An Advertising Revenue Model for Access ISPs

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***Abstract*— Faced with the unrelenting traffic growth and rising costs, access ISPs (Internet Service Providers) realize that their traditional revenue model of flat subscription fees is unsustainable. Regulatory concerns, e.g., about content-specific charging, constrain the ISPs' search for new revenue sources. This paper analyzes a revenue model where an access ISP acts as a publisher of ads to users who explicitly opt for an ad-sponsored access plan of the ISP. First, we conduct a survey showing a substantial interest of users in ad-sponsored Internet access. Then, we mathematically characterize the advertising revenue model and asses its economic feasibility based on real data from two access ISPs and an ad publisher. While the ad revenues are tangible, they do not completely cover the costs of the access ISPs. Even in relative terms, a larger access ISP benefits more from the advertising, with the ad revenues covering up to 50% of the ISP's capital expenditure. Complementing the subscription fees, the access ISPs can leverage the ad revenues to meaningfully incentivize the users with better Internet connectivity, such as 6-9 Mbps in extra data rates or 12-20 GB in extra data caps for the two considered ISPs.**

***Index Terms*— Economics; regulation; Internet access; traffic growth; cost; revenue model; advertising; ad-sponsored plan; user incentive; data rate; data cap.**

I. Introduction

An access ISP (Internet Service Provider) typically supplies Internet access for a large population of residential users who pay monthly subscription fees to the ISP. The access ISP uses the subscription revenues to sustain its costs, including those of maintaining the extensive communication infrastructure needed to reach individual users. The costs also include traffic charges paid by the access ISP to its transit providers for supporting the global Internet connectivity for its users.

With powerful transformations reshaping the Internet economy, an access ISP increasingly finds itself playing a losing game in the emerging economic landscape [1]. On the cost side, the access ISP faces the tremendous traffic growth that requires expensive upgrades of the ISP's communication infrastructure. Besides, the unrelenting growth in the interdomain traffic keeps increasing the access ISP's transit costs. On the revenue side, the access ISP does not benefit from the traffic growth because the residential users typically pay flat fees. In spite of its sumptuous profit margins in the past, the traditional Internet-access business model is clearly unsustainable in the long run.

Responding to the challenge, access ISPs seek to reinvent their business to boost revenues or reduce costs. While there are many dimensions to explore, good options are scarce. As access markets become saturated, attracting a significant amount of additional users is a difficult proposition. Due to stiff competition in the access markets, the users are reluctant to pay larger fees for their subscriptions or switch from the flat fees to usage-based pricing [2]–[4]. More palatable to the users are data caps that limit the transfer of data for heavy hitters [5]. Also, ISPs host caches of CDNs (Content Delivery Networks) to curb the transit costs of interdomain traffic [6]. While data caps, caching, remote peering [7], and other cost-control measures stem the tide, they do not solve the overall problem. Access ISPs need a new revenue model.

Regulatory concerns constrain the access ISPs' quest for practicable revenue models. Because providers of popular content are financially well-off, an access ISP might consider charging the popular content providers for the delivery of their content to the users of the access ISP [8], [9]. Whereas it is common for the content providers to have no direct interactions with the access ISP, a variation of the above revenue model is to charge a neighboring transit ISP that hosts a popular content provider [10]. However, such revenue models cause widespread concerns among the public and governments, leading to the principle of net neutrality that precludes the access ISPs from content-specific charging for their connectivity services [11], [12]. While net-neutrality regulations remain controversial, there is broad consensus on inappropriateness of other revenue models, e.g., those where the access ISP injects ads (advertisements) into web traffic without consent of the content providers or users [13], [14].

In this paper, we focus on an advertising revenue model that might significantly benefit the access ISPs without prompting regulatory intervention. The model relies on an explicit agreement with the user allowing the access ISP to display ads in a dedicated space on the user's screen. The access ISP collaborates – directly or through ad networks – with advertisers and collects payments for displaying the ads. The ISP can leverage the ad revenues to reduce or potentially eliminate completely the subscription fee for the user. Such ad-sponsored access plans can benefit the ISP by attracting new users. As an alternative incentive to the user, the access ISP can utilize the ad revenues to offer higher data rates or caps at the same subscription fee. Because the advertising revenue model incorporates the explicit consent of the user and does not involve content-specific charging, the model can be viewed as more net-neutral and less likely to come under scrutiny from regulators. Real ISPs OVIVO Mobile [15] and Samba Mobile [16] have already staged pilot trials of ad-sponsored access plans. While both ISPs are now defunct,

* Part of the work was done when Pradeep Bangera and Syed Hasan were with Carlos III University of Madrid.

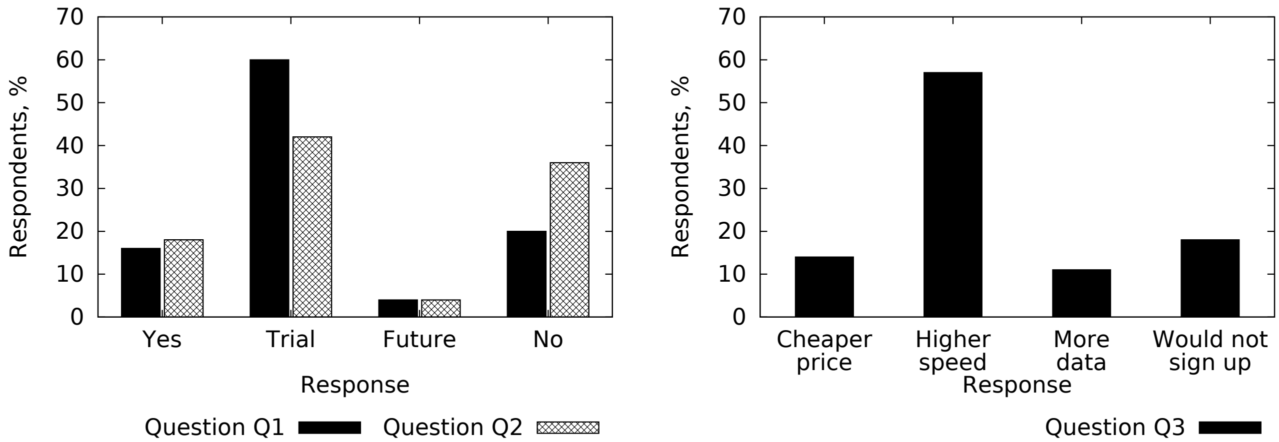

Fig. 1: Interest of the surveyed users in ad-sponsored Internet access plans.

our work seeks to clarify the conditions for viability of the ad-sponsored access model.

The paper contributes via its multifaceted assessment of the advertising revenue model. First, we conduct a market survey showing that a majority of the surveyed users are interested in trying an ad-sponsored access plan. Then, we mathematically characterize the advertising revenue model and evaluate its economic viability based on real ad prices and financial reports from two access ISPs, one large and one medium-sized. Due to uncertainties about the future settings where ad-sponsored access plans might be used, we also analyze sensitivity of the advertising revenue model to its parameter values. The main conclusions of our study include the following:

1) While tangible in offsetting the costs of the access ISPs, the ad revenues do not cover all of the costs.
2) Even in relative terms, a larger access ISP benefits more from the advertising revenue model.
3) When using the ad revenues to incentivize the users with better connectivity at the same subscription fees, the access ISPs can offer significant increases in the data rates and caps.

The rest of the paper is organized as follows. Section II provides extra background information on online advertising. Section III presents the advertising revenue model for access ISPs. Section IV reports on the user survey. Section V characterizes the revenue model mathematically. Sections VI and VII describe respectively the methodology and results of the model evaluation. Section VIII discusses related work. Finally, section IX concludes the paper with a summary of its contributions.

II. Online advertising

Online advertising has become a major source of revenues for content providers. By acting as a publisher of ads, a popular commercial website can afford displaying its regular contents without charging subscription fees. In its turn, the free access to the contents increases the number of users and thereby raises ad revenues.

There exist different bases for calculating the ad revenues. With the CPM (Cost Per Mille) approach, the advertiser pays the publisher for 1,000 ad impressions displayed to users. The CPC (Cost Per Click) method links the payment amount to the number of clicks by the users on the displayed ads. The CPA (Cost Per Action) model determines the payment based on the number of actions, such as purchases of the advertised products by the users. CPM and CPA are respectively the least and most risky for the publisher's ability to generate revenues by displaying the ads.

III. Advertising revenue model for access ISPs

While online advertising proves itself highly rewarding for content providers, it is reasonable for access ISPs to consider raising revenues by publishing ads as well. In this paper, we analyze an advertising revenue model where the access ISP and user explicitly agree that the ISP displays ads in a dedicated space on the user's screen. For example, the dedicated space can be a panel created on an edge of the user's web-browser window by an ISP-provided browser plugin that periodically fetches and displays ads on the window panel. Whereas the ad publishing by access ISPs in general and its browser-plugin implementation in particular face various technical, security, and privacy challenges, these kinds of issues are out of scope for the given paper. Instead, we focus on economic aspects of the advertising revenue model.

The access ISPs have flexibility in how to utilize their ad revenues. One potential usage is for offsetting the costs of the ISPs. Another option is to reduce, or eliminate altogether, the subscription fees for the users. A third possibility is to offer the users higher data rates or caps at the same subscription fees. In this study, we quantify the ad revenues and incentives enabled by them.

Compared to the revenue models that prompt the net-neutrality concerns, the considered ad-sponsored revenue model for access ISPs is less likely to come under scrutiny of regulators. In this model, the access ISPs obtain the user's consent to display ads, do not interact with content providers, and do not engage in content-specific charging.

IV. User survey

Since the advertising revenue model involves the express agreement with the user, the interest of potential users in such an access plan is a critical issue. Users generally dislike ads, especially when an ad disrupts the web-browsing experience by being tastelessly designed, obstructively placed in the browser window, or unexpectedly playing audio or video files. On the other hand, data from many economic domains suggest that users still prefer to pay indirectly by watching ads rather than directly by paying money.

To assess the willingness of users to adopt an ad-sponsored access plan, we conduct a market survey of more than 100 anonymous residential users in India. The users are invited to participate in the survey via WhatsApp groups. The survey, which is also available at https://www.surveymonkey.com/r/8BQ8TNN, comprise the following 3 questions:

Q1) If your ISP proposes you to sign up for a new Internet plan that is cheaper or has faster speed or provides more data than your existing Internet plan, but comes with non-intrusive online ads sent by the ISP, would you sign up?

Q2) If receiving more ads brings you more discounts in the form of a smaller price or speed increase or data-limit increase, would you be interested in receiving more ads?

Q3) If you decide to sign up for a new ad-sponsored Internet plan, which one of the following will be your primary criterion to migrate from your current plan to the new plan: cheaper price, higher speed, or more data?

Figure 1 presents our survey results. 76% of the respondents to question Q1 express their willingness to try an ad-sponsored plan either unconditionally or after a trial, with 20% of the respondents being uninterested. The 62% positive versus 36% negative responses to question Q2 reveal significant tolerance of the users to watching more ads. With respect to the preferred kind of incentives, 57% of the respondents to question Q3 favor higher data rates, 14% prefer lower subscription fees, and only 11% find the largest value in higher data caps. Overall, the survey indicates a substantial interest of residential users in ad-sponsored Internet access and distinguishes higher data rates as the most preferred incentive.

V. Mathematical characterization

As the first step to evaluating the ad revenues and user incentives, this section mathematically characterizes the advertising revenue model, with table I summing up the notation. Without loss of generality, we assume the CPM method for calculation of the ad revenues. With C denoting the CPM, cost c of a single ad impression is $c = C/1000$. The access ISP has n users and displays ads to each user with frequency f measured in impressions per minute. On average, a user daily spends t minutes online. Assuming a 30-day month, we then express the monthly AARPU (Average Ad Revenue Per User) as:

Notation	Description
C	CPM (Cost Per Mille)
c	Cost of a single ad impression
n	Number of users
f	Ad frequency
t	Average daily usage
r	AARPU (Average Ad Revenue Per User)
R	Ad revenues
E_c	CapEx (Capital Expenditure)
C_I	CPM for ad revenues to match CapEx
P	Monthly subscription fee
h	Normal data rate
d_h	Normal data cap
l	Throttled data rate
d_l	Throttled data cap
p	Per-unit price
U_h	Normal utility function
U_l	Throttled utility function
α	Price sensitivity of the normal utility function
β	Price sensitivity of the throttled utility function
a_h	Coefficient of the normal utility function
a_l	Coefficient of the throttled utility function
U	Monthly user utility

TABLE I: Notation in the mathematical characterization.

$$r = 30 \cdot t \cdot f \cdot c. \tag{1}$$

Then, ad revenues R of the access ISP during the month are:

$$R = n \cdot r. \tag{2}$$

While our study seeks to understand whether the access ISP can offset its network costs by the ad publishing, we also express CPM price C_I needed for the ad revenues to match CapEx (Capital Expenditure) E_c of the access ISP:

$$C_I = \frac{100 \cdot E_c}{3 \cdot n \cdot t \cdot f}. \tag{3}$$

The ISP offers an access plan with monthly subscription fee P and data caps. The ISP provides access at normal data rate h from the beginning of the month until the user exhausts normal data cap d_h. Subsequently, and until the end of the month, the access is provided at throttled data rate l. The number of days during that second phase effectively determines throttled data cap d_l.

We model the user utility with alpha-fair functions [3]. For the normal and throttled phases of the month, the user utility is expressed as:

$$U_h = a_h \cdot (1-\alpha)^{-1} (h \cdot d_h)^{(1-\alpha)} - (p \cdot h \cdot d_h), \tag{4}$$

$$U_l = a_l \cdot (1-\beta)^{-1} (l \cdot d_l)^{(1-\beta)} - (p \cdot l \cdot d_l) \tag{5}$$

Parameter	Measurement unit	Access ISP	
		Airtel	DEN
Number of users, n	Thousand	1,508	23
ARPU	Rs	1,034	750
CapEx, E_c	Million Rs	422	57
Revenue	Million Rs	1,560	17
OpEx	Million Rs	2,195	46

TABLE II: Monthly annual-report data for the access ISPs.

Access plan	Fee P (Rs)	Normal rate h (Mbps)	Throttled rate l (Mbps)	Data cap d_h (GB)
A1	1,899	16	0.512	80
A2	2,199	16	0.512	120
A3	2,499	16	0.512	200
A4	2,099	24	1	80
A5	2,399	24	1	120
A6	2,999	24	1	200
A7	2,399	40	1	80
A8	2,699	40	1	120
A9	3,299	40	1	200

Access plan	Fee P (Rs)	Normal rate h (Mbps)	Throttled rate l (Mbps)	Data cap d_h (GB)
D1	700	5	1	30
D2	1,000	5	2	50
D3	1,250	5	2	100
D4	900	20	1	30
D5	1,300	20	2	50
D6	1,550	20	2	100
D7	1,200	50	1	30
D8	1,600	50	2	50
D9	2,100	50	2	100

TABLE III: Access plans of: (top) Airtel and (bottom) DEN.

where α (or β respectively) denotes the price sensitivity of the utility function, and coefficient a_h (or a_l) represents the utility value with per-unit price p, data rate h (or l), and data cap d_h (or d_l). After solving $U_h{}' = 0$ and $U_l{}' = 0$, we derive a_h and a_l as follows:

$$a_h = p \cdot (h \cdot d_h)^{\alpha}, \quad a_l = p \cdot (l \cdot d_l)^{\beta}. \tag{6}$$

Then, we compute per-unit price p as the ratio of subscription fee P to the sum of the rate-cap products during the two phases:

$$p = \frac{P}{h \cdot d_h + l \cdot d_l}. \tag{7}$$

Finally, the total utility of the user over the entire month is:

$$U = U_h + U_l. \tag{8}$$

Year-month	CPM (Rs)
2015-01	86
2015-02	85
2015-03	86
2015-04	86
2015-05	53
2015-06	68

TABLE IV: Ad prices from TellyReviews.

VI. Evaluation methodology

Based on the above mathematical characterization, we evaluate the advertising revenue model and seed the assessment with real data from 2 access ISPs and an ad publisher. Since the specific settings for future usages of the model are difficult to predict accurately, we also analyze its sensitivity to parameter values.

A. Annual-report data of access ISPs

The 2 access ISPs in our evaluation are Bharti Airtel Limited [17] and DEN Networks Limited [18], or Airtel and DEN for short. Table II presents relevant data derived from these 2 Indian ISPs' annual reports published in 2015. While Airtel is a large ISP that serves 1.5 million users, DEN is medium-sized with 23 thousand users. Here and later, our paper quotes financial figures in Rs (Indian rupees). At the time of our study, the exchange rate is 66 Rs for 1 United States dollar. The annual reports provide the number of users, ARPU (Average Revenue Per User), and consolidated CapEx. We determine the monthly revenue by multiplying ARPU by the number of users. By subtracting the revenue from EBITDA (Earning Before Interest, Tax, Depreciation and Amortization), we obtain the consolidated OpEx (Operating Expense).

Each ISP offers users a choice of 9 access plans. Table III presents the subscription fees, data rates and caps of these access plans A1, …, A9 of Airtel and D1, …, D9 of DEN.

B. Ad prices

Our evaluation utilizes real ad prices from TellyReviews, an Indian website that provides weekly reviews and updates on popular television shows [19]. At the time of this study, the website attracts 591,000 visitors and 1.6 million webpage views per month and publishes ads from 4 ad networks OnClickAds, WordAds, AdSense, and Gravity. Table IV shows the average monthly CPM prices from TellyReviews between January and June 2015. Over this period, minimum, average, and maximum CPM prices C_{min}, C_{avg}, and C_{max} are 53, 77, and 86 Rs respectively.

C. Sensitivity analysis

To deal with uncertainties about future usages of the advertising revenue model, we examine how it performs over ranges of its parameter values. In particular, we consider synthetic

CPM	Measurement unit	Ad revenues	
		Airtel	DEN
C_{min}	Million Rs	143	2.2
C_{avg}	Million Rs	210	3.2
C_{max}	Million Rs	235	3.5

TABLE V: Ad revenues of the 2 access ISPs.

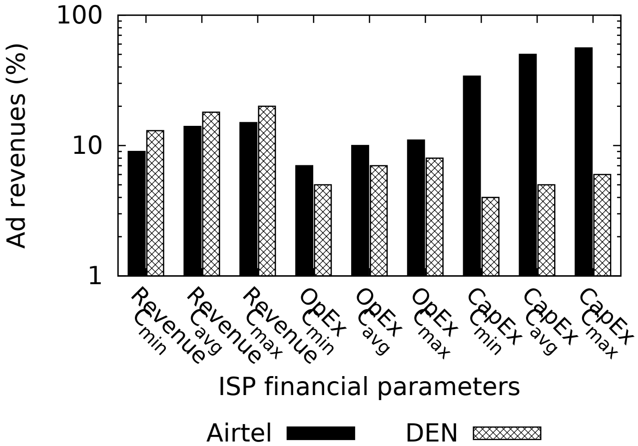

Fig. 2: Ad revenues vs. actual revenues, OpEx, and CapEx.

normal, log-normal, and Zipf-Mandelbrot distributions to represent the daily usage by individual users. Whereas the average daily usage is estimated to lie between 20 and 360 minutes for Indian users [20]–[23] and be 60 minutes globally [22], we set the average daily usage to 60 minutes in all 3 considered distributions, with most individual values falling between 20 and 120 minutes. To understand the importance of modeling the users individually, we also consider the fourth setting where the daily usage of each user is fixed at average value $t = 60$ minutes. Our study assesses sensitivity of its results to average daily usage t, CPM C, and ad frequency f. In the default setting, our evaluation uses $C = C_{avg} = 77$ Rs, $f = 1$ impression per minute, $t = 60$ minutes, and $\alpha = \beta = 0.5$.

VII. Evaluation results

A. Ad revenues

Table V gives an initial glimpse at the potential ad revenues of the 2 access ISPs when the CPM is set to C_{min}, C_{avg}, or C_{max}. With the CPM set to C_{max}, the ad revenues are 235 and 3.5 million Rs for Airtel and DEN respectively. To put these absolute numbers into perspective, we compare the potential ad revenues of the 2 ISPs with their actual subscription revenues, CapEx, and OpEx. Again with the CPM set to C_{min}, C_{avg}, or C_{max}, figure 2 shows the ad revenues for Airtel to be 9-15%, 7-11%, and 34-56% of its subscription revenues, OpEx, and CapEx respectively. The ad revenues for DEN are 4-6% of its CapEx.

Focusing on CapEx as the basis for gauging the significance of the ad revenues, figures 3 and 4 examine how high CPM C_I needs to be for the ad revenues to match a specific percentage of the CapEx. Both graphs contain a shaded area where the average daily usage is at most $t = 60$ minutes, and C_I does not exceed $C_{avg} = 77$ Rs. The shaded area represents the settings that can be viewed as economically feasible. For Airtel, figure 3 shows that fully covering the CapEx requires either $C_I = 155$ Rs with $t = 60$ minutes or an increase of the average daily usage to 120 minutes with $C_I = C_{avg}$. These two settings are far from the economically feasible area. In the economically feasible settings, the ad revenues cover about 50% of Airtel's CapEx. Figure 4 shows a less rewarding picture for DEN, with the ad revenues covering about 6% of its CapEx in the economically feasible settings.

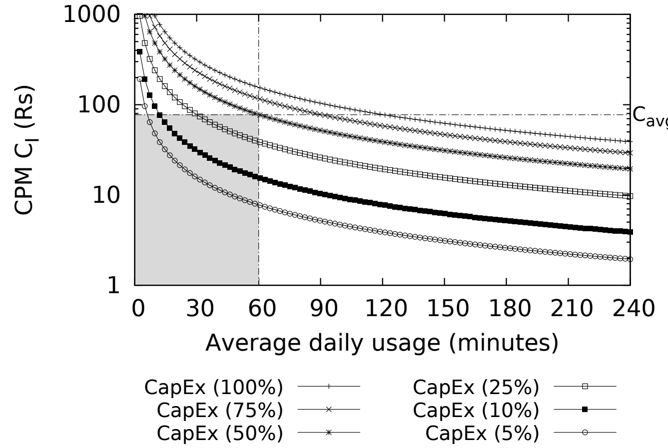

Fig. 3: CPM needed for Airtel's ad revenues to match different CapEx fractions.

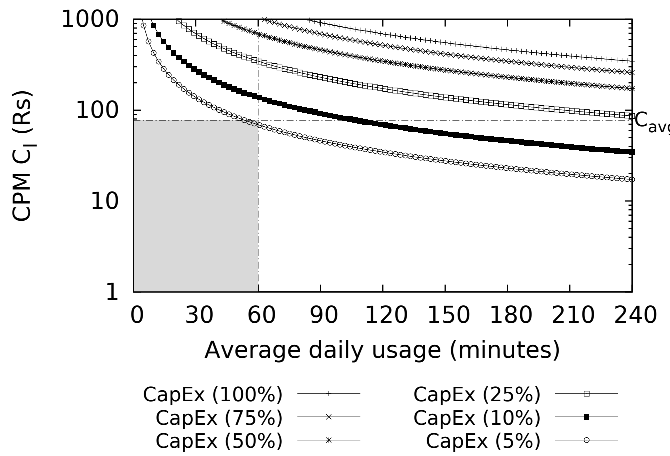

Fig. 4: CPM needed for DEN's ad revenues to match different CapEx fractions.

Figure 5 plots qualitatively similar dependences of the relative ad revenues on the CPM with all 4 daily-usage distributions for either ISP. The plotted profiles are quantitatively close as well, except for Airtel with the Zipf-Mandelbrot distribution that yields significantly lower revenues. In the

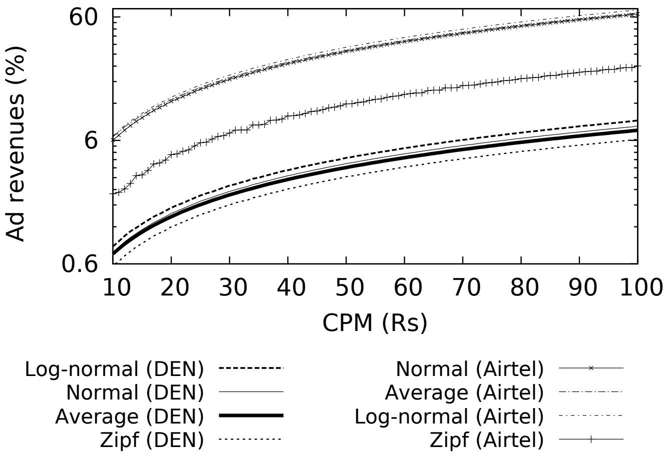

Fig. 5: Ad revenues vs. CapEx for the 4 considered daily-usage distributions.

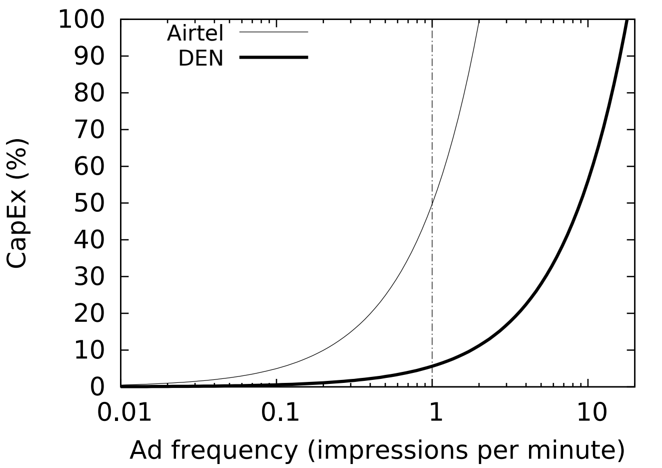

Fig. 6: Covering the CapEx with different ad frequencies.

other 3 settings for Airtel, the ad revenues rise from 7% to 56% as the CPM increases from 10 to 100 Rs.

While the access ISP has some flexibility in how frequently it displays ads to users, figure 6 plots the percentage of the CapEx that the ad revenues cover with different ad frequencies. For Airtel, covering 100% of the CapEx requires 2 impressions per minute. For DEN, the respective ad frequency is 18 impressions per minute and clearly not practicable.

Summing up the above diverse perspectives, we observe that the ad revenues do not fully cover the costs of the access ISPs. Nevertheless, the ad revenues are tangible. Even in relative terms, a larger access ISP benefits more from the advertising revenue model.

B. User incentives

While the ad revenues do not cover all the costs of either access ISP and do not enable it to eliminate user subscriptions, the ISP can maintain the same subscription fees and utilize

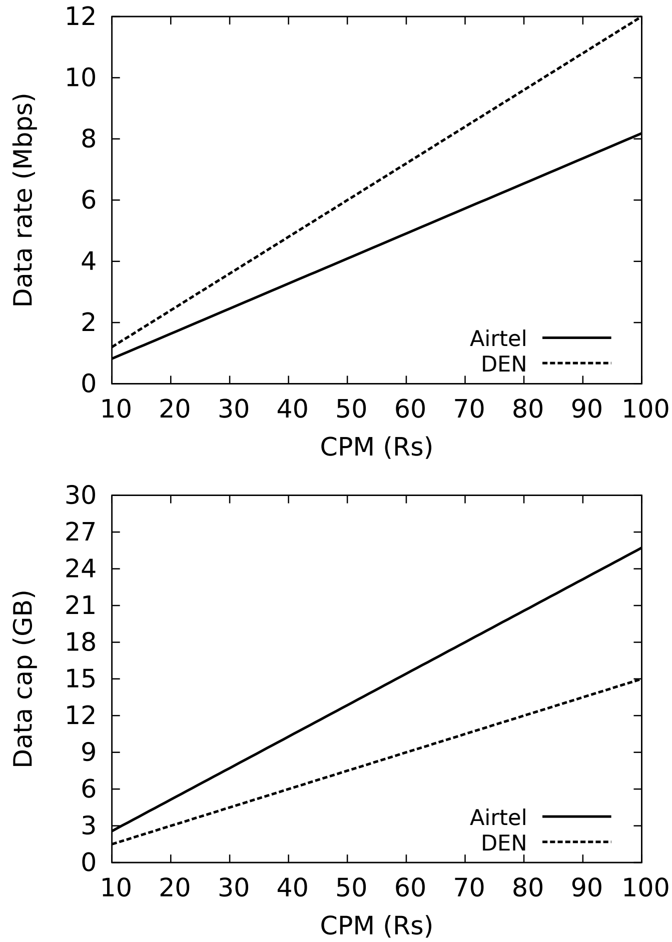

Fig. 7: User incentives in the form of ad-sponsored increases in: (top) normal data rate or (bottom) normal data cap.

the ad revenues to offer higher data rates or caps, thereby attracting additional users. To evaluate this option, we utilize the access-plan data of Airtel and DEN in table III. After grouping together the plans with the same data caps, we record the incremental increases in the fee and normal data rate across the plans within each group. Then, we compute the *incremental rate price* for the ISP by dividing the sum of all fee increments by the sum of all corresponding rate increments. Similarly, by grouping together the plans with the same normal data rates and recording the fee and cap increments within every group, we determine the *incremental cap price* for the ISP by dividing the sum of all fee increments by the sum of all corresponding cap increments. For Airtel and DEN respectively, the incremental rate price is 22 and 15 Rs/Mbps, and the incremental cap price is 7 and 12 Rs/GB.

Based on the computed incremental rate and cap prices, we project the ad-sponsored incentives that the access ISPs can offer in the form of extra data rates or caps. Figure 7 plots the incentives as functions of the CPM. In the default setting with $C_{avg} = 77$ Rs, Airtel and DEN can respectively offer 6 and 9 Mbps in extra data rates, or 20 and 12 GB in extra data

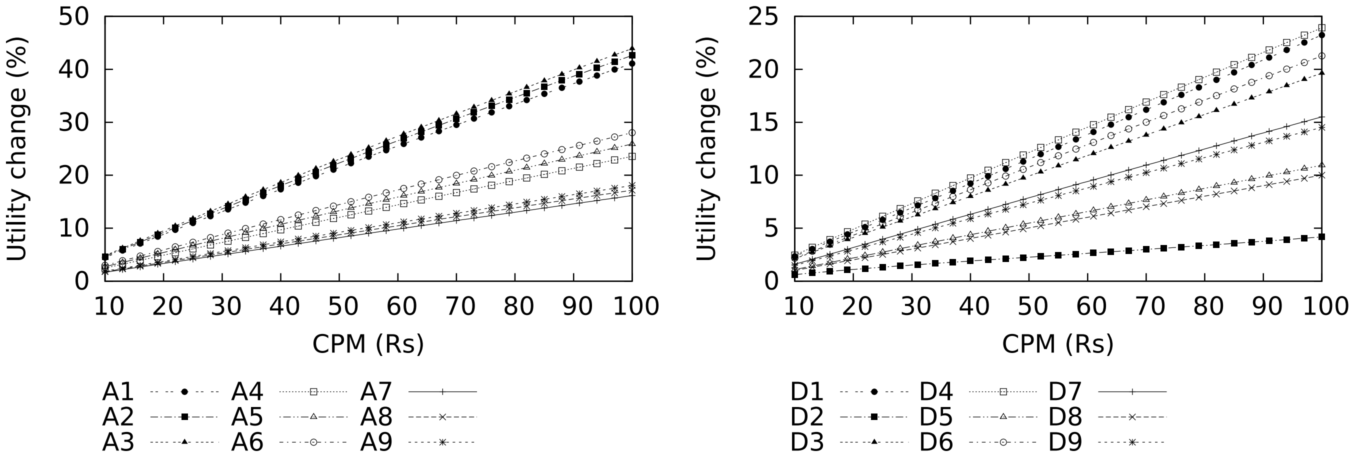

Fig. 8: Change in the user utility with the ad-sponsored increase in the normal data rate for: (left) Airtel and (right) DEN.

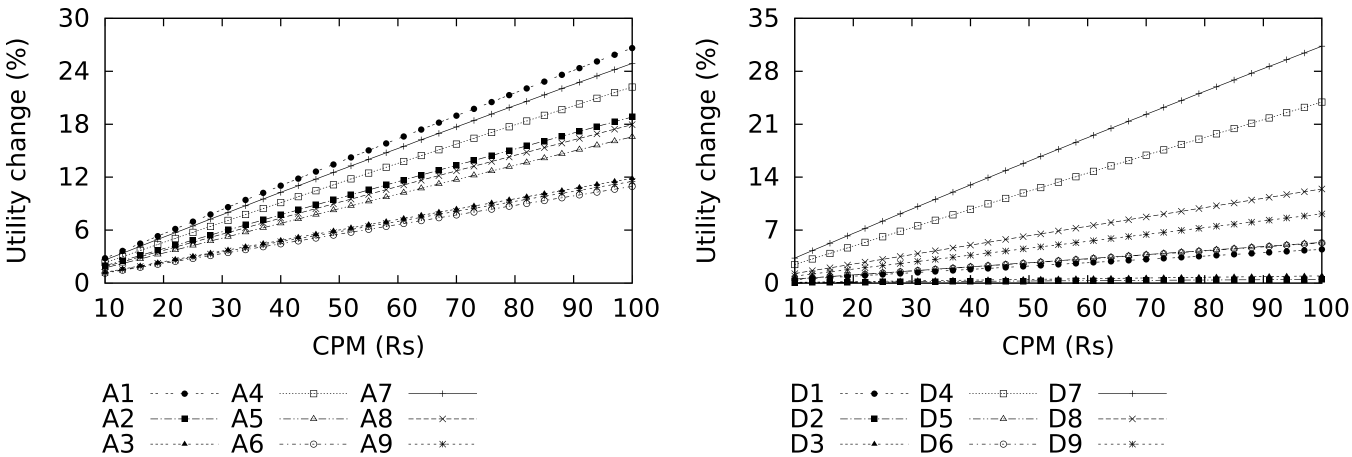

Fig. 9: Change in the user utility with the ad-sponsored increase in the normal data cap for: (left) Airtel and (right) DEN.

caps. Thus, while Airtel is better positioned to incentivize the users with higher data rates, DEN is stronger in incentivizing the users with higher data caps.

To assess how the users perceive the ad-sponsored increase in the normal data rate, figure 8 plots the respective change in user utility U for different CPMs. For Airtel, the user utility improves the most with its slowest access plans A1, A2, and A3 and increases the least with its fastest access plans A7, A8, and A9. Within each group of plans with the same normal data rates, the user utility improves more with plans that have higher normal data caps. For DEN, figure 8 shows a qualitatively different picture without a clear correlation between the utility increase and normal data rate because DEN more prominently involves the throttled data rate as a differentiator between its access plans. The user utility increases more with DEN plans that have lower throttled data rates.

Figure 9 presents how the user utility changes with the ad-sponsored increase in the normal data cap. For Airtel, the utility improves the most for the plans with the smallest data caps and lowest throttled data rates. For DEN, while plans D1, D2, and D3 offer only negligible improvements in the user utility, the user-utility increase is the largest with plan D7 and reaches 24% in the default setting with $C_{avg} = 77$ Rs.

Altogether, the above results show that the access ISPs can leverage the advertising revenue model to offer significant increases in the data rates and caps. Complementing the subscription fees, the ad revenues can meaningfully incentivize the users with better Internet connectivity.

VIII. Related work

While there is a large body of research on how ISPs can reduce their costs [24], [25], our paper deals with ISP revenues. A lot of the prior work on ISP revenue models pivots around economic relationships between ISPs and content providers. [26] investigates differences in hosting of ads versus regular contents. [27] proposes an arrangement where content providers sponsor the network costs incurred by ISPs due to ad traffic. Similarly, [28], [29] analyze incentives for partnerships between ISPs and content providers as well as implications of these partnerships for users. Charging of content providers by ISPs to offset the costs of delivering content traffic is also the focus of [8], [12], [30], [31]. Our work differs from the previous studies by analyzing the advertising revenue model where an access ISP does not interact with content providers at all; instead, the access ISP acquires ads directly from advertisers or ad networks to display the ads with an explicit consent by the user.

IX. Conclusion

Whereas access ISPs increasingly find themselves playing a losing game in the emerging economic landscape, they seek new revenue models that are unlikely to raise regulatory concerns. In this paper, we analyzed the advertising revenue model where an access ISP acquires ads and displays them to users who explicitly opt for an ad-sponsored access plan of the ISP. First, we conducted the survey that indicates a substantial interest of residential users in ad-sponsored Internet access and distinguishes higher data rates as the most preferred incentive. Second, we mathematically characterized the advertising revenue model and evaluated its economic viability based on real data from 2 access ISPs and an ad publisher. We also examined sensitivity of the advertising revenue model to its parameter values.

Our results showed that the revenues from the ad publishing do not fully cover the costs of the access ISPs. This is consistent with the fates of OVIVO Mobile and Samba Mobile. On the other hand, we also demonstrated that the ad revenues are tangible, indicating the promise of a hybrid model that combines ads and subscriptions. Even in relative terms, a larger access ISP benefits more from the advertising revenue model, with the ad revenues covering up to 50% of the ISP's CapEx. We showed that the access ISPs can leverage the advertising revenue model to offer significant increases in the data rates and caps, with 6-9 Mbps in extra data rates or 12-20 GB in extra data caps for the 2 considered ISPs. Hence, access ISPs can utilize ad revenues to meaningfully incentivize users with better Internet connectivity. Future work can strengthen our results by surveying more than 100 users and evaluating the model viability for more than 2 ISPs.

X. Acknowledgments

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