource adaptation process (e.g., screen resolution of the requesting peer).

Step 6_v1_a and 6_v1_b: The C_SP then selects the peer sender who is within the locality range of the request peer and is capable of sending the requested resource based on the registered information of shared content and DIA descriptors of their hosting peers, as well as the forwarded peer IDs. Next, the C_SP uses the stored idling peer list in the local cache to determine if there are potential idling peers who have higher terminal capabilities than the peer sender (i.e., processing power) in terms of adapting the resource. If a potential adaptation peer is found from the list, the super peer requests the peer sender to transfer the resource to the adaptation peer for adaptation. If no peer sender or adaptation peer can be found in the locality, then the search is expanded into the nearest locality clusters until either a result is found or a predefined search boundary is reached (i.e., 5 locality clusters).

Step 6_v2 (alternative step): If no potential adaptation peer is found, then the peer sender simply adapts and sends the resource by itself.

Step 7_v1 and step 7_v2 (alternative step): the adaptation peer or the peer sender performs the resource adaptation accordingly and then transmits the resource directly to the request peer.

4. Simulation

A java-based simulation was created to evaluate the performance of the proposed architecture and multi-

thread technology is deployed to simulate the simultaneous interactions between peers. The simulation is initialized by preloading the network with a specified number of normal peers, super peers and resources. Normal peers are further classified into ‘provider peers’ and ‘freeloaders’. The resources are populated into the network according to the Zipf distribution. To simulate heterogeneous devices, four classes of device capability and bandwidth are currently used to simulate access through Desktop, Laptop, PDA and mobile phone devices with different connections. These system settings and peer behaviors conform to the findings in the survey from [9] and in particular, Liang et al.’s survey on KaZaA [1].

Table 1. Simulation settings

Total no. of peers	100,000
No. of category super peers	1,000
No. of locality super peers	1,000
No. of provider peers	8,000
No. of freeloaders	90,000
No. of unique resources (initially during startup)	5,000
Resource size	10-300 Mbs
Percentage of total resources owned by freeloaders	30%
Percentage of total resources owned by provider peers/super peers	70%
Zipf skew factor	0.271
No. of new peers joined the network while running	20,000
No. of peers left the network while running	20,000
Total no. of requests	500,000

During the simulation, a predefined number of randomly generated/selected peers with resources are allowed to join/leave the network at random intervals, as well as the popularities of old resources being allowed to gradually decrease. Requests are generated by peers in the system at random time intervals.

The following comparisons are made between the performance of the proposed architecture (PROP_1), the proposed architecture without utilizing idling peers for adaptation (PROP_2) and traditional P2P systems where resources are simply downloaded and consumed by peers without any adaptations (TRAD). We assume that with PROP_1, 10% of total peers are capable of performing adaptations for other peers when they are idling. The simulation settings in Table 1 were used to

obtain the results and we have also simulated other peer compositions which have shown similar trends in the results.

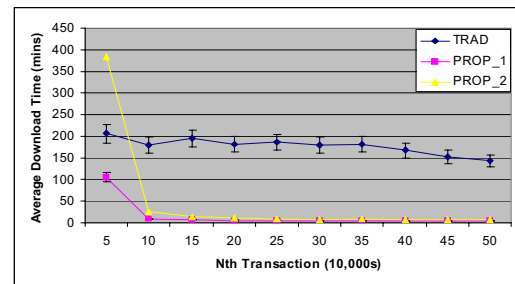


Figure 2. Average download time (vertical bars denote 95% confidence intervals)

Average download time is used as a performance metric to compare the three systems. As shown in Fig. 2, PROP_2 had a much higher average download time initially (in comparison to TRAD), due to the extra time spent adapting/down-scaling resources to appropriate sizes, but the additional adaptation time quickly dissipates as more adapted resource variations match peer capabilities. On the other hand, PROP_1 closes this initial gap by utilizing the computing power of high-end peers to adapt resources for the low-end peers in the network and also reduces the overall download time throughout the simulation.

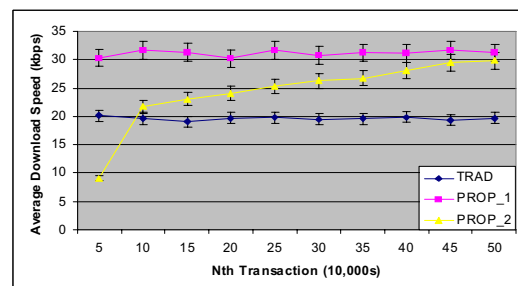


Figure 3. Average download speed of low-end peers (vertical bars denote 95% confidence)

The number of resources on the network was also periodically recorded. We found that PROP_2, on average, has 10-15% more resources in the P2P network than TRAD as whenever adaptation occurs during a transaction, two adapted copies of the resource are created (i.e., on both the provider peer and request peer side). Next, in comparison to PROP_2, PROP_1 further increases the overall number of resources by 10% as every time an adaptation task is forwarded to an idling peer, one additional copy of the original resource is created during the process (i.e., original copy transferred to the idling peer to be adapted). These increases in available resources boost the average download speed as less congregated downloads (i.e., multiple peers downloading from the

same peer) would occur in the network and it is particularly evident with low-end PDA and mobile phone peers as shown in Fig. 3.

5. Conclusion

In this paper, we have proposed an architecture that facilitates dynamic resource adaptation in a P2P network. The architecture utilizes the Digital Item and DIA concepts from MPEG-21 to support a UMA concept for P2P resource sharing. Simulation has shown that our system reduces the average download time while increasing resource availabilities and download speeds.

6. References

- [1] J. Liang, R. Kumar, and K.W. Ross, "The KaZaA Overlay: A Measurement Study," *Computer Networks* (Special Issue on Overlays), 2005.
- [2] F. Pereira, I. Burnett, "Universal Multimedia Experiences for Tomorrow," *Signal Processing Magazine*, IEEE, Volume: 20, Issue: 2, March 2003, pp. 63 – 73.
- [3] R. Lienhart, M. Holliman, Y. Chen, I. Kozintsev, M. Yeung, A. Zaccarin, and R. Puri, "Challenges in Distributed Video Management and Delivery," *Handbook of Video Databases*, CRC Press, Boca Raton, Florida, 2003.
- [4] J. Bormans, J. Gelissen, and A. Perkis, "MPEG-21: The 21st Century Multimedia Framework," *IEEE Signal Processing Magazine*, March, 2003.
- [5] V. Iverson, T. Schwartz, Y. Song, R. Walle, E. Santos and D. Chang, "MPEG-21 Digital Item Declaration FDIS," ISO/IEC JTC1/SC29/WG11/N4813, May, 2002.
- [6] A. Vetro, S. Devillers and C. Timmerer, "ISO/IEC 21000-7 FDIS – Part 7: Digital Item Adaptation," ISO/IEC JTC1/SC29/WG11/N6168, January, 2004.
- [7] B. Yang, and H. Garcia-Molina, "Design a Super-Peer Network," in proceeding of the 19th International Conference on Data Engineering (ICDE'03), Bangalore, India, March, 2003.
- [8] L. Rong and I. Burnett, "Dynamic Adaptation and Updating of Media Streams with MPEG-21," *Consumer Communications and Network Conference 2004 (CCNC04)*, Las Vegas, USA, January, 2004.
- [9] S. Saroiu, P. K. Gummadi, and S. D. Gribble, "A Measurement Study of Peer-to-Peer File Sharing Systems," in proceeding of the *Multimedia Computing and Networking*, January, 2002.