Co-operative Content Adaptation Framework

Satisfying Consumer and Content Creator in Resource Constrained Browsing

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ABSTRACT

Mobile Web is characterized by two salient features, (i) ubiquitous access to content and (ii) limited resources, like bandwidth and battery. Since most web pages are designed for the wired Internet, it is challenging to adapt the pages seamlessly to ensure a satisfactory mobile web experience. Content heavy web pages lead to longer load time on mobile browsers. Pre-defined load order of items in a page does not adapt to mobile browsing habits, where user looks for different snippets of a page to load under different contexts. Web content adaptation for mobile web has mainly focused on the user to define her preferences for content. We propose a framework where content creator is additionally included in guiding the adaptation. Allowing content creator to specify importance of items in a page also helps in factoring her incentives by pushing revenue generating content. We present mechanisms to enable cooperative content adaptation. Preliminary results show the efficacy of cooperative content adaptation in resource constrained mobile browsing scenario.

Categories and Subject Descriptors: H.3.5 [**Online Information Services**]: Web-based Services

General Terms: Design, Performance

Keywords: Mobile Browsing, Content Adaptation

1. INTRODUCTION

Mobile web popularity and usage is surpassing fixed Internet. But mobile web tends to suffer from restrictions, like data usage cap, low network bandwidth, limited battery power. Yet, the users often expect the same level of experience as the wired Internet. Web pages, which were mostly text based, have evolved in complexity with various embedded media content [2, 3]. Bloated web pages take longer to download on mobile, consuming more resources [7]. On mobile web, where the average connection speed can vary from 324 Kbps to 7.8 Mbps [1], user experience varies significantly. Several companies are developing multiple web experiences, namely mobile optimized websites. But many companies lack the budget and resources to manage multiple web experiences.

Browsing habits of users in mobile web and fixed Internet are significantly different. While desktop and tablet users often search for deeper information, the mobile user tends to seek small snippets of easily consumable information compatible with the context. The possible contexts can be diverse and dynamic in nature.

Web content adaptation has been an answer to the challenges, especially to adapt to the device, network and browser variability. Adaptation to manage scarce resources like limited data download plans is addressed by [4]. On use of context and user preference, Urica uses explicit user preference [6], while Mimosa automatically determines user context to adapt the content [5]. However, none of the web content adaptation approaches include the content creator, who is well-aware about the semantic importance of the content.

We propose that the content creator and the user to be part of the web content adaptation process, while adapting content under resource limitations. In cooperative content adaptation, the content creator tags the importance of each item in a page during creation. For instance, in a news page, the content creator can tag the most important news item. The user expresses her preference for different content blocks, like image, video, audio and advertisements, under different contexts. For example, while walking, user may prefer audio content over video. Before servicing a web page request, first a combined score for each item in a page is computed based on the importance assigned by content creator and the preference set by user for the context she is in. Then, items are loaded based on the highest combined score, thereby loading the most relevant items till a resource is used up.

2. ADAPTATION FRAMEWORK

Two key design considerations in cooperative content adaptation are (i) ease of assigning preferences or scores for items, and (ii) combining the scores to generate an ordered list for loading sequentially. A web page consists of different classes of content, viz. text, image, audio, video, advertisements. A user specifies the order of importance among these items in different contexts, instead of assigning importance to each individual item. On the other hand, the content creator assigns importance to each item, thereby ranking each item. The implementation of the score assignment framework can benefit from the HTML5 standards by introducing additional attributes.

Given user and developer preferences for each item, and the resource budget of the device, the content selection problem is formulated as follows. Let there be m items in a page consisting of images, videos, audios, and ads *etc.* Let there be n resources for which the maximum usage budget is specified as R_j, where $j \in \{1, 2, \ldots, n\}$. Let X be the boolean vector which denotes a specific selection of items. We need to find the selection X which maximizes a utility function, $\mathcal{F}$, as: $arg\, max\, \mathcal{F}(X),\ x_i \in \{0, 1\}$

such that: $\forall j \in \{1, 2 \ldots, n\} \quad \sum_{i=1}^{m} x_i r_{ij} \leq R_j$

We aim to maximize the combined user and developer satisfaction, based on their scores for individual items. Therefore the utility function, $\mathcal{F}$, is the sum of the combined scores of user and developer, represented as: $\mathcal{F}(X) = \sum_{i=1}^{m} x_i z_i$, where z_i represents a composite score (single value) per item by combining the user and developer's score for that item.

We consider a vector, Z, of size m, that contains the z_i values. Z is computed as: $Z = f(\mathcal{D}, \mathcal{U})$, where $\mathcal{D}$ and $\mathcal{U}$ are vectors of size m representing developer and user scores for each item respectively. For our experimental purposes, we apply the scalar product operator on the $\mathcal{D}$ and $\mathcal{U}$ vectors: $Z = f(\mathcal{D}, \mathcal{U}) = \mathcal{D}.\mathcal{U}$.

Implementation of the framework assumes an intermediate proxy, hosted by a service provider, that executes the optimization algorithm for item selection and delivery. However, this requires user preferences to be exposed to the service provider. Alternatively a privacy preserving design, similar to client only browser [8], can also be implemented where the selection of items is done on the device. Instead of fetching each item, the device receives a summary file that provides the size of each item on the web page. With the sizes as input, the optimization algorithm runs on the device.

3. PRELIMINARY RESULT

To validate cooperative content adaptation, we load a web page from a news site with and without adaptation. We observe the difference in how the items in a page are loaded when user and content creator preference is taken into consideration, in comparison to without any adaptation. The request for the page is issued from an Android browser. User preferences and content creator scores for each item is shown in Figure 1.
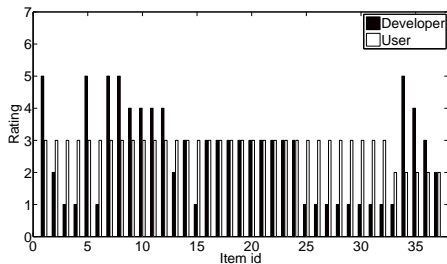
**Figure 1: News site: Preference scores from developer and user for each item in the page**

Figure 2 shows the order in which the items were loaded from the same page without and with adaptation. With cooperative content adaptation, more relevant items are loaded early into the browser. Hence if there is a cutoff in terms of number of bytes to be loaded, with adaptation more relevant items will be loaded before the less relevant items.

4. CONCLUSION

User experience in mobile web is affected by factors, like device diversity, network bandwidth and resource limitations. Growing complexity of web pages adversely affects page load time in a mobile browser. When a mobile user is interested in a snippet of a page, waiting for the entire page to load could be frustrating. Dynamic web content adaptation, guided by user preference in different contexts, helps in improving user experience in mobile web. However, involving content creator in the adaptation process can improve user experience further. Cooperative content adaptation technique takes into account user's preference for content
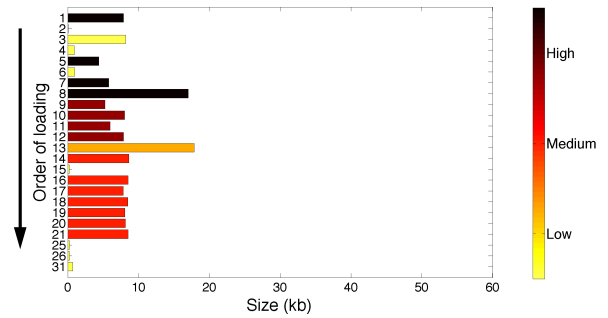
(a) Web page items loaded without adaptation
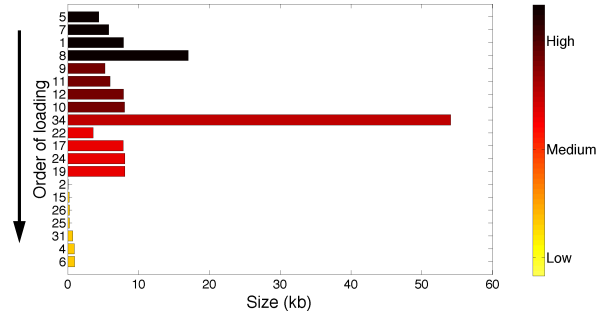
(b) Web page items loaded with adaptation

Figure 2: News site: Comparison of items selected and the loading order with and without using cooperative adaptation. Y-axis shows the item id and loading order, color and length of the bar denotes combined importance score and load time for the item respectively.

types, along with importance assigned by content creator, to generate an order to load the items in a page. Under resource constraints, like limited download capacity, more relevant items are loaded first. Preliminary result on a news site shows the efficacy of the approach.

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