Summary Review Documentation for

“Breaking for Commercial: Characterizing Mobile Advertising”


Reviewer #1

Summary: This paper analyzes the energy consumption of the advertising and analytics services used by mobile applications. Then it proposes AdCache, a cached based delivery mechanism to retrieve ads under optimal network conditions, and demonstrates that it can indeed reduce energy consumption of mobile ads.

As far as I know, this is the first paper that characterizes mobile ads traffic using real data. However, I find the motivation for AdCache lacking – the overall impact of the paper is questionable given that ad traffic accounts for only 1% of total volume. The methods utilized AdCache are not new.

Strengths: Interesting measurement study: use of real traces to characterize mobile ads & its energy impact. Real implementation of AdCache on Android devices to optimize mobile ads delivery.

Weaknesses: The motivation for AdCache is lacking/weak. This is very specific study and provides solutions aiming only at Ad traffic. Given that only 4-5% users click on the ad, and mobile ads only account for 1.3% of bytes and 5.4% of flows, the overall impact (especially from energy saving perspective) is questionable.

AdCache uses well-known techniques (batching/caching), where the bandwidth/power savings are expected. Also, the evaluation of AdCache is rather thin.

Comments to authors: The first part of the study is informative and provides a nice characterization of mobile ad traffic across different device types and ad services. It attempts to dig a little bit deeper to understand user interactions with ad service in terms of repeated downloads & click rate. However, the Click popularity (4-5% users w/ ≤1 click) shown in Table 4 does not provide a convincing motivation for AdCache. Since the analysis is done based on one day of trace, it’s also hard to say anything about the ‘increasing’ trend of mobile ads.

Given that mobile ads only constitute a small part (1.3% average) of the overall smart phone traffic, it’s unclear if the energy savings achieved by AdCache is really that significant. In addition, other types of mobile traffic, e.g., bursty and/or periodic data transfer, have been shown to have huge impact on energy consumption. In fact a multitude of optimization techniques have been proposed to cope with bursty & periodic data transfer, would those have taken care of some of the periodical ad communications? It would have been nice to put this work in larger context to get a better understanding of the real impact of AdCache.

Section 5 compares the energy cost of fetching ads under cellular network and wifi for different ad service & refresh rate. However, given that energy consumption is highly dependent on the SNR, it’s too pre-mature to draw any conclusions from this single set of experiments regarding which connectivity (3G vs. WiFi) incurs higher energy cost.

The basic mechanisms for AdCache are not that novel – the ideas of pre-fetching, caching, hunting for better network condition for transmissions have been previously employed to save bandwidth (scarce resources), which naturally also lead to energy savings on devices. Nevertheless, it is nice that the paper demonstrates through real implementation that AdCache indeed saves energy by avoiding repeated download and batching activity reports.

Evaluation of AdCache is done by comparing energy consumption with mobile ads running in isolation on Android devices. It would have been more convincing to consider realistic and typical usage scenarios with normal mobile traffic/apps running (or perhaps with synthetic workload generated based on traces).

Reviewer #2

Summary: The paper conducts a measurement study on ad traffic by monitoring the traffic of 3 million users over a day. The authors use a set of regular expressions to isolate ad traffic from other traffic. The authors then present a system called AdCache that improves the energy consumption of ad delivery.

Strengths: The paper presents several interesting findings about ad traffic. For example, 1% of traffic on iPhone and 3% of traffic on Android are ad traffic; 1% of the users use 2MB of data per day for ads; ads are not bunched together and instead are downloaded periodically, and this increases the energy consumption because of 3G tail; most ads are served by a single CDN/server.

Weaknesses: Measurement study lacks focus and structure. Ad-Cache system seems hastily put together and is not presented in detail. Also, I am not convinced that it provides significant benefits.

Comments to authors: AdCache: I buy the problem: ads increase the energy consumption and use up data bandwidth of the user. The AdCache solution downloads all the ads in batches and then presents them to the user. The main savings is batches, as it reduces the 3G tail energy (there is not much benefit for WiFi, and the authors acknowledge this). However, ads only form 1% (or 3%) of the traffic. Given this, there are no evaluations of the energy savings of AdCache with respect to the entire data download. Unless
the percentage energy savings is high, AdCache does not provide significant benefits.

Ads are periodically refreshed. If the servers do not change the ads in batches, AdCache will end up downloading at intervals, rather than in a single batch, and many of the energy savings are likely to go away.

There is no evaluation on how much ad bandwidth is reduced due to AdCache although the authors hint that AdCache reduces ad bandwidth. I think bandwidth is a big win for a solution like AdCache, but without an evaluation it is hard to tell.

It is unclear how the ads are presented to the user. The authors say "the ads are served according to the policy defined by the server that takes into account the importance of the campaigns". What does that even mean? What are the policies?

Measurement study: It is unclear what the focus of the measurement study is. For example, the authors present results based on a specific ad server that shows that the server repeatedly downloads a static icon. This does not say much at all. Further, the additional bandwidth due to the repeated downloads is 100KB per day for over 99% of the users. In other words, a specific Ad provider has one instance of a repeated download that does not amount to too much bandwidth. So what are we learning from this?

Other comments:
1. How did you measure energy for 3G and WiFi? For WiFi, does it include the energy to scan and associate? For 3G, is the tail cost amortized between user data and ad data. In general, if there was other traffic, how did you account for the energy consumption of the user data vs ad data.
2. There are some amusing sentences in the paper. For example, "Without having any data to confirm or deny, we have reasons to believe..."(!!?)

Reviewer #3

Summary: This paper presents a large scale study of mobile ads. The authors collected packet traces of mobile devices from a major European operator. Their study shows that mobile ads consumed a non-negligible fraction of bandwidth, and as a result, power drain on mobile devices. They proposed a mobile ad cache architecture that reduces ads refresh rate, and caches ads on mobile devices. Simulation results show their proposal can save energy on mobile devices.

Strengths: One of the first studies on this topic. I think their findings are interesting, and can open new venues for future research on improving the efficiency of mobile ads delivery.

Weaknesses: The measurement techniques used in this work are not impressive, and not thoroughly validated.

Comments to authors: Section 2 Identification of ad traffic. It'd be useful to validate the precision and recall of the identification technique: What fraction of identified traffic is not ads-related, and what fraction of ads-related traffic is missed by the identification technique. The accuracy of the ads identification technique is essential to the accuracy of your measurement results, but this work does not seem to evaluate the accuracy of the technique. Also, why do you exclude mobile web ads?

Section 3.2 Users volumes. Can you shed some light on why the user ads traffic distribution is long tailed? Why do some users have so much ads traffic? Can you also break down ads traffic by applications? Which applications tend to generate a lot of ads traffic?

Section 5.3.3. In Figure 13, why the power consumption for Millennial Media does not decrease consistently as the length of the refresh intervals increases?

Section 6. It'd be useful to evaluate the tradeoffs of using an adcache. Can you use your trace data to show what fraction of ads will become stale if using a cache? Also what fraction of ads will be different if not using a cache? This evaluation is helpful in providing a more balanced view on the benefits of using an adcache.

Reviewer #4

Summary: This paper studies mobile advertisements and analytics. It shows that the amount of traffic contributed by ads is significant and their impact on devices and the network is negative. It presents a mechanism called AdCache to alleviate both these issues.

Strengths:
- Mobile ads is a hot topic
- This is the first large scale measurement of mobile ads based on phone subscriber-side data
- Observations lend weight to conventional wisdom
- Analysis is thorough and proposed system to overcome issues due to ads is reasonably effective

Weaknesses:
- Poor writing; key parts of the approach are not clear.
- Study of energy impact does not appear novel.
- AdCache design is also not entirely novel. Also, it appears to have drawbacks that can curtail adoptability.

Comments to authors: To the best of my knowledge, yours is the first paper that takes a comprehensive view of mobile ads and analytics workloads from the view-point of mobile subscribers. Other studies have, e.g., crawled the app store, but they don’t quite tell you what the real workload is. So kudos on conducting this study and on gaining access to and thoroughly analyze a very large dataset. Hope there are more interesting things you can mine from this data (e.g., flow level characteristics of add vs non-ad traffic; longitudinal study etc.)

My key concerns, as briefly mentioned above are the following:

- There are several issues with writing. There are, of course, numerous typos (some listed below), but there are also key parts of the paper that are difficult to parse (also listed below), especially in the latter half. This makes it hard to understand the depth of the contributions.
- Several prior works have looked at the interplay between the wireless radio state machine and the mobile energy consumption. Your observations regarding energy consumptions did not reveal anything unexpected based on what we already
know from prior works, e.g., [6]. Btw, couldn’t you simply "overlay" mobile ad traffic patterns you observed atop these prior observations to estimate energy consumption (rather than instrument and measure)?

- AdCache does appear to impose limitations on what type of ads can be served. In particular, it may make it hard to serve ads that are highly context and time-dependent. Your approach can serve ads that are stale by a couple of hours (meaning they could correspond to context that’s couple hours old) – isn’t that a problem? In justifying your design, you claim that ads are "delay tolerant", which suggests to me that you don’t think this is an issue, but I disagree. Also, AdCache prefetching-based design is not entirely novel. Others, e.g., PrivAd have looked at similar designs, albeit for different purposes (privacy, in the case of PrivAd).

- You don’t tell us much about the ads – sizes, locality/commonality etc. On the whole, I don’t view above issues are show-stoppers necessarily, but they do put a question mark on the stated contributions of the work. Clearer writing could elevate the contributions and address most of these issues.

Some other low level comments:

Sec 1: "A number of related works focus on systems, energy, privacy aspects..." provide citations for each.

Last paragraph: when you talk about how AdCache works, you may also want to justify that prefetching ads way ahead of time is OK.

Sec 2: "ad networks are interested in maximizing .... through targeting" – what does targeting mean here?

Sec 3: "This suggests that device form factor and usage patterns have strong implication on the amount of traffic generated by the device” – I don’t think the evidence you have is statistically significant for you to reach this conclusion.

What are the implications of your observation that Android devices have double the ad volume of Apple devices? Without context of explanation, this observation appears pointless.

3.2: "Users Volumes"?? "in average" (at multiple places) –> "on average"?

3.3: "respect the" – missing to; "Three set" –> sets;

Sec 4: You start out by saying that ad objects are downloaded every time the ad is fetched despite the objects being static, but you don’t say why this design choice was made.

Sec 4.1 was in general hard to follow as the writing took a sharp dive.

"Most of the ads correspond to banners corresponding to content provider images..." – does not parse. "...we found the popularity of these objects to be high..." – how high? Show a CDF of popularity and convince us that you are focusing on the right kind of traffic.

Why do you focus on just one object? And why this specific object?

"Given the nature of the object, the absence of caching is surprising" – how do you know caching is not in use??

4.3: "money income"??

Why not show a distribution of ad-click probabilities across users than averages (which could be hiding a lot of interesting artifacts)?

Sec 5: "cannot take any conclusions" – "make"?

For 3G, the experiments were conducted under ”good network conditions” – how long did a given experiment last? Were conditions good throughout? What if that was not the case?

"DLS” – DSL

Monitor power monitor needs a citation.

Section 5.3.2 does not show anything new. Most of what’s here is already known.

"significantly impact on” – drop "on".

Second paragraph of 5.3.3 is riddled with typos and hard to parse. What are you trying to say here? ”Also observed in Google’s services such as...” – can you provide a citation for this?

Sec 6: way too many errors to list.

You list a simple set of techniques before the start of 6.1 that your approach uses. Which of these are unique for mobile ads. They all seem generically applicable to *any* prefetching/caching solution.

You say cache updates happen when ads expire – how do you know when they expire?

This section could use some comments on how manage relevance of ads served from cache, especially given that they may correspond to a stale context. Also, is there any way you can measure the impact on relevance?

What is the workload you used for figure 16? Results are not easy to interpret with full details.

Reviewer #5

Summary: This paper analyzes a 1 day network trace from a large mobile network to quantify network traffic from in-app ads, analytics, etc. The paper shows that ads account for a significant fraction of mobile network traffic and that lot of this traffic is redundant. Therefore, the authors design and implement AdCache, a system that pre-fetches ads on mobile phones and caches them for later use. Results show that AdCache significantly reduces the energy overhead imposed by ads.

Strengths: + First study to quantify in-app ad traffic on mobile networks. Large-scale dataset.

Weaknesses:

- Poorly motivated: the paper establishes the cache-ability of ad traffic based on the workload of a single object app@2x.png. So, it’s unclear if the ad workload is indeed cacheable. Moreover, it’s unclear if the fix is just to modify HTTP libraries.

- Energy improvements are overblown: the assumption is that there is no other concurrent network traffic from a user’s phone when an ad is being fetched on that phone. Given the authors’ dataset, they do not need to make this assumption.

- AdCache takes control away ad providers of which ads they can show on-demand. Unclear if ad providers will be comfortable with that.

Comments to authors: The authors have access to a unique dataset – a network trace of 3 million mobile phone subscribers.
But, unfortunately, the authors do a poor job of using this dataset for studying in-app ad traffic.

First, all the ad traffic that you identify is based on rules that you came up with. Is there any reason to believe that you are not missing out on several more rules, because of which all the traffic you identify are under-estimates? While this is fine for quantifying the extent of ad traffic (the fraction of ad traffic would be even more if you are missing rules), but this would impact several of your observations – the fraction of regex traffic accounted for by mediation and analytics services, the fraction of flows and bytes of Google services, etc. You need some way that your rule-set is comprehensive enough. Also, please provide some examples of your rules rather than requiring the reader to lookup your Excel spreadsheet.

It is unclear why you think that the fact that ads account for 1% of all network traffic is significant motivation. This 1% traffic could have a non-proportional impact on energy, but the traffic share as such is underwhelming. I think you are better off motivating your work using Figure 3 – that, for 25% of Android users, ads account for over 20% of network traffic.

The visualization of data in Figure 6 is overkill for establishing the fact that most ad services are served by a single organization. You might as well say that in the text and present the dominant provider for every ad service as a table.

Your whole proposal hinges on the cache-ability of ad traffic and unfortunately your analysis here is disappointing. You only show the cache-ability of a single object! Why is this sufficient? You need to show the CDF across objects, in the regex logs, of the avg/median number of times that object was downloaded per user.

You say that you identify sessions by grouping together all flows that overlap in time. What is the time threshold you are using here to group flows into sessions? The paper "Web Caching on Smartphones: Ideal vs. Reality" from Mobisys 2012 found that several state-of-the-art HTTP libraries, that are used by smartphone apps, have bugs in their caching implementation. So, perhaps the repeated downloads that you observe are due to this? In which case, we simply need to fix these libraries rather than use AdCache.

As you yourself state, the energy savings shown with AdCache assume that there is no other concurrent network traffic when ads are being fetched. But, you do not need to make this assumption. Your trace contains all the network traffic from the users being monitored. So, you should really do a trace-driven simulation to evaluate the energy savings with AdCache. Your current results are meaningless, since obviously energy consumption will be lesser when ads are being cached. If there is other network activity whenever an ad is being fetched, energy savings with AdCache will be minimal.

Do you have any reasons to believe that ad providers will be fine with AdCache usurping their control over what ads are shown to users? This is a huge assumption of the viability of AdCache.

The description of AdCache is very poor. It mixes up way too many implementation details with design details. For example, the long discussion about securing the database with a dynamic token comes out of nowhere. You have enough space in the paper to clearly describe your design decisions first and then present implementation details. Also, the opt-in profile for ensuring privacy comes as a surprise since you don’t motivate any additional privacy concerns caused by AdCache.

Response from the Authors

The structure of the paper has been changed to emphasize more the methodology used on the paper and the inefficiencies behind advertising traffic on mobile devices to better support the design decisions of our proposed solution. For that, we demonstrated that mobile ad traffic is generally found in isolation and it is responsible for an important energy and spectrum waste.

- Title has been changed as suggested by the reviewers.
- Section 2 describes better the methodology followed to obtain the rule-set later used for the analysis and how it was performed. It also provides some background about ad networks and the scope of our analysis.
- We completely changed the focus of Section 3. This section describes the general properties of mobile ad traffic (volume, players in the ecosystem, type of content—which is generally static content such as images) and two sections emphasizing the inefficiencies introduced by such traffic on mobile systems. First, we demonstrate that the most popular mobile applications with ad traffic for AdMob are generally offline by nature such as games. Second, ad traffic flows are very frequent and important part of it is related to re-downloads of static objects as a result of a lack of caching capabilities on the SDKs.
- Section 4 focuses on the energy and spectrum implications of ad traffic. Ad traffic is generally found in isolation, so it is responsible for an important amount of energy waste. To evaluate the implications on a modern smartphone, we evaluate the impact of few refresh rates for the most popular ad networks found in Section 3. We provide a throughput trace to better emphasize the inefficiencies at the transport layer across mobile ad services.
- Sections 5, 6, and 7 have minor improvements. They were mainly focused on the writing but few additions were added to make our claim clearer.