Application Networking on Peer-to-peer Networks

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ABSTRACT
This paper proposes the AN.P2P architecture to facilitate efficient peer-to-peer content delivery with heterogeneous presentation requirements. In general, the AN.P2P enables a peer to deliver the original content objects and an associated workflow to other peers. The workflow is composed of content adaptation tasks. Hence, the recipient can reuse the original object to generate appropriate presentations for other peers.

Categories and Subject Descriptors
C.2.5 [Computer Communication Networks]: Local and Wide Area Networks - *Internet*; I.6.3 [Simulation and Modeling]: Applications

General Terms
Design, Performance, Experimentation

Keywords
Application Networking, Peer-to-peer content distribution

1. INTRODUCTION
In recent years, peer-to-peer systems witness more heterogeneous service requirements due to the emergence of diverse user devices. However, conventional peer-to-peer file sharing applications cannot effectively deal with these requirements due to the lack of system support for content adaptation. For instance, a piece of high quality media content shared by a desktop peer can not be easily rendered on a smart phone peer because of its limited processing capability.

A suggested solution is to allow the *home peer*, which publishes the content, to adapt the content presentation before it is sent to the *requesting peer*. The retrieved object presentation will be shared by the peer. However, the main drawback of this method is that the fully adapted presentation has significantly reduced reusability for other peers with different presentation requirements.

In particular, the reduction of peer sharing benefit could cause longer query forwarding path or even the query failure. In addition, on the proximity aware routing substrates, the prolonged query path implies longer transmission distance for the response object.

This paper proposes the architecture of Application Networking on peer-to-peer (AN.P2P) to facilitate efficient peer-to-peer file sharing for heterogeneous presentation requirements. The key idea of this study came from the observation that despite of the heterogeneous requirements for content presentations, the processes to generate the presentations are homogeneous. It means that different presentations are generated from the same original object and the uniform adaptation workflow. Hence, if we allow the peers to deliver the original object and an associated content adaptation workflow, the recipient peers would be able to reuse the object to generate the appropriate presentations.

2. ARCHITECTURE
The architecture of the AN.P2P platform is shown in figure 1. Any peer can install the platform on top of its peer-to-peer routing substrate. The AN.P2P Proc. is the central process of the AN.P2P platform; the AN.P2P Storage is used to store and manage the original content authored on this peer; the AN.P2P Cache is used to cache the retrieved object replicas and the associated workflow; and the ANlet Pool is used to store mobile applications, each of which performs a particular content adaptation task. In AN.P2P platform, we defined a standard mobile application interface, ANlet. Applications that implement this interface can be loaded dynamically by the AN.P2P peers.

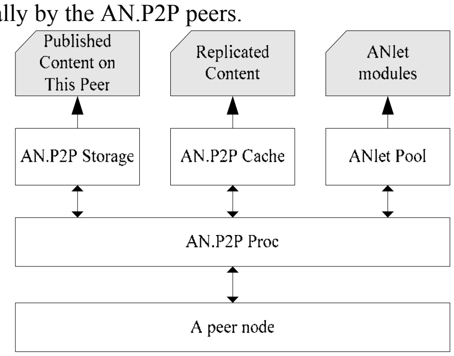

Figure 1 Structure of AN.P2P on a single peer node

The general operations of the AN.P2P network are illustrated in figure 2.

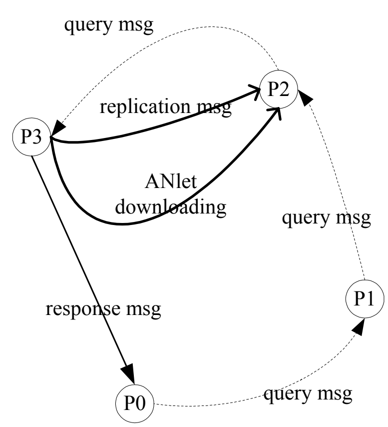

Figure 2 General operations of AN.P2P

To publish a piece of content, the content provider inserts the original object and an associated workflow to the home peer. The workflow is composed by multiple content adaptation tasks, each

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of which needs to be instantiated with a particular ANlet. The workflow also provides the URLs from which the relevant ANlets can be retrieved.

Upon receiving a query for the content, the home peer will generate the appropriate content presentation according to the requesting peer's presentation profile carried in the query message. The generated presentation is sent directly to the requesting peer within a response message. In addition, the home peer can select an intermediate peer to replicate the original object and the associated workflow. The replication message will be cached by the selected peer.

When this intermediate peer receives a new query for the same content, it can retrieve the object from the local cache. According the URL supplied by the associated workflow, the peer downloads the ANlets to instantiate the workflow tasks. Then the peer inputs the object to the workflow to generate the content presentation for the new requesting peer. Finally, the downloaded ANlets will be stored in the application pool for later reuse.

Therefore, the original content object and the workflow can be populated within the network to serve peers with various presentation requirements.

Theoretically, the AN.P2P platform is not mandatory to be installed on each peer. When an AN.P2P peer delivers object to an ordinary peer, it sends an appropriate content presentation as if the AN.P2P mechanism was transparent to the peer. In contrast, when an AN.P2P peer replicates to another AN.P2P peer, it can send the original object and the associated workflow. We believe this back compatibility feature could facilitate the adoption of AN.P2P mechanism into existed peer-to-peer networks.

3. PERFORMANCE

An AN.P2P prototype has been implemented based on the Pastry structured substrate [1]. We verify the effectiveness of the AN.P2P using an emulated P2P-DRM service [2]. It supplies copyrighted media contents to peers on the PC, the PDA or the smart phone.

When authoring a piece of content, the content provider first secures the original media object using an encryption key. Then the content provider encapsulates the secured object and an associated P2P-DRM workflow in a XML container, which is published on its home peer and any peer can download it freely. To render the content, the client's media player needs to retrieve a license that supplies the key to disclose the secured object.

The P2P-DRM workflow is composed by two ANlets. Each of them contains the key to decrypt the associated object, transform it, and write it back securely using the key. The first ANlet can trim the original media object to a thinner version according to the type of the recipient device. In particular, the peers resided on PC can render the full quality media content, while the peers on PDA or the smart phone can only render partial quality content. The second ANlet inserts the watermark into the response media object. It uses the certificate of the requesting peer to generate the watermark. Hence, the recipient of the media content can be traced using its embedded watermark. Any unauthorized broadcasting of this content will be detected by scanning its embedded watermark.

We simulate a plain peer-to-peer network by restricting both ANlets to the home peer of each content. In this case, all queries need to be forwarded to the home peer of the requested content, because the watermarked content is not authorized to be sent to other peers. However, in the AN.P2P network, we allow the original object and associated workflow to be replicated to the PC and the PDA based peers. By executing the ANlets, these peers can adapt the media quality and generate the correct watermark to other peers.

We measure the performance of the two methods above in a network of 256 peers and 1024 published media contents. The user requests follow the Zipf-like distribution with λ=0.7. The simulation results are given in figure 3 and 4 respectively.

Figure 3 presents the average query hops under different peer cache size. The result shows that the AN.P2P method can help to reduce the average query hops due to the reuse of original object replicas. In contrast, the plain peer-to-peer method cannot benefit from peer sharing because the final response objects have little reusability.

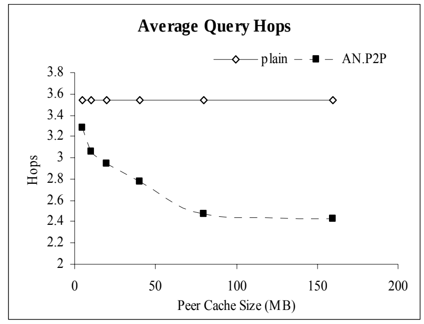

Figure 3 Average query hops

Figure 4 shows the multiplication of the size of response object and the corresponding distance between the source and the target peer. The figure shows that the AN.P2P method significantly outperforms the plain method. When the peer cache size reaches 80MB, the size*dist value of the AN.P2P method is only 60% to that of the plain method. This implies the AN.P2P can help to reduce the user perceived latency of downloading the objects.

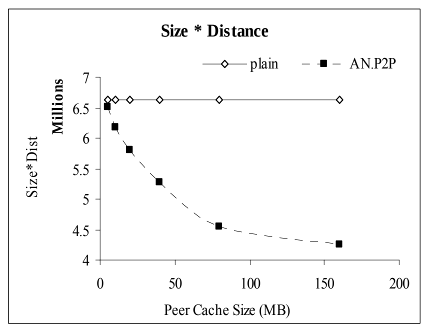

Figure 4 Response cost

In summary, the simulation results show that the AN.P2P method can effectively improve the overall system performance due to the reuse of original objects and the associated content adaptation workflow.

4. REFERENCES

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