A Game-theoretical approach to the understanding of Basic Attention Token (BAT) & its influence on User Attention

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1 Introduction and Motivation

Human attention is a limited resource as there are only 24 hours in a day and therefore only so many things that we can focus on. Throughout history, advertising has been used as the primary mechanism to capture attention, raise it to a level of interest to incite a desire that then translates into action, also referred to as the AIDA model. Many tech companies and web sites use this model to generate revenue streams. In this paper we take a look at how excessive advertising can negatively affect a user's experience on the internet and how the use of the Basic Attention Token can counteract these effects.

To begin, let us look at the process of web browsing. Browsing can be directed where the target of a web search is clearly defined, semi-directed where the target is less clearly defined, or undirected where there is no specific goal. Directed and semi-directed browsing differ from undirected browsing in terms of motivation, involvement, benefits, and nature *(Novak, Hoffman and Duhachek, 2003)*. People who engage in undirected browsing are driven by curiosity or seek entertainment, whereas directed browsing implies a search for particular information. From a user's perspective, while advertisements can satisfy certain informational or emotional needs, they can also negatively impact the browsing experience. Gibbs *(2008)* reports examples of usability problems in news sites due to advertisements such as "causing the user to lose his place and to perceive the text below the advert as an entirely new story" or users struggling to find the "close" button to get rid of a pop-up advert". There are several consequences for the quality of the user experience due to advertising. Users may become confused and exhausted due to an increase in cognitive load which can result in a failure of information seeking tasks *(Brajnik and Gabrielli, 2010)*. Users may also be subjected to fake ads that trick users into clicking on them and then downloading malicious code including ransomware. The sites most frequently hit by mal-advertising are news and entertainment sites *(Tuttle, 2015)*. These factors have led to users adopting ad-blocking software, and reducing the number of visits and time spent on these sites which has negative impacts on revenues. Thus, the onus is on the advertisement publishers (websites) to improve the user experience.

However, since Google and Facebook claim over 73% of online digital ad revenue and can be credited with 99% of growth in US total online ad budget from 2015 to 2016 *(Ingram, 2017)*, the state of the market is such that in order to grab user attention despite advertisements, publishers end up creating content optimized for clicks. This has resulted in a reduction of high-quality content, and has led to the creation of "clickbait" content which negatively affects the end user experience in the long term.

The paper, therefore, A. looks at the concerns associated with the current state of advertisement and its effect on attention B. Uses Coase theorem to explain the mutually beneficial situation among publishers, advertisers, and users, and finally, the novelty that this paper adds is by using game theoretic Bayesian modeling to explain how and when adoption of Brave Browser takes place.

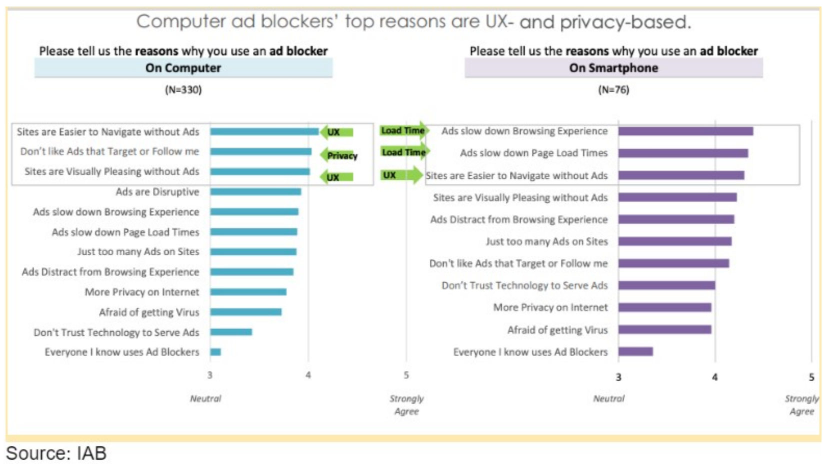


Figure 1: Source: IAB, 2016

2 The Basic Attention Token (BAT)

One of the new approaches to solving the problems plaguing the digital advertising industry involves the idea of paying users to watch ads. Our paper focusses on the Basic Attention Token (BAT) which is embedded in the Brave browser. Brave was originally an open-source, privacy-focused browser that automatically blocked third-party ads and tracking. In 2019, an opt-in feature known as 'Brave Rewards' was introduced which allowed users to be paid BAT to view and interact with advertisements. BAT is a token based on Ethereum that utilizes smart contracts to confirm user attention, allowing advertisers to verify user engagement without infringing on privacy. Each month, BAT is transferred directly either to the inbuilt Brave Wallet or to other Ethereum-compatible wallets. Users receive 70% of the tokens they earn with the rest split between the publisher and Brave *("Basic Attention Token (BAT): Fixing Digital Advertising with Brave", 2019)*. Whereas initially BAT could only be used to purchase vouchers for online retailers, a partnership with Uphold, a global digital money platform, in 2017 now provides users with a way to directly convert it into fiat currencies *("Uphold to support Brave's Basic Attention Token", 2017)*.

2.1 BAT and Attention Span

There are two ways the user's attention might be affected. Let these two scenarios be **Scenario A** and **Scenario B**.

Note: Detailed calculation of the Basic Attention Metric Score is shown in the appendix

Scenario A (More Awareness about Attention)

Due to the existence of the BAT with the Brave Browser consistently tracking the user's attention time spent, the users might become more aware of the value of attention and screen time which might lead them to be more rational in their usage. Plus, with more targetted advertisements and a relatively uncluttered screen, users might spend less time engaging with irrelevant ads. Overall, this would increase the user's utility as their disturbance from advertising would decrease and would also be compensated for their distraction.

Scenario B (Moral Hazard)

The user's attention and the time duration they spend viewing an advertisement play a strong role in determining the value of BAT, there might be a serious issue of Moral Hazard attached to tokens.

Since the user knows that they are going to be compensated for their attention, they may expose themselves to more advertising in quest of earning a higher value of the BAT. In such a scenario, the BAT would incentivize distraction.

Moreover, targeted advertisements are likely to increase user engagement which would further lead to increased distraction. Over a period of time, this could potentially lead to people purposefully engaging with advertisements in order to artificially increase the price of the BAT which poses a serious threat.

To conclude, the probability of Scenario A or Scenario B would largely depend on the data around BAT and the Attention Span. At the moment due to the relatively recent release of the BAT in 2021, there is a lack of data available. Also, whether Scenario A or Scenario B is optimum would depend on the payoffs of the Scenarios which would largely depend on the preferences of the users (whether they would prefer a higher BAT value or less distraction).

3 Coase Theorem

With the introduction of the BAT, there is a greater focus on the value of Attention and the user's focus. Hence, this ensures that the user receives fast loads of ads, more targeted advertising, minimal malware, a simple viewability matrix, and User Privacy. All of this is corroborated by the very underlying nature of how the BAT functions. The BAT acts as an intermediary between three parties: Advertisers, Publishers, and Users as shown below (**Figure 2**).

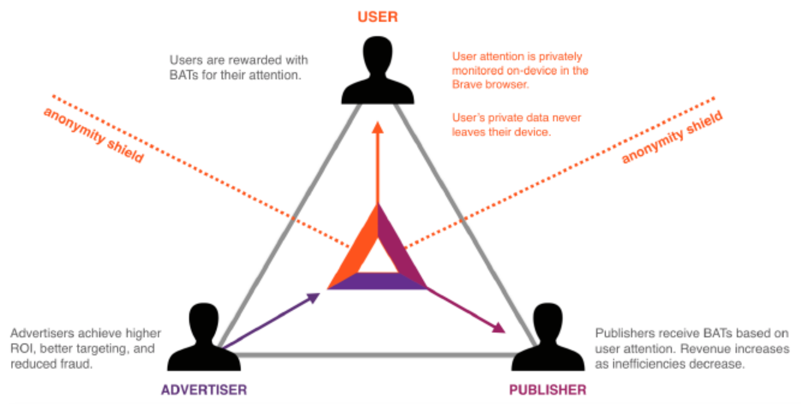


Figure 2: Source: Brave Software, 2021

BAT's operating mechanism ensures an optimal contract between the three parties leading to automated (via Blockchain) negotiation between them which is then reflected in the value of BAT. For instance, if there is excess user attention being captured on websites, then the user would be compensated in the form of a higher value of the token.

It would be useful to understand the mutual benefit for each of the parties through the Lens of the Coase Theorem (*Brave Software, 2021*);

Let there be a total social cost (P_a^c) in the online ad ecosystem;

$$P_a^c = P^a + P^d + P^p + P^s \tag{1}$$

Where

P^a is the cost to the advertiser.

P^p is the privacy loss. Due to BAT's anonymizing features, this would be zero.

P^d is the data costs. There will be some amount of Pd due to certain data and network costs.

P^s are the security risk costs (Hacking etc). The use of zero-knowledge proofs and cryptographic methods would lower this.

Therefore, in a BAT based online ecosystem, the total social costs would be;

$$P_a^c(\text{BAT}) = P^a + P_{\text{BAT}}^d + P_{\text{BAT}}^s \tag{2}$$

And after first-order approximation;

$$P_a^c(\text{BAT}) = P^a + P_{\text{BAT}}^d \tag{3}$$

The remaining social cost (P^a) can further be used by including Publisher Premium Content, loyal Publisher points, etc.

Figure 3: Source: https://messari.io/asset/basic-attention-token/chart/price

Hence overall, as can be seen from the above, the Coase theorem demonstrates that the BAT system eventually lowers the total social cost making all parties better off by lowering costs across the board. In order for the Coase Theorem to hold, there are two conditions that are quintessential: Low Transaction Costs and Clearly defined Property rights. The fact that BAT is based on Blockchain technology and is automated on a user-friendly browser like Brave satisfies these conditions.

However, this also does make the BAT extremely volatile in nature due to the underlying volatility in parameters such as attention, publishing, and advertising. The graph **Figure 3** shows the value of the BAT in the past 24 hours.

4 Model: Brave Browser (Technology) Adoption

4.1 Premise

In this section, we create a simple model of adoption of Brave Browser by drawing on the idea of informational conformity from *(Bikchandani, Hirshleifer and Welch, 1992).* This model will attempt to explain when and why would people converge towards adoption of Brave Browser (and thereby, the BAT). Informational conformity is the acceptance of evidence about reality provided by others *(Myers, 2009).* This explains technology adoption in the following manner: "I observe my friend casually using his new Iphone. He seems to love it." So I think to myself, "If my friends love it, it must be worth it for me. So I will buy one."

(Ye, et al., 2014) argues that perceived security and perceived ease of use are essential for the switching of browsers that are near substitutes. We incorporate this feature in our model as the private signal received by the users, who subsequently update their belief about whether to keep using the current browser or switch to Brave. We eventually show the condition necessary for the information cascade: when it is optimal for the browser users, having observed the actions ahead of him, to follow the behavior of preceding users without regard to his own information. In our model, information cascade starts from user 3, meaning, regardless of his own private signal about brave browser, user 3 and subsequent users would start adopting Brave and, thereby, BAT.

Our basic premise is we view Brave as the utility maximizing browser, which by extension, increases the utility of its users through a. Enhanced privacy b. More limited but personalized ads. So if we are the social planner, how would we want to encourage the adoption of Brave?

4.2 Setting up the Model

Consider a group of internet browser users (henceforth, 'users').
If they use their current browser, payoff= C_o. (assume 0) *We shall also derive the general case. The utility here is ordinal in nature and merely indicates ranking.*

Use Brave Browser: if "good" (G), payoff $=B_g$ (assume 1); if "bad" (B), payoff= B_b (assume -1)

Note here that: The 'bad' and 'good' characterization of the browser is from the perspective of the users. The users have a prior belief (with certain probability) about the Brave browser being good or bad. This prior belief, we assume, is same for all the users in our model. Only the private signals and its probability can vary.

4.2.1 Prior Beliefs

So, each user has a prior belief that the new browser–Brave–is G with probability $\frac{1}{2}$

$$P(G) = P(B) = \frac{1}{2}$$

Note here that: The prior belief doesn't necessarily have to be half. Assuming any general prior belief would yield useful results. However, assuming half would imply the indifference state of the users, so it is not completely an unrealistic behavior and in fact the general state of matter for the users.

4.2.2 Private Signals

The browser users update their probability based on the private signal they receive. The private signal here could mean multiple things: reading a review of Brave in the Internet, or seeing an 'educative' ad–basically any form of signal that would educate users about the nature of Brave browser. So the signal can be either High (H) or Low (L). So,

$$P(H/G) = p > \frac{1}{2}, P(L/G) = 1 - p, P(L/B) = P > \frac{1}{2}, P(H/B) = 1 - p$$

where P(H/G) is the probability that user receives high signal given the browser is actually Good. P(L/B) is the probability that the user receives low signal given the browser is actually bad.

Note here that $P(H/G) = p > \frac{1}{2}$ as the chances of receiving high signal is more when the browser is actually Good. And the chances of receiving a bad signal is high when the browser is actually bad. Users sequentially decide which browser to adopt, starting from User 1, then User 2, and then User 3 and so on.

4.2.3 Analysis: User 1

Suppose user 1 receives private signal H (private signal, here could mean that he reads a review of the Brave browser). Will he adopt?

Bayes' rule:

$$\begin{aligned} P(G/H) &= \frac{P(H/G)P(G)}{P(H/G)P(G) + P(H/B)P(B)} \\ &= \frac{p.1/2}{(p.1/2) + (1-p).1/2} \\ &= p > \frac{1}{2} \end{aligned}$$

Expected payoff of adopting Brave Browser:

$$\begin{aligned} payoff &= p.B_g + (1-p).B_b \\ &= p.1 + (1-p). - 1 > \frac{1}{2} \end{aligned}$$

So, if signal high, then the User adopts Brave Browser.
By similar logic, if low signal, the user doesn't not adopt Brave.

$$P(G/L) = 1 - p < \frac{1}{2}$$

4.2.4 Analysis: User 2

User 2 observes User's 1 choice to adopt A_1 and observes his own private signal.

Observation A_1 here is that user 1 adopted Brave.

Suppose User 2's signal is H. Will he adopt Brave? That is, what is the probability that the User 2 will adopt Brave given he receives High signal and User 1 has adopted Brave, A_1?

$$\begin{aligned} P(G/A_1H) &= \frac{P(A_1H/G)P(G)}{P(A_1H/G)P(G) + P(A_1H/B)P(B)} \\ &= \frac{P^2}{P^{+}(1-P)^2} \end{aligned}$$

where,

$$P(A_1H/G) = P(A_1/G)P(H/G) = P(H/G)P(H/G) = p^2$$

and

$$P(A_1H/B) = P(A_1/B)P(H/B) = P(H/B)P(H/B) = (1-p)^2$$

We obtain,

$$P(G/A_1H) = \frac{P^2}{P^2 + (1-p)^2} > p$$

if $p > \frac{1}{2}$

But if User 2 receives signal L (along with A1), will he adopt?

$$
\begin{aligned}
P(G/A_1L) &= \frac{P(A_1L/G)}{P(A_1L/G) + P(A_1L/B)} \\
&= \frac{P(1-P)}{P(1-P) + P(1-P)} \\
&= \frac{1}{2}
\end{aligned}
$$

In this case, User 2 is indifferent between adopting Brave and not adopting. We can assume that he tosses a coin and only adopts if head appears.

4.2.5 Analysis: User 3 and subsequent 'n' users

Suppose User 3 observes A_1 and A_2 (both have adopted brave browser). We now argue that he will himself then adopt Brave, even if his private signal is L, that is:

$$
\begin{aligned}
P(G/A_1A_2L) &= \frac{P(A_1A_2L/G)P(G)}{P(A_1A_2L/G)P(G) + P(A_1A_2L/B)P(B)} \\
&= \frac{P(A_1A_2/G)P(L/G)}{P(A_1A_2/G)P(L/G) + P(A_1A_2/B)P(L/B)} > \frac{1}{2}
\end{aligned}
$$

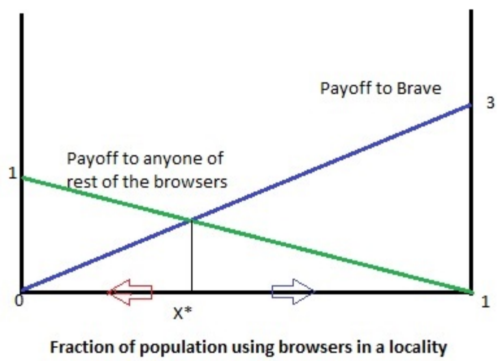
If $P > \frac{1}{2}$

Note: Detailed calculation is shown in the appendix

This means that if user 1 and 2 have adopted brave browser, user 3 and any subsequent users will adopt the Brave browser irrespective of the private signal he receives. This is the inception point of information cascade.

5 Implications & Economics

The aforementioned model is useful insofar as it is able to explain the real world phenomenon. As of now, the Google Chrome has 63.37 % market share, Microsoft Edge has 7.75 %, Firefox 7.48 % and the rest occupies the remaining fraction. *(Netmarketshare Team, 2019).* In a market of 3.22 billion, Brave currently has only 54.5 million users *(Brave.com, 2022).* The meagre fraction occupation of the Brave could be explained by two factors: a. The low adoption of the Brave by the users in their vicinity b. the low probabilistic and low kind of signals obtained by the user. From the perspective of the social planner one can increase the adoption of brave by ensuring the critical mass of population use Brave. This is illustrated through Game Theoretic Notion in the figure below.



Here, X is the fraction of population using Brave and $1 - x$, the rest of the browsers.

$$F_B(x) = 3x$$

$$F_R(x) = 1 - x$$

Where, F_B and F_R is the payoff for an individual using brave browser and rest of the browser respectively. As evident, it is a function of the proportion of population using the same browser.

At $X = 0$ and $X = 1$ we have stable Nash equilibrium but at $x = x^*$ we have unstable Nash equilibrium.

Critical population: So for the social planner to ensure that Brave browser usage is Nash equilibrium, it has to educate population beyond $X = X^*$. Otherwise, it will be stuck at the rest of the browsers.

Furthermore:

Wrong direction: Information cascade in the Bayesian model could also go in the wrong direction. It is possible that Brave Browser may be rejected based on faulty information early on, or just plain bad luck. This depends on the probability of both the high signals and low signals. Hence, policy making attending to disseminating educated information about Privacy is indispensable.

Order of signal timing: Order of signal is important in that it defines the adoption. If first two receive high signal and the rest receive low, adoption will happen anyways. But if the first 2 receive low and rest high high, adoption is unlikely. Hence, sheer timing plays crucial role.

6 Conclusion

The research on BAT is still in its infancy with most of the research focusing on developing the understanding about BAT itself. The paper discusses the possible impacts on user attention span with the introduction of BAT: *Scenario A (More awareness about Attention)* and *Scenario B(Moral Hazard)*. The paper has also attempted to advance that through Coase theorem, throwing light on the optimal conditions of low transaction and well-defined property rights. In addition, if the optimistic assumption of this paper about Brave browser being a utility maximizing browser is at all true, then the social planner needs to take into account the critical mass of population necessary to educate to make it an equilibrium strategy. That, we believe, is the unique contribution of this paper, which has tremendous scope for further research. In toto, Brave browser and BAT is an innovative technology that could redefine how users' attention and productivity gets affected.

References

Basic Attention Token (BAT): Fixing Digital Advertising with Brave. (2019). https://medium.com/@blockescence/basic-attention-token-bat-fixing-digital-advertising-with-brave-da8ff1712b1a

Bikhchandani, Sushil Hirshleifer, David Welch, Ivo. (1992). A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades. *Journal of Political Economy*. 100. 992-1026. 10.1086/261849.

Brajnik, G., Gabrielli, S. (2010). A review of online advertising effects on the user experience. *International Journal of Human-Computer Interaction*, 26(10), 971-997.

Brave.com (2022) Brave Talk. https://brave.com/2021-recap/

Crypto research, data, and Tools. Messari Crypto. (n.d.). Retrieved May 5, 2022, from https://messari.io/asset/basic-attention-token

Gibbs, W. (2008). Examining users on news provider web sites: A review of methodogy. *Journal of Usability Studies*, 3, 129–148.

Ingram, M. (2017). How Google and Facebook have taken over the digital ad industry. *Fortune Tech*.

Interactive Advertising Bureau. Ad Blocking: Who Blocks Ads, Why and How to Win Them Back. Tech. rep. Interactive Advertising Bureau, 2016. url: http://www.iab.com/wp-content/uploads/2016/07/IAB-Ad-Blocking-2016-Who- Blocks-Ads-Why-and-How-to-Win-Them-Back.pdf.

Myers (2009) Normative and Informational Influence When Decision-Making in Groups https://www.apa.org/ed/precollege/undergrad/ptacc/normative-informational-influence.pdf

Netmarketshare (2019). Market Share Statistics for Technologies. https://netmarketshare.com/browser-market-share

Novak, T. P., Hoffman, D. L., Duhachek, A. (2003). The influence of goal-directed and experiential activities on online flow experiences. Journal of consumer psychology, 13(1-2), 3-16.

Software, B. (2021, February 10). Basic attention token (BAT) White Paper .Retrieved from https://basicattentiontoken.org/static-assets/documents/BasicAttentionTokenWhitePaper-4.pdf

Tuttle, H. (2015). The rise of malvertising. *Risk Management*, 62(8), 44.

Uphold to support Brave's Basic Attention Token. (2017). https://www.cryptoninjas.net/2017/08/18/uphold-support-braves-basic-attention-token/

Ye, Chen Seo, DongBack Desouza, Kevin Papagari, Sridhar Jha, Sanjeev. (2006). Post-Adoption Switching Between Technology Substitutes: The Case of Web Browsers, 116.

Appendix

Computation of Attention Metric

One of the metrics used is a score which rewards a publisher for a thresholded and bounded function of the amount of time spent on an open and active page. For example, one "point" could be awarded for a two second view of the page, with two points for a 30 second view, and 3 for a 60 second view, with diminishing or bounded returns for longer views. The present implementation of this score is a quadratic score whose formula is as follows:
score is given by:

$$\frac{-b + [\sqrt{b^2 + 4a \star duration}]}{2a} \tag{4}$$

Here a = 13000, b = 11000 and *duration* is measured in milliseconds. This gives a minimum threshold of 25 seconds to achieve a score of 1. The upper bound is set to be around 12 minutes of attention given to the article, with a maximum score for a given piece of content of 7.

User 3 calculation

$$P(A_1A_2/G) = p^2 + p(1-p)0.5; P(L/G) = 1-p$$

Given G and A_1A_2 happens (both adopts) if both see H (probability p^2) or if 1 sees H and 2 sees L with a coin toss that is head (probability p(1-p)0.5)

$$P(A_1A_2/B) = (1-p)^2 + (1-p) * 0.5, P(L/B) = p$$

Given B, and A_1A_2 happens (both adopts) if both see H (probability $(1-p)^2$) or if 1 sees H and 2 sees L with a coin toss that is head (probability p(1-p)0.5)