
ADBRAIN
DEMYSTIFYING
CROSS-DEVICE
Essential reading for product management,
business development and business
technology leaders
Includes a contribution from the IAB
iab

EXECUTIVE SUMMARY

This guide is intended to provide Marketers with an introduction to cross-device, and more importantly a framework for evaluating cross-device solutions. For the purposes of this guide "Marketers" include direct brands, media agencies, programmatic specialists and publishers. Different types of businesses will focus on different cross-device applications but the evaluation process will be very similar.

Cross-device is a new opportunity in the digital advertising ecosystem, but a crucial one since it allows Marketers to understand how a single customer is interacting with their brand across devices. Without that understanding it is impossible to build effective and efficient marketing strategies. The good news is there are several options in the market today.

In summary, this guide introduces the following concepts and discussion points:

- Why understanding cross-device is so critical in today's digital landscape
- The key applications of cross-device technology that can benefit brands, publishers, and technology vendors alike
- The advantages and disadvantages of different cross-device technologies
- How to evaluate cross-device vendors
- How to measure and compare cross-device performance

It is essential reading for product management, business development and business technology leaders.

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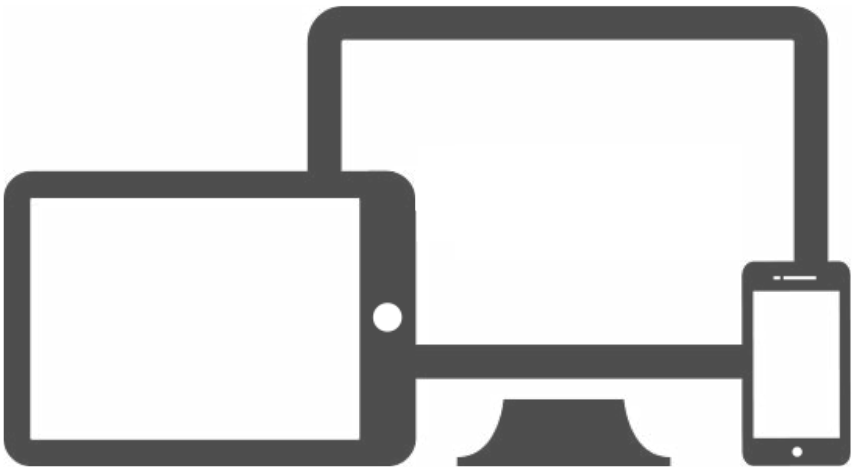

We're at a point now where mobile accounts for 34% of digital display advertising spending (IAB UK / PWC Digital Adspend Study). This is testament to the fact that mobile delivers results, both from a branding and DR perspective. When you couple this with the proliferation of smartphone and tablet devices it presents a huge opportunity for businesses from all sectors. In fact, according to a recent Ericsson Research study, the average US household now posseses 5.2 internet connected devices and this figure is only set to grow as we head into the era of The Internet of Things and wearable technology.

> "The good news is that developments in cross-device technologies have opened up a world of possibilities"

As the growth curve continues we're seeing the emergence of cross-device campaigns. This is being driven by the consumer appetite to engage with content on any number of different devices and screen sizes, for advertisers this means being able to reach the same consumer with relevant messages across the different devices they use throughout the day. Tying this consumer behavior together with relevant and targeted advertising is the challenging part, however the emergence of sophisticated probabilistic methods of targeting has made cross-device campaigns a much stronger proposition.

Despite all this progress there is still a need for education in this area, a point highlighted in our latest IAB Mobile Agency Snapshot Study where 89% of agency employees agreed that 'Not being able to track cross-device campaigns is holding back the growth of mobile.' For digital advertising to continue its impressive growth advertisers and agencies need to feel confident that their investment will drive results. The good news is that developments in cross-device technologies have opened up a world of possibilities, including the promise of cross-channel attribution. It's truly an exciting time to be a part of this industry, but with new opportunities comes new challenges and it's clear that education will play a role in bringing the industry up to speed, which will ultimately deliver better advertising experiences.

Mike Reynolds, Senior Mobile Executive at the IAB

01 INTRODUCTION TO CROSS-DEVICE

Recent studies have shown that 90% of internet users are now using more than one device to accomplish a task over time.[1] Couple that with new numbers showing that there are now 2bn global smartphone users, with an additional 400m projected by the end of 2017, and it's clear that consumer behaviour has become increasingly cross-device.[2] Despite all of these developments there is no built-in technology that allows Marketers to track people across those different digital properties.

This is the so-called cross-device challenge. How can a Marketer optimize their online content, maximize their yield, plan media campaigns effectively, manage user profiles, track conversions and measure true reach / frequency without knowing when they are interacting with the same user, just on a different device?

By 2016 digital media ad spend will overtake TV in the US, consequently the cross-device challenge will intensify as consumers shift to emerging platforms.[3]

ABOUT THE AUTHOR

Adbrain is at the cutting-edge of providing intelligent technology solutions that can transform the cross-device challenge into an opportunity.

Adbrain ingests billions of data points daily and overlays sophisticated artificial intelligence technology to create a single, privacy-safe view of the consumer across devices. We enable Marketers to understand who their audiences are by identifying linkages between devices. This in turn drives precise and innovative cross-device applications from media buying to analytics and attribution. Adbrain's solutions have been designed to plug-in to the Marketer's existing media delivery or data platforms.

Adbrain was founded two years ago and currently has offices in London, New York, and San Francisco. We currently work with leading brands, publishers, and advertising / marketing technology businesses.

For more information please visit our website or email your questions to **CrossDeviceExplained@adbrain.com**

In this fast moving and highly innovative space we expect further developments to occur, but we believe this document will remain relevant for some time.

SO, WHAT IS A CROSS-DEVICE SOLUTION?

Cross-device solutions all share the same basic functionality of linking devices together. In practice, this means creating connections between the IDs that the advertising industry uses to track user interactions, create profiles and manage ad delivery.

For desktop and mobile web these are mainly cookie IDs, and for mobile apps they are mobile device ids (IDFA, Android Advertising ID). In the simplest terms, the task at hand is to pair multiple IDs together that belong to the same user.

These sets of ID pairs are called device graphs, and it's these graphs that form the basis of cross-device applications.

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CREATING VALUE FROM DEVICE GRAPHS

WHY DOES MY BUSINESS NEED A CROSS-DEVICE SOLUTION?

At a high level the idea of understanding a single user across multiple devices is compelling. However, in practical terms it isn't always clear to Marketers what the tangible applications to drive business value and incremental revenue actually are.

As a starting point here are some of the highest value applications of cross-device.

MEDIA-CENTRIC APPLICATIONS

1. **Cross-Device Audience Amplification**

   Take audiences identified via one channel and market to them on other devices. Activating an audience across different channels is a way to extract greater value from your existing data management platforms. For example, a publisher could leverage its desktop user profile data when that user appears in their app.

2. **Cross-Device Retargeting**

   Mobile to desktop - Retarget users who have researched your products on their mobile devices when they are on their respective desktop devices (and are more likely to complete a complex transaction).

   Desktop to mobile - Reach your engaged desktop users on their mobile devices (to encourage them to download, install and interact through your apps).

   Desktop to desktop - Ensure a single user's profile is ported across all browsers on a single or multiple desktop devices.

3. **Cross-Device Frequency Capping**

   A device graph can be deployed within a media adserver to limit the number of ads a single user sees for a particular brand or product across all devices. This yields significant reduction in media wastage. For example, Marketers can avoid showing ads on one device to users who have already been exposed to that same ad across other devices.

4. **Cross-Device Sequential Messaging**

   Delivering a tailored ad to a user based on their previous interaction with an advertising campaign is a proven brand engagement tactic. Access to a device graph allows this tactic to be extended across screens. For example, a desktop ad can be tailored to reflect the user's previous interactions with that campaign across mobile devices.

ANALYTICS AND AUDIENCE-CENTRIC APPLICATIONS

1. **Cross-Device Conversion Uplift**
   A device graph means you can understand how a conversion is attributed to media interactions across screens. This is very much the Holy Grail for many Marketers since it allows them to truly understand the overall impact of investing in different media channels. For example, this type of insight analytics allows a Marketer to finally understand how mobile media dollars drive performance and brand engagement on other, non-mobile channels.

2. **True Unique Reach and Frequency**
   Access to a device graph provides a much clearer view of how many actual people have been reached, and at what frequency. This makes for more effective media planning and reduced media wastage. For example, true cross-device reach would allow you to optimize a media plan by removing mobile placements that aren't delivering incremental reach to desktop placements.

3. **Cross-Device Segment Creation**
   Create segments of users based on their interactions across multiple devices. For example, create a segment of users who have downloaded an app but continue to interact only on desktop.

4. **Predictive Modelling**
   Collapse device-specific data signals to the user level prior to model run-time to increase volume of data signals. Parameterize mobile vs desktop data signals separately at model run-time to create output reflective of device specific behaviors.

Not all cross-device vendors will support these application so with this list of examples in mind it is necessary to define how the technology can be applied to your business.

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COMPARING CROSS-DEVICE VENDORS

When evaluating vendors there are a few key questions to consider. These questions will have a material impact on how much value can be extracted by the Marketer.

QUESTION	FACTOR TO CONSIDER
How is the cross-device service accessed?	Can the Marketer use the vendor's solution with their existing technology? Does the solution support all the applications listed above?
What input data is used to create the device graph?	Does the Marketer have to contribute their own data? Does the input data scale in terms of volume and new markets?
How are the linkages between devices created?	Is the number of matches constrained by the vendors' other products? Are matches created with due respect to the end user's privacy? Are the matches created performant i.e. correct?

ACCESSING A DEVICE GRAPH

In general there are three ways that a vendor may make its device graph available to Marketers:

1. **Coupled to media activation**

   The vendor only allows the Marketer to access their device graph when the Marketer also uses the vendor to run media campaigns. Put differently, the Marketer has to use the vendor as a media partner to access the device graph.

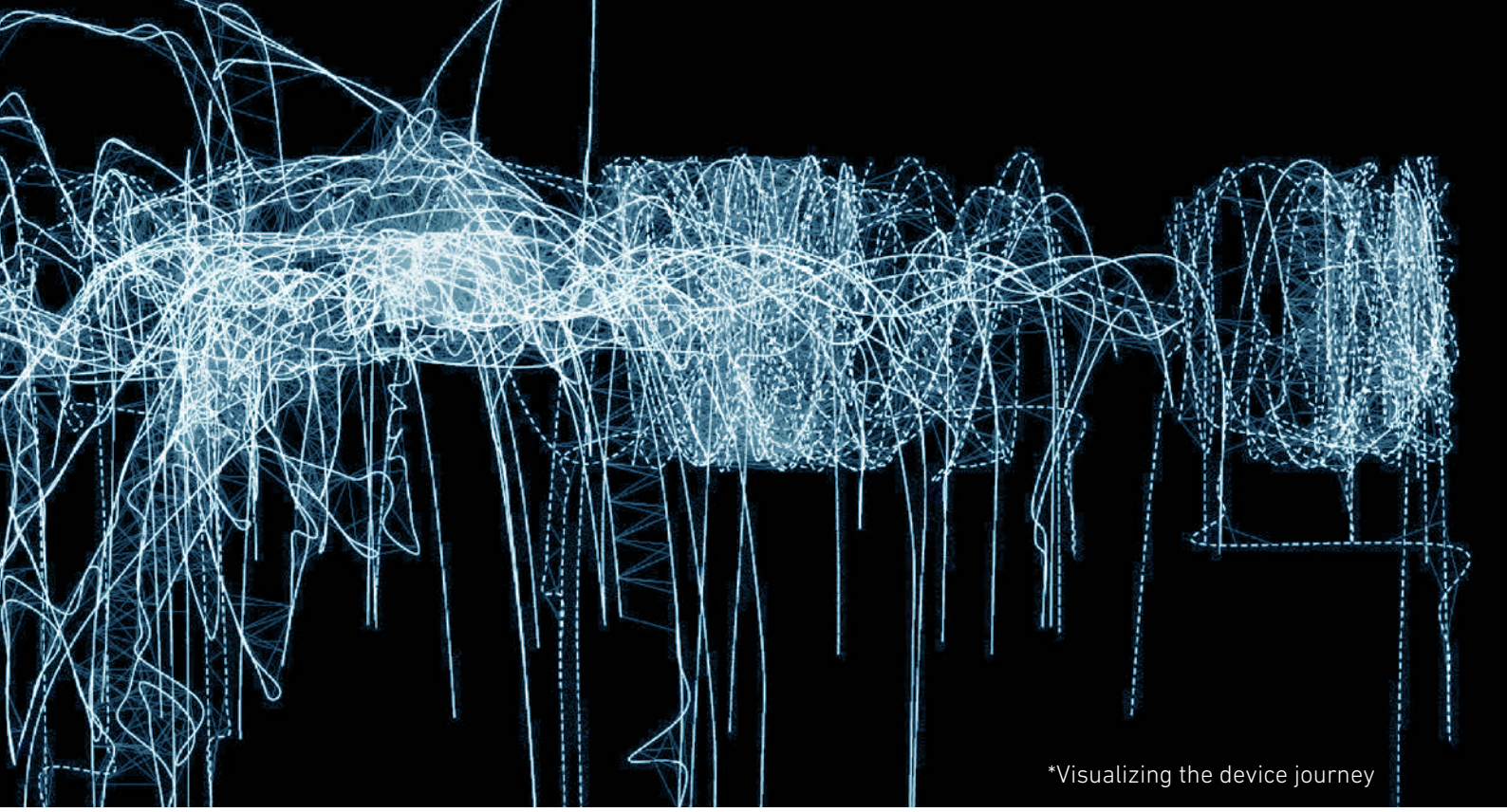
   These vendors will typically charge on a media CPM for every impression delivered using cross-device data. For example, the device graph vendor may provide cross-device path to conversion attribution, but only for campaigns executed on the vendor's media platform.

Advantage:

- For some vendors coupling the device graph with media makes for a simpler deployment and a quicker activation for Marketers.

Disadvantages:

- Media coupled solutions typically are less flexible since the Marketer can only use the device graph for media provided by the vendor. This means the Marketer may need multiple vendors for each part of their media plan.
- A solution that is coupled to media limits the value of the applications above. For example, cross-device path to conversion attribution is very much limited in value if not run across all components of a media plan.
- Vendors who also operate a media business may not disclose their media margins, which makes it difficult to evaluate the added technology cost.



*Visualizing the device journey

2. Enabled through an intermediary

Here the vendor may provide access to some or all of its device graph features via an intermediary DSP, SSP, Adserver or DMP.

These vendors will typically charge on a media CPM for every impression delivered using cross-device data.

Advantages:

- This allows the Marketer quick and easy access to the vendor's solution, which is particularly useful for simple tests.
- The Marketer can seamlessly access the device graph with very limited integration work.

Disadvantages:

- The Marketer may not be able to access all of the vendor's device graph functionality since there will be less flexibility for the Marketer vs having a closer direct integration with the vendor.

3. Decoupled from media activation

In this model the vendor provides access to the device graph within its pre-existing ad tech infrastructure.

These vendors will typically charge a monthly licence fee based on the quantity of data provided to the Marketer.

Advantages:

- This solution means the Marketer retains control of their media activation i.e. no need to change media plans. The vendor provides new cross-device services to enhance the Marketer's existing technology.
- Allows the Marketer to create their own intellectual property and their own products/services to create their own differentiated end user propositions.
- Clear commercial distinction between media and technology fees.

Disadvantage:

- The Marketer needs to activate the output of the device graph in their own ad tech platforms and for some vendors this integration can be time consuming.

The trade-off is between transparency and control vs simplicity. Each Marketer should consider that trade-off as part of their broader vendor evaluation because it significantly impacts how the partnership is structured.[4]

INPUT DATA FOR THE DEVICE GRAPH

It's important to ask where the data a vendor uses to create its device graph actually comes from.

It is an area worth scrutinizing since it strongly influences the strength of the vendor's solution in two ways:

1. Does the input data include data derived from the Marketer's media impression footprint? If so, then this could mean the Marketer's data is helping to create an asset that advantages others. While there is nothing intrinsically wrong with a vendor leveraging all the data available to provide a better service to all customers, this is something that most Marketers would need disclosed.

2. Does the input data scale both in terms of coverage of a single market, but also other markets of interest? This point is crucial because there is significant value in working with a vendor who can service a global business (e.g. minimizing the costs of having multiple different vendors in different markets).

Broadly speaking, there are three strategies a vendor may use for input data:

1. Input data derived from media campaign impressions

In this model the vendor will use data signals collected from impressions served in the media campaigns that the vendor is running on behalf of the Marketer.

For vendors that run a media business this is technically easy to do and hard to monitor because they have free access to load their code into the ads they are serving. Vendors can also follow this strategy by asking marketers to place non-frequency capped "tracking tags" into the Marketer's media campaigns.

Advantage:

- The advantage of this solution is principally with the vendor – helping them to create connections between IDs at reduced cost. This can benefit the Marketer if that cost saving is passed through to the them.

Disadvantages:

- There is scope for the Marketer to indirectly benefit a potential competitor (client X's media helps build the device graph for competitor Y to use). It's unlikely that the client will be directly compensated for this value exchange.

- Vendors who rely on media impression data to build their device graph will be constrained by the media footprint they have access to. This type of device graph cannot scale without media scale.

2. Input data contributed by the marketer

Another common scenario is when the vendor makes no attempt to build their own data sources. These vendors offer a service where the marketer contributes their own data for the vendor to process and create a device graph.

Advantage:

- The integration will be very "deep" since data must flow seamlessly between vendor and Marketer. This type of data flow often makes it simpler to activate cross-device applications.
- For similar reasons there can be an advantage here in terms of data security, particularly where the vendor deploys its solution onto the Marketer's hardware (an on-premises software only solution).
- It's clear that the marketer's data will only be used to benefit that specific client, and not others. This is not often clear with other approaches.

Disadvantages:

- One key disadvantage is the reverse of the key advantage. A "deep" integration is only efficient once the costly and time consuming integration process is finished.
- Scale (volume and geography) for these solutions can by definition never exceed the scale of the Marketer's data and every customer starts with an "empty" device graph. Even the larger marketers are unlikely to have sufficient data to fuel a truly scaled device graph.

3. Input data derived from owned and operated content

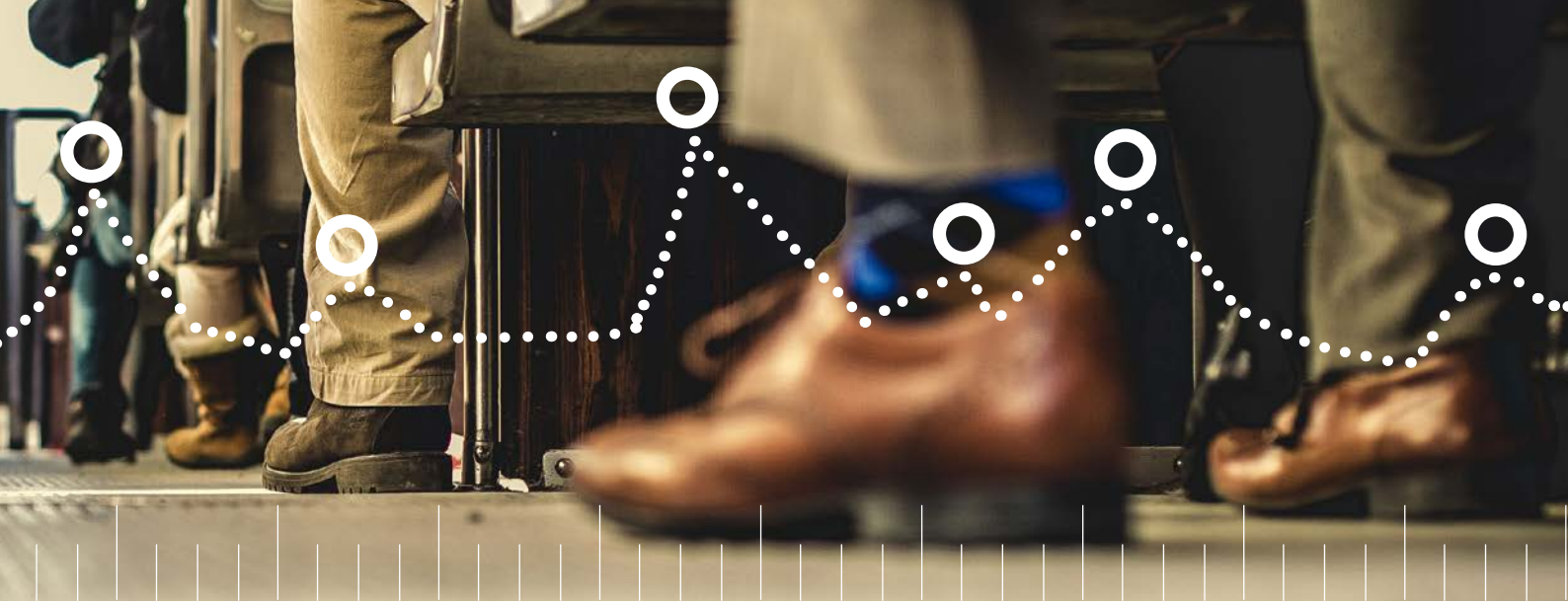
A minority of device graph vendors have access to data from their own media properties. Businesses such as Amazon, Google, Yahoo, AOL, Microsoft, Yandex and so on natively have access to the type of data required to fuel a device graph, specifically user login data.

Advantage:

- Device graphs built on this type of login based input data tend to be of high quality (see next section).
- The vendor natively owns this data as it comes from its own user base and hence has no additional cost. This may be passed through to the Marketer.

Disadvantages:

- These solutions are limited to a fixed scale in the short to medium term (constrained by the size of the vendor's user base) which can be a particular problem when global coverage is required.
- Very often these solutions are tightly coupled with media in some way - these are the so called "walled gardens" where cross-device solutions often only apply within the vendor's media environment.



4. Input derived from data partners

The final option is where vendors derive input data from data partners entirely independent of campaigns run by or websites controlled by the Marketer.

Advantage:

- Marketers get access to a pre-existing device graph that's ready to use.
- Data from the Marketer's media impressions aren't used to enhance the vendor's device graph. Therefore there is no risk of a Marketer's data potentially advantaging a competitor who is using the same device graph.
- Vendors can deploy device graphs into new markets by expanding existing data partnerships. There is no long time-lag while the vendor ramps up their media business.
- Vendors in this category will also allow Marketers to optionally work as both a device graph customer and a data partner which provides an enhanced version of the Marketer contribution model described above.

Disadvantages:

- This strategy creates a data acquisition cost for the vendor and typically means they will need more sophisticated mathematical algorithms to create linkages between devices. Both of these can mean there is a higher cost to the marketer.

HOW ARE DEVICE LINKAGES IDENTIFIED?

Each vendor will have its own approach for creating the linkages between IDs. There are two important dimensions for evaluating the strength of these approaches.

1. **Is the matching solution respectful of consumer privacy?**
2. **Does the matching solution scale?**

In market there are currently three general solutions. Each option uses different strategies for what types of ID will be linked together and different strategies for how the linkages themselves are created:

GRAPH TYPE	TYPE OF ID LINKED	LINKAGE CREATED
Deterministic	Deterministic	Deterministic
Pure Probabilistic	Deterministic	Probabilistic
Probabilistic & Statistical IDs	Statistical + Deterministic	Probabilistic

1. Deterministic device graph

In this model the vendor has access to data from registered users who log in to content from more than one device but using the same login credentials.

Some vendors have access to this data because they control those login portals, whereas other vendors will rely on login data provided by 3rd parties.

Advantage:

- Vendors that use this type of login data to create connections between IDs will often have device graphs that perform very well.
- From a privacy perspective, vendors that have a direct consumer relationship can ensure they have respected the consumer's privacy in an appropriate way.

Disadvantages:

- These devices graphs are hard to scale. Linkages are acquired from logged in users and so to increase the number of linkages the vendor needs more logged in users. The device graph scale is limited by the size of the registered user base.
- Even the behemoths with large logged in user bases will not be able to attain 100% coverage.

2. Pure probabilistic

While deterministic device graphs create linkages between IDs based on users logging in to a property from different devices, probabilistic device graphs create those linkages using algorithms to predict that two IDs belong to the same actual user. These predictions are never known with certainty, rather they have a probability of being correct hence the name.

Pure probabilistic device graphs work by finding linkages between so-called deterministic IDs. Deterministic IDs are IDs broadcasted by internet connected devices. These IDs are called deterministic because they do not change (unless the user resets them or they expire) and they uniquely identify a single device.

These deterministic IDs are broadcast by the PC, Tablet or Mobile Device specifically for the purposes of advertising (primarily Cookies, IDFA, Android Advertising ID). These IDs are sometimes known as privacy-safe IDs because the end user has relatively high levels of transparency and control over them.

Pure probabilistic device graphs work by looking for similarities in how IDs have interacted and, if those similarities exist, then inferring it is the same individual using both devices. An example for how these type of device graphs work is given in the next section with reference to Adbrain's approach.

Advantage:

- Probabilistic solutions tend to scale. The only limiting factors are the quantity and quality of input data and the robustness of the technology.
- These solutions are also highly respectful of end user privacy if the vendor has set up an appropriate policy.

Disadvantages:

- By nature probabilistic device graphs will never be 100% correct.
- They require a huge amount of input data and sophisticated math, so these are hard for Marketers to build in-house. This is also a costly process that may be passed on to the Marketer.
- This approach is highly dependent on devices broadcasting their deterministic IDs, this poses a problem when such IDs are not available.

3. Probabilistic with statistical IDs

One downside with a pure probabilistic approach is that not all devices will be broadcasting a deterministic ID. In other words there can be device "blind spots" where no deterministic ID exists.

In particular, this blind spot exists for the Apple Safari web browser where 3rd party cookies are by default not allowed. For probabilistic solutions this presents more of an issue since they rely on 3rd party cookies.

This blind spot means that some vendors with a probabilistic approach to linking IDs will also take a probabilistic approach to creating the IDs themselves. These vendors use code deployed to an actual device to create a statistical ID (or fingerprint) when there is no deterministic ID being broadcasted.

In other words, these probabilistic with statistical ID device graphs will try to create a new ID for a device if that device isn't broadcasting one.

Advantage:

- Smaller blindspots in the device graph due to absence of deterministic IDs.

Disadvantages:

- From a scale perspective this solution is imperfect since the vendor can only create these statistical IDs if they have also had access to a device to serve their code and therefore the device graph is constrained by served impressions.

- From a privacy perspective the Marketer needs to assess the privacy risk of choosing a vendor that uses these statistical IDs (even if they aren't using them for the Marketer specifically). Problems can arise when the vendor creates a statistical ID for a user who has previously opted out, this typically happens when a vendor has no record, or is unaware of the user's preference.

PROBABILISTIC DEVICE GRAPHS WITH DETERMINISTIC MATCH DATA

Vendors that use probabilistic methodologies are usually doing so in order to maximize scale and coverage. However, those vendors can still use login based deterministic linkage data to enhance their solution. In other words, these vendors can use login based data to help develop the best performing probabilistic algorithms. For example, the vendor may start by creating five versions of their algorithm, and can then use login based data to understand which of those five performs the best. Not only can the vendor now use the best performing algorithm, but they can now also create five more variants of it and then find the best of those.

This process can be repeated many times over to create a kind of evolutionary process. This is known as optimizing a device graph based on login data. Similarly, a probabilistic device graph can be augmented with whatever (usually small number of) known deterministic login based linkages that are available.

AN EXAMPLE OF PURE PROBABILISTIC MATCHING

Adbrain's approach can be used as an example of a pure probabilistic matching approach (although we do also enhance with deterministic login based linkages).

Our algorithms analyze our input data to predict the probability that different devices belong to the same user by looking primarily at devices locations throughout the day. When Adbrain does this it only uses the privacy safe deterministic IDs available on devices that exist for advertising purposes.

For example, if a particular ID for a smartphone and a particular ID for a laptop are often found together throughout the days and weeks, over time these two devices can be predicted to belong to the same user.

This is a pure probabilistic approach because it doesn't create any statistical IDs or fingerprints and only estimates a probability that a user X is using devices Y and Z.

04

MEASURING DEVICE GRAPH PERFORMANCE

Perhaps the area where most discussion exists currently is around device graph performance. Device graph performance means how "correct" the matches that a vendor provides actually are. Correctness can be measured using three metrics: accuracy, precision and recall.

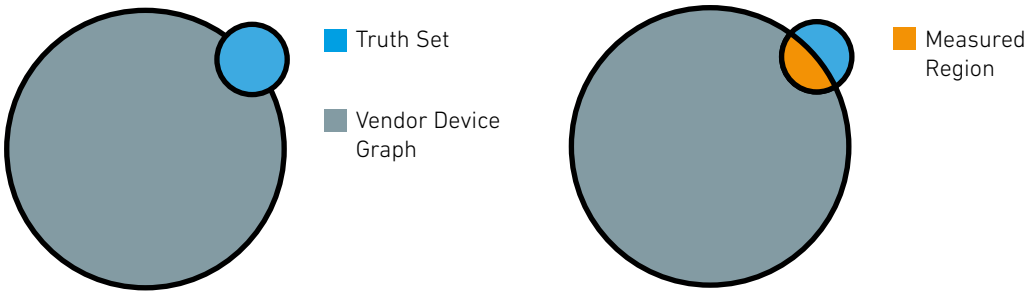
ONE: Scale is as important as performance.

TWO: Accuracy is not the best measure for device graph performance.

THREE: Recall and precision are more useful metric, but there is a usually a trade-off between these two.

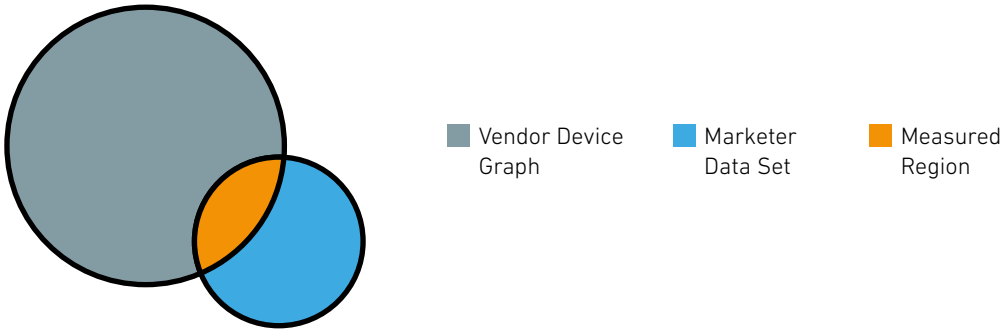
SCALE VS PERFORMANCE

In order to measure these performance metrics the vendor needs access to a source of ground truth – this is a data source that includes known matches between IDs and known non-matches (i.e. when 2 IDs are paired and when 2 IDs aren't paired). This effectively means that vendors measure performance only for the section of their device graph which overlaps with the truth set:



The results from the section of the device graph that is measured will only apply to the rest of device graph if the region measured is a representative sample. In other words, Marketers need to be certain that the orange section in the diagram above was not pre-selected in any way, for example the vendor hasn't chosen a particular part of their device graph to be measured.

Marketers must be aware that even when a representative sample has been tested the device graph performance metrics will not necessarily reflect their experience with the service:



Of the data the Marketer wishes to apply to the vendor's device graph it is only the overlapping region that will be subject to the measured device performance. A Marketer may have one million users but if only one hundred thousand of those exist in the device graph it is only that subset that will perform as per the metrics, the other nine hundred thousand IDs will not be matched at all.

This is a crucial point to understand. In some ways a vendor's device graph scale is as important as device graph performance.

DEVICE GRAPH PERFORMANCE METRICS

"Accuracy" is the most commonly published metric by vendors.

The problem is that this is a commonly misunderstood metric, it's not particularly relevant when evaluating a vendor. Primarily this is because any reasonable device graph will perform well on the basis of accuracy and therefore this metric is not highly differentiating. For example, using independent validation data some existing vendors have reported accuracy scores anywhere between 91% and 97%.[6]

WHAT IS ACCURACY?

Accuracy is the number of matches the vendor correctly identified as existing plus the matches the vendor correctly identified as not existing divided by the total number of predictions.

In other words it is the number of times the vendor got a prediction correct, including non-match predictions, from all the predictions it made. This is not a very useful measurement for the following reasons:

1. **The Marketer usually derives less value if the vendor correctly predicts that a linkage doesn't exist than predicting correctly if one does.**

2. **Even an "unsophisticated" algorithm will deliver Accuracy because there are many more non-matches than actual matches. For example:**

    a. There are 100 people in the world with 2 devices each

    b. Therefore there is a total of 200 unique IDs

    c. Therefore there are 19,900 possible pairs

    d. Of which we know only 100 are correct (100 people with 2 devices)

    e. There are 19,800 non-matched pairs (i.e 19,800 ID pairs that don't exist)

    f. An algorithm that randomly picks pairs of IDs as its non-match predictions has a 99.5% (19,800/19,900) chance of being correct

    g. An algorithm that predicts every possible pair combination will get an accuracy of approximately 99.5%

To understand fully the Marketer can use the confusion matrix in the following section.

IF NOT ACCURACY, THEN WHAT?

Instead of accuracy the following two metrics are more useful measuresments:

- **Recall** - Of all the matches that actually do exist, how many did the vendor identify?
- **Precision** - Of all the matches that the vendor said were true, how many actually were true?

The relevancy of these metrics will depend on what the Marketer is trying to achieve. The Marketer must also understand the scale vs performance concept described above.

WHAT IS RECALL?

A high recall means that a vendor has predicted a large number of the matches that exist, but tells us nothing about the number of matches predicted that didn't actually exist.

A vendor can improve recall by using a mathematical approach that is optimized towards predicting all the linkages that really exist but doesn't place any negative weighting on incorrectly predicting linkages that weren't true.

Therefore optimizing towards recall usually means that the majority of real linkages are predicted but at the cost of predicting quite a few linkages that aren't true.

WHAT IS PRECISION?

A high precision means that if the vendor predicts a linkage exists it is very likely to be true, but tells us nothing about how many of the real linkages were predicted.An approach to maximize precision could be to only predict a linkage only if there are several data signals to reinforce that linkage at the expense of not predicting a probable linkage where there is less corroborating data.

Optimizing towards precision therefore means that the linkages predicted are more likely to be true, but at the cost of not predicting all of them.

RECALL VS PRECISION

There is no reason why a device graph can't have high precision and high recall. However, typically improving one of these metrics comes at the expense of the other.

For example, if I am trying to match siblings from a group of people I could optimize the graph towards one of two goals:

- To maximize recall I could simple match together all people of a similar age. This would mean I am likely to correctly match nearly all the real siblings but also match together a lot of unrelated people.

- To maximize precision I could match based on age, hair colour, height, weight, accent and eye colour. This would mean the siblings I predict are likely to be accurate but I will probably miss some siblings (who happen not to share hair colour, for example).

In practical terms for vendors using a probabilistic approach there is a trade-off between creating a large set of linkages that have high recall vs a smaller set of linkages that have high precision.

Some vendors will actually have two sets of algorithms to create sets of linked IDs - one set of algorithms will create linkages that have high recall but low precision and the other create a set of linkages that have high precision but low recall.

In other words some vendors have a **recall optimized graph** and a **precision optimized graph**. In most cases Marketers will probably get most immediate value from a recall optimized graph.

APPLICATIONS FOR RECALL

As a rule of thumb, for applications that involve delivering ads to a user to drive some kind of transaction, a high recall is crucial. The Marketer will gain more by reaching all the "in target" users across all devices compared to the cost of reaching some users that aren't "in target".

This equation holds true because the cost of serving an ad is several orders of magnitude less than the value of a successful transaction.

In other words, because media is relatively cheap the cost benefit of reaching some "out of target" users to reach more "in target" users is positive, so you can think of this as a net gain.

APPLICATIONS FOR PRECISION

As a rule of thumb, this metric is more important when we think about analytics and understanding consumer journeys. For analytics the Marketer doesn't want to draw incorrect conclusions from incorrect linkages. Instead it is better to draw correct conclusions from whichever subset of correct linkages is available. In other words the benefit of exclusively analyzing data for truly matched IDs is greater than the cost of not being able to analyze all the data available.

An exception to this rule might be where a Marketer is running a brand focused campaign targeted to a particular audience that will be measured based on number of impressions to "in target" users (e.g. GRP reporting). In that scenario precision would again be useful as the "cost" of reaching one incorrect user is equal, or greater than, the "benefit" of reaching one correct user.

05

THE CONFUSION MATRIX

When a vendor creates a device graph it is creating a list of IDs that the vendor thinks can be matched to each other and therefore the vendor is making two types of prediction:

1. **A positive prediction** - predicts that there is a match between two IDs, **or**

2. **A negative prediction** – predicts that there is no match between two IDs

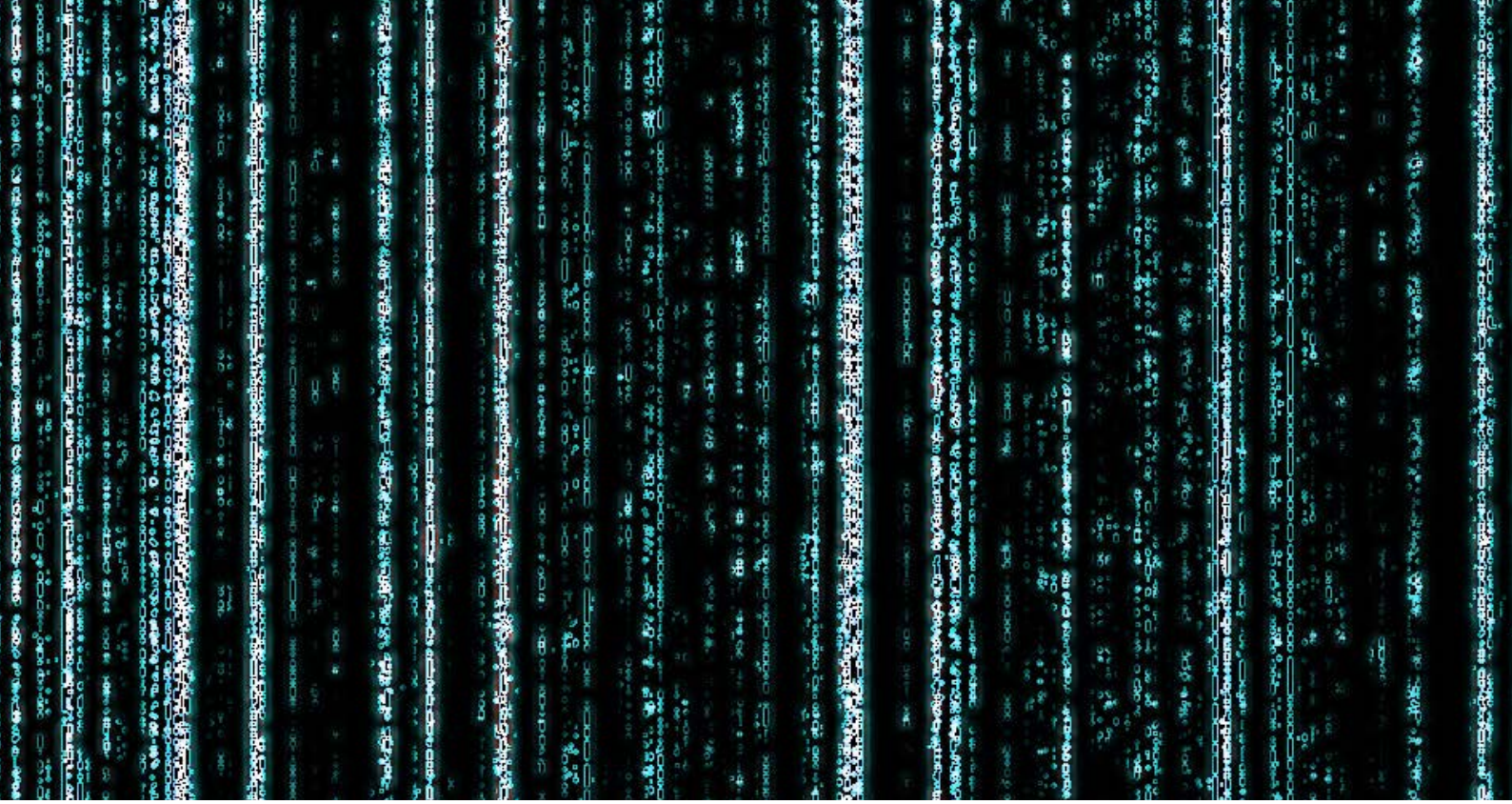
Each prediction will either be false or it will be true. Therefore overall there are four possible outcomes - each prediction a vendor has made, positive or negative can be scored true or false.

1. **A false positive prediction** – vendor made a positive prediction that was false i.e. predicted a match when there wasn't one. (FP)

2. **A true positive prediction** - vendor made a positive prediction that was true i.e. predicted a match that did indeed exist. (TP)

3. **A false negative prediction** – vendor made negative prediction that was false i.e. predicted there was no match when actually there was a match. (FN)

4. **A true negative prediction** – vendor made negative prediction that was true i.e. predicted there was no match and there was indeed no match. (TN)



Mathematically:

Recall = TP / (TP + FN)

Precision = TP / (TP + FP)

Accuracy = (TP + TN) / (TP + FP + TN + FN)

Because true negative predictions are always an order of magnitude bigger than any other predictions (simply because a single ID is only paired to a tiny fraction of all the other IDs in the world) the accuracy equation means this metric will tend to 100%:

TN >> TP, FP, FN

(TP + TN) / (TP + FP + TN + FN) trends to TN / TN

EXECUTING A DEVICE GRAPH PERFORMANCE TEST

In order to do this the vendor needs access to a truth set (that contains known matches and non-matches). Once they have this they can construct a confusion matrix and score their predictions:

ID	VENDOR PREDICTION	TRUTH SET	ID	VENDOR SCORE
c1	IS MATCHED TO	IS MATCHED TO	d1	TRUE POSITIVE
c2	IS MATCHED TO	IS MATCHED TO	d2	TRUE POSITIVE
c3	IS MATCHED TO	IS NOT MATCHED TO	d3	FALSE POSITIVE
c4	IS NOT MATCHED TO	IS NOT MATCHED TO	d4	TRUE NEGATIVE
c5	IS NOT MATCHED TO	IS MATCHED TO	d5	FALSE NEGATIVE
c6	IS NOT MATCHED TO	IS MATCHED TO	d6	FALSE NEGATIVE

EXAMPLE EVALUATION OF DEVICE GRAPH PERFORMANCE: ADBRAIN'S METHODOLOGY

Adbrain has validated its recall optimized device graph using truth data sets provided by Twine Data. We used our recall optimized device graph since this matches the use case for many of our customers.

Using the evaluation methodology described below, Adbrain has validated its recall optimized device graph with a Recall of 85%. The accuracy was 95%.

Twine Data manage a network of publishers and merchants who provide them with login based mobile ID pairs for the US market; in other words Twine can provide data that tells Adbrain with perfect confidence that Mobile Advertising ID A belongs to the same user as Mobile Advertising ID B.

> The type methodology Adbrain adopted to measure performance of our device graph is a more complex version of the following:

STEP ONE

Create a list of all the matches predicted as existing (positive predictions) and all the matches predicted as not existing (negative predictions).

ADBRAIN POSITIVE PREDICTIONS	
A	B
C	F
D	F
F	G

ADBRAIN NEGATIVE PREDICTIONS	
A	C
A	D
A	F
A	G
B	C
B	D
B	F
B	G
C	D
C	G
D	G

STEP TWO

Examine validation partner's known matches and known non-matches.

PARTNER KNOWN POSITIVES	
A	B
A	F
A	H
D	J

PARTNER KNOWN NEGATIVES	
A	J
A	D
H	B
H	F
H	J
H	D
B	F
B	J
B	D
F	J
D	F

STEP THREE

Logically, in order to score a pair that Adbrain has predicted, the validation partner has to have data for both the IDs in the predicted pair.

Therefore we filter the records predicted by Adbrain and the records in the truth set to only those pairs that contain IDs known to both partners.

For example, the validation partner has no knowledge of ID C or ID G and Adbrain has no knowledge of ID H or ID J. Predicted pairs that include those IDs are removed from the analysis:

ADBRAIN POSITIVE PREDICTIONS (FILTERED)	
A	B
~~C~~	~~F~~
D	F
~~F~~	~~G~~

ADBRAIN NEGATIVE PREDICTIONS (FILTERED)	
~~A~~	~~C~~
A	D
A	F
~~A~~	~~G~~
~~B~~	~~C~~
B	D
B	F
~~B~~	~~G~~
~~C~~	~~D~~
~~C~~	~~G~~
~~D~~	~~G~~

ADBRAIN POSITIVE PREDICTIONS (FILTERED)	
A	B
A	F
~~A~~	~~H~~
~~D~~	~~J~~

ADBRAIN NEGATIVE PREDICTIONS (FILTERED)	
~~A~~	~~J~~
A	D
~~H~~	~~B~~
~~H~~	~~F~~
~~H~~	~~J~~
~~H~~	~~D~~
B	F
~~B~~	~~J~~
B	D
F	~~J~~
D	F

STEP FOUR

Build the confusion matrix and compute metrics.

ID	ADBRAIN PROBABILISIC	PARTNER KNOWN	ID	ADBRAIN SCORE
A	IS MATCHED TO	IS MATCHED TO	B	TRUE POSITIVE
D	IS MATCHED TO	IS NOT MATCHED TO	F	FALSE POSITIVE
A	IS NOT MATCHED TO	IS NOT MATCHED TO	D	TRUE NEGATIVE
A	IS NOT MATCHED TO	IS MATCHED TO	F	FALSE NEGATIVE
B	IS NOT MATCHED TO	IS NOT MATCHED TO	D	TRUE NEGATIVE
B	IS NOT MATCHED TO	IS NOT MATCHED TO	F	TRUE NEGATIVE

Recall = TP / (TP + FN) = 1 / (1+1) = 50%

Precision = TP / (TP + FP) = 1 / (1 + 1) = 50%

Accuracy = (TP + TN) / (TP + FP + TN + FN) = (1 + 3) / (1 + 1 + 3 + 1) = 67%

INTERPRETING DEVICE GRAPH PERFORMANCE

When evaluating device graph performance it is prudent to evaluate these results with the following considerations in mind:

- The scale of the device graph overall, and its ability to scale further (in volume and geographic coverage).
- Some vendors will evaluate a sample (i.e. the best performing sections) of their device graphs. This is known as over-fitting and can produce misleading results.
- Whether recall or precision are more important metrics to your business.

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SUMMARY

EVALUATION QUESTIONS

1. Consider whether or not you want a cross-device solution that can only be accessed if you also buy media from the vendor.

2. Look for a vendor that can support as many applications as possible that can also allow you to build differentiated products and services for your clients and customers.

3. Look for vendors that are transparent about what data they use to create their device graph and whether or not their approach can actually scale in terms of volume, and different geographies.

4. Recognize which vendors are also a media business, and whether or not their device graph operates independently of their media. For example, can they provide a device graph in markets where they have no media footprint?

5. Consider the privacy components of a potential vendor – in particular think carefully about any vendors that have a media footprint where they could deploy fingerprint or statistical ID code.

6. Consider if login based pure deterministic device graphs will provide the geographic scale you require.

7. If not, can additional vendors complement login based matches with probabilistic device graphs?

8. Understand that device graph performance (accuracy, recall and precision) has to balanced against scale - remember that the overlap between your data and the vendors device graph is crucial.

9. Understand that accuracy is only one way of measuring device graph performance. Precision and recall are often more useful. Ask the vendor about recall in particular.

10. Ask vendors if they publish performance numbers only using a sample of their graph, for example using a small amount of truth-set validation data to over-fit results.

11. Finally, it is important to explore the kind of relationship you'll have with a vendor. The Marketer will likely benefit from a collaborative and transparent partnership that suits specific business needs.

AND FINALLY, DEVICE GRAPH 2.0

When evaluating vendors, Marketers may be exposed to second generation device graphs. These are probabilistic device graphs that are designed to provide the most flexible and most scalable solutions.

These device graphs 2.0 have the following standout features:

Flexible access - Marketers can choose how and in which platforms they want to use the vendor's technology.

Data ownership - Input data to the device graph is collected independently of the Marketer and not dependent on the Marketer's data to function.

Scale - Device graph input data is not constrained in any way by the size or geographic reach of the vendor's media footprint / ad network.

Deterministically validated and optimized - The device graph is measured and trained using an independent deterministic data set.

In the majority of cases most Marketers will benefit from a device graph 2.0, including supplementing any login based device graphs available to the Marketer.

Marketers will likely find the development of cross-device solutions a complex addition to the ecosystem since, as with all areas of innovation, there are many new concepts to absorb. But the opportunity is massive, cross-device can drive new marketing and enterprise applications, offering deeper user insights and more memorable and rewarding consumer experiences.

This guide is designed to be educational, from here the Marketer should be prepared to ask the tough questions and ultimately make an informed decision that will empower them to truly transform their business.

For more information please visit www.adbrain.com or email your questions to CrossDeviceExplained@adbrain.com

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