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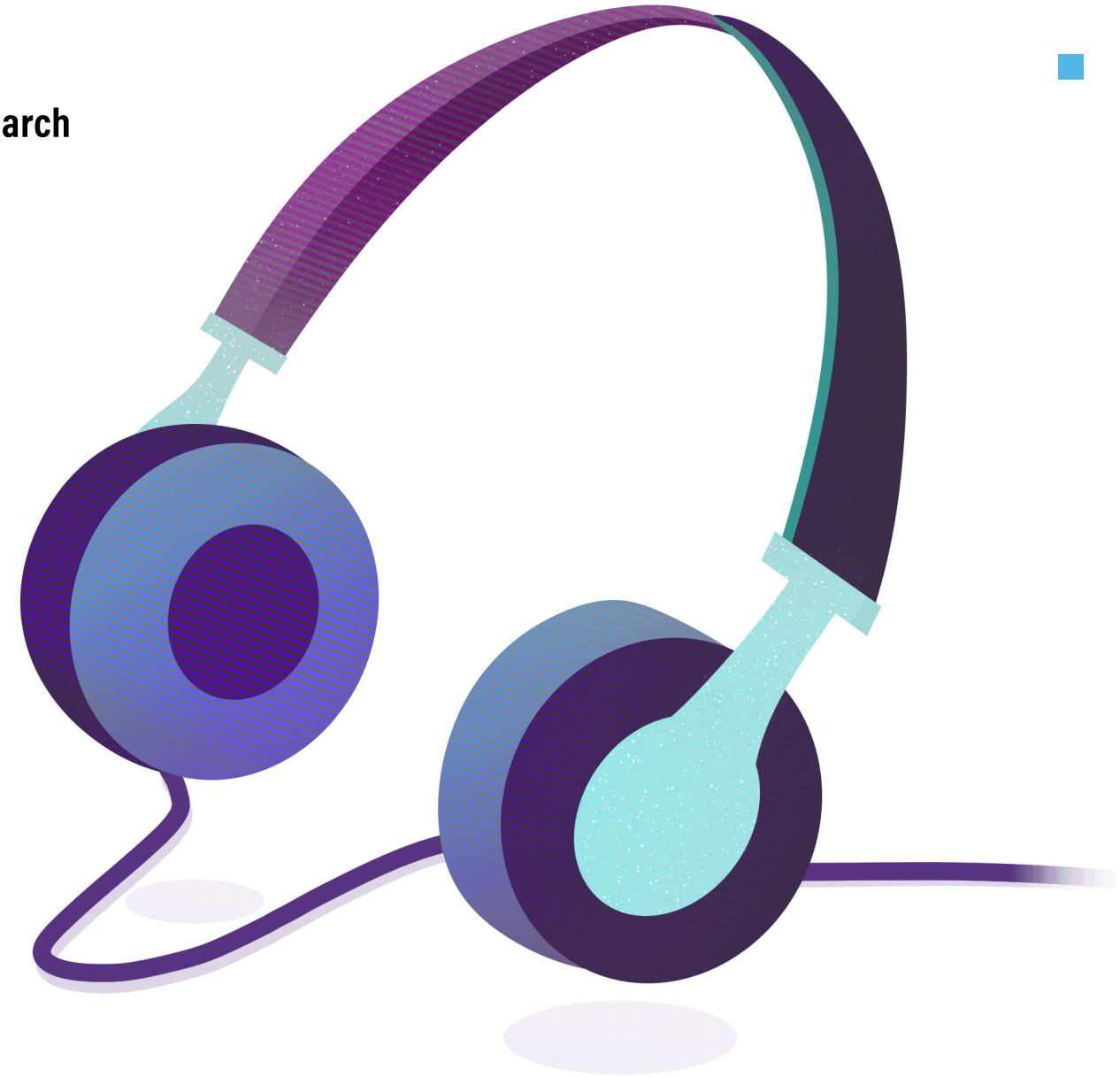

Understanding Innovation in Interoperable Systems

A Podcasting Case Study

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December 2023

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ACKNOWLEDGEMENTS

We would like to thank Sukhi Gulati and John Sullivan for their invaluable feedback on an earlier draft of this paper. All views in this report are those of CDT.

This work is made possible through a grant from the John S. and James L. Knight Foundation.

SUGGESTED CITATION

Luria, M. and Nicholas, G. (2023) Understanding Innovation in Interoperable Systems: A Podcasting Case Study. Center for Democracy & Technology. https:// cdt.org/insights/understanding-innovation-in-interoperable-systems-a-podcasting-case-study/

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Executive Summary

In a wide range of industries, policymakers have considered encouraging or mandating data interoperability to facilitate more entrants and promote competition and innovation. However, some incumbents in these industries argue that interoperability would entrench existing technological design and stifle innovation. In this paper, we attempt to better understand the relationship between interoperability and innovation by looking at the case study of podcasting and the innovation that has emerged across its ecosystem. We analyze nine podcasting apps, six podcast hosting services, and five podcast directories to catalog the novel features each offers.

We then organize those features, from those that best facilitate the movement of data between systems (interoperable) to those that most impede that movement (anti-interoperable). Our analysis reveals a bifurcated ecosystem: one of smaller apps and services that leverage or improve on interoperable systems and another of larger platforms that attempt to offer paradigm-shifting innovations, but that to some extent also undermine interoperability and externalize certain costs to users. We conclude that in designing competition policy, policymakers should not focus on whether interoperability encourages or discourages innovation, but on what kind of innovation it introduces, and how interoperability might impact all relevant stakeholders.

Introduction

Interoperability has always been a fundamental characteristic of networked technologies that allows them to communicate with one another. For instance, the internet runs on many interoperable standards, like TCP/IP, HTTP, HTML, RSS, and SMTP (Chao & Schulman, 2020). Sectors that have come to harness the power of the internet in their own operations also have developed interoperable standards, from financial systems (Packin, 2020) to health care (Braunstein, 2018) to automotive (Kerber, 2018). In addition to enabling communication, interoperability bolsters the development of new, innovative technologies by allowing them to exchange data with existing ones.

Many of these standards were rolled out and popularized during the early days of the internet, when a pervasive culture of openness and interconnectivity maximization made such technological architectures relatively uncontroversial (Clark, 1995; Zuckerman, 2013). Although that culture has shifted towards one of enclosure and platformization (Srnicek, 2017), today's policymakers seek to emulate the success of older interoperable systems in facilitating new market entry and bolstering competition and innovation by encouraging or requiring data interoperability in a wide range of industries (Graef, 2015; Nicholas, 2021). As the logic goes, interoperability lowers switching costs and allows new entrants to leverage existing infrastructure and network effects to bootstrap their own products (Rubinfeld & Gal, 2016). Examples of policymakers attempting to bring these dynamics into other sectors include text messaging platform interoperability in the EU Digital Markets Act, patient data interoperability from the 2020 Interoperability and Patient Access Final Rule, and social media interoperability in the proposed ACCESS Act in the U.S.

However, the seemingly interoperable systems developed in the internet's nascent days that these laws attempt to emulate are rarely so simple. The example of podcasting, the creation and sharing of on-demand audio online, reveals that what from the outside seems to be a straightforward interoperable system (users can listen to podcasts on any podcast app), is actually assemblages of interoperable and non-interoperable systems, with different actors and ideologies pitted against one another. Since the early 2000s, the RSS open standard has been the dominant technology underlying the podcasting ecosystem, allowing anyone to build their own podcasting app, host their own podcast online, or create their own directory of podcasts. Although some areas of concentration have emerged — for instance, Apple is by far the

most dominant podcast directory — the existing regime has allowed the medium of podcasting to flourish, growing in the number of listeners, shows, and revenue (IAB, 2021).

However, a closer look at the podcasting ecosystem reveals a more complicated picture of the role of interoperability, both technically and ideologically. Companies, particularly larger ones such as Spotify and Google, have begun to build their own, non-interoperable alternative podcasting ecosystems that they claim can offer features that would not be possible using RSS. As Spotify Head of Podcast Product Maya Prohovnik said in a 2022 investor call (Spotify, 2022):

> *"Think about it: Podcasting has been around for almost two decades and it's remained largely unchanged, mainly because of the limitations of RSS. We've been able to replace RSS for on-platform distribution, which means that podcasts created on our platform are no longer held back by this outdated technology."*

The tenor of this conflict between pro- and anti-interoperability advocates in podcasting echoes that which policymakers face in other sectors; smaller actors and new market entrants tend to favor interoperability so they can more easily compete, while larger, established actors tend to oppose interoperability because it makes it more difficult to distinguish their products and build new features (Gal & Rubinfeld, 2019). Both claim to be the bastions of innovation (von Hippel, 2005).

In this paper, we seek to push past the binary of more-versus-less innovation to help policymakers learn about the kind of innovations interoperability and non-interoperability can each offer. To do this, we examine the case of podcasting and its features, sort them based on their relationship to interoperability, and identify the values and stakeholder benefits each group of features offers. Our findings suggest that more interoperable and more anti-interoperable features lead to two very different kinds of innovation: the prior allows for many smaller, quality-of-life innovations while keeping the possibility of larger shifts open; the latter can more easily introduce paradigm-shifting innovations but is also prone to enclosing businesses and externalizing costs to users. We therefore conclude that when potentially mandating or promoting interoperability, policymakers should consider the kind of innovation they would like to encourage within a particular domain.

Definitions

Podcasting

Hansen (2021) argues that the term *podcast* has come to refer to three different concepts: "(1) a piece of on-demand audio, downloadable or streamable to computers or mobile devices [...] (2) an on-demand internet radio-style show that recurs over time [...] [and (3),] a collection of downloadable files, of any format, served with accompanying metadata via an open updatable internet feed, primarily RSS" (p. 195). In this paper, we adopt the first of these three definitions.

Podcasting is a complex socio-technical ecosystem, in which many actors take part and can be affected by innovations, including listeners (end-users who listen to podcasts), podcasters (those who produce podcasts), and platform intermediaries (those who connect listeners to podcasts). We identify three distinct intermediaries within the technical ecosystem of podcasting where innovation may occur:

- **Podcast apps**: Applications that provide an interface through which users can access and listen to podcasts. Examples include Apple Podcasts, Spotify, Overcast, and Pocket Cast.
- **Podcast directories:** An organized collection of podcasts. Often, podcast directories bundle together RSS feeds submitted by podcasters or podcast hosting services. Sometimes, like with Apple Podcasts and Podcast Index, a directory is publicly available via API for any podcast app to integrate with. Other times, like in the case of Spotify and Stitcher, their podcast directory is limited to their own podcasting app.
- **Podcast hosting services:** Services that allow podcasters to provide media and related metadata, and in turn host their podcasts on an RSS feed. Hosting services also often allow podcasters to submit their shows to directories. Examples include BuzzSprout, Podbean, Libsyn, and Spotify's Anchor.

Some companies offer products that fill multiple of these roles. Apple, for instance, has both a directory and an app. Some companies that fill multiple roles also vertically integrate their products by providing additional data access: For instance, Spotify runs an app, directory, and hosting service, and podcasts that use their hosting services gain access to unique analytics that come from the app (Spotify, n.d.).

Interoperability

Gasser (2015) defines *interoperability* as "the ability to transfer and render useful data and other information across systems, applications, or components." The term represents a continuum rather than a binary and is to some extent a subjective measure. For instance, two podcast directories that make their content available via API may both be considered interoperable, but if one of them has fewer or no restrictions on what podcasts they will list, that service could be considered more interoperable. Similarly, actors may have differing views on what constitutes "useful" data or ease of transfer.

In this paper, we refer to the two ends of this spectrum as *interoperable* and *anti-interoperable*, the latter referring to the obstruction of transferring useful data and other information across systems. Anti-interoperability can be implemented on a narrow technical level, such as developing proprietary interfaces and not allowing data transfer into or out of a system (Pagano et al., 2013), or at a market level, such as design patterns or predatory pricing mechanisms that encourage platform lock-in (Bamberger & Lobel, 2017). Companies can also be anti-interoperable by first adopting an interoperable standard and then adding proprietary features to gain dominance and ultimately eliminate competition. This strategy was famously practiced by Microsoft and was internally referred to at the company as "embrace, extend, extinguish" (The Economist, 2000).

Some features that actors offer have little to do with the transfer of data at all, neither bolstering it nor impeding it. While these features are not as central to the focus of this paper, we occasionally refer to these as *local* features, and on the continuum, place them somewhere between interoperable and anti-interoperable.

Background

The evolution of the term podcast over the past two decades reflects the fragmentation of the digital broadcasting ecosystem (Rime et al., 2022). In its narrowest and oldest sense, a podcast is a digital file, usually an audio file, distributed online via an RSS (Really Simple Syndication) feed that can be downloaded onto a personal device (Markman, 2011). RSS was created in 1999 by Ramanathan Guha and Dan Libby and initially served to pull in articles and blog posts from other websites that adhered to the spec, to be broadcast to the user through any interoperable interface, but specifically at the time over the My Netscape widget on the Netscape homepage. In 2000, Dave Winer added the `<enclosure>` tag to allow RSS to deliver high-quality media, including audio files (Hansen, 2021). By the early 2000s, there were already many different audio shows hosting their own RSS feeds, directories collecting different RSS feeds and distributing them together, and "podcatcher" apps that users could use to download files. The ecosystem was kludgy and technically complicated but was already roughly divided into the technical roles that exist today (Sullivan, 2019).

The first large technology company to integrate podcasting into its services was Apple when, in 2005, iTunes incorporated a podcatcher. This meant that shows could submit their hosted RSS feeds to Apple and the company would collate them as "available" in their podcast directory via iTunes. Unlike other podcatcher options, iTunes required no configuration, or copying-and-pasting links to RSS feeds. Apple also decided to make its directory interoperable, meaning any podcasting app could use its API to serve Apple's podcasts. The ease of use and flexibility for listeners, podcasters, and podcast app developers made the iTunes directory, and in turn RSS, the dominant means for distributing podcasts (Sterne et al., 2008; Sullivan, 2019).

While iTunes made consuming and distributing audio over RSS available to the masses, it also offered only a limited subset of features from those that RSS offers, with little change since its initial release. For example, it requires podcasters to provide artwork and flag whether or not their content is explicit (Apple, n.d.). New features, such as transcripts and listener analytics, and monetization approaches, such as paywalls and targeted advertising, were difficult to build on top of Apple's infrastructure because by adhering to a standard adopted by many instead of managing a centrally controlled repository, podcasters' RSS feeds and users' listening apps were decoupled from one another.

Since Apple made podcasting widely available, it has grown into a massive industry. In 2005, 15% of the population over the age of 12 listened to online audio every month; today, that number is 75% (Edison Research, 2023). According to the Interactive Advertising Bureau, revenues from podcasting reached nearly $2 billion in 2022 and may approach $4 billion by 2025 (IAB, 2022).

With an increasing number of actors in this space, podcasting has evolved in several different directions, as companies try to differentiate their products from one another, with each new actor attempting to introduce an innovative take on "podcasting." Some media outlets that host their own content, such as the New York Times and NPR, have built their own bespoke apps, bypassing RSS altogether. Some technology companies, such as Luminary and Stitcher, built platforms that include iTunes' directory but also add their own premium, paywalled content. Walling and paywalling content may reduce the reach of these podcasts but create new opportunities for smaller companies to monetize. Larger players, like Spotify and Google, have sought to create their own market-making opportunities by building competing RSS feeds to which users can submit their podcasts and that offer podcasters more data about how listeners engage with their podcasts, to provide novel monetization options.

Yet, podcasting still fundamentally rests upon the interoperability of the RSS protocol, allowing all these new approaches to podcast distribution to include millions of podcasts from the outset. Innovation in podcasting, as a result, necessarily encompasses a connection to its RSS roots, either attempting to expand and strengthen RSS, stepping away from it to alternative models, or simply happily staying within its current boundaries to serve the stakeholders at play.

To get an idea of how these come into play in practice, we analyzed a total of 9 podcasting apps, 6 podcasting hosting services, and 5 podcasting indexes. We did so by systematically going through each system and listing out all the user features we could identify. Then, we used Affinity Diagramming, a method that allows researchers to group pieces of qualitative data based on their similarity to each other (Lucero, 2015), to group them by category. By laying out and ordering existing features of podcasting, we reflect on specific feature groups, and examine where, along the spectrum from anti-interoperable to interoperable, each group lies. Through a combined technical and user experience perspective, we set out to form a better understanding of current and future innovations in the world of podcasting, and more broadly in interoperable systems.

Findings

The findings present a selection of innovative features across the podcasting ecosystem and their impact on different stakeholders involved in podcasting. We discuss these examples in more detail, their relationship with interoperability, and who these innovations are intended for. This is not intended to be an exhaustive list of features, but rather a representative sample of the types of innovations we observed, categorized by how they fit into the podcasting interoperable ecosystem.

Adding new RSS tags

Features that improve podcast interoperability often extend or build on top of the existing interoperable structure, which in the case of podcasts is RSS. The RSS standard is designed to be extensible: developers can add new data fields to their feeds without affecting existing ones (see Table 1). For instance, when Apple first created its own podcasting directory as part of iTunes, it required participating podcasts to incorporate a handful of tags, such as `<itunes:explicit>` (whether an episode contains explicit content or not), `<itunes:image>` (cover art for the show), and `<itunes:category>`. Apple has used these data fields to improve its own podcasting app's appearance and organization, but as these fields get passed on in Apple's openly available podcast directory, other applications can benefit by making use of them too, for instance, to visually mark a listening app who's podcasts contain explicit content.

Apple has been slow, however, to introduce new RSS tags into their protocol. Other large companies with their own directories, such as Google, have tried to add their own tags, but have failed to gain adoption and ended up resorting back to Apple's standard (Google, n.d.). This may be in part because as the dominant player, Apple has little financial incentive to invest in changing or upgrading its standards, especially when those new standards do not create value that Apple can easily capture. (Apple does not earn money from its directory, and every podcasting app would have access to the same features.) It may also be because introducing new tags poses a difficult collective action problem: podcasting hosting services must support them, podcasting apps must implement them, and podcast hosts must supply the data. In other words, it requires vast and timely support across the board to include new tags on RSS as a standard, and not all actors have the incentives to do so.

Feature	Involved Actors
Adding new RSS tags	Apps; directories; hosting services
File hosting functionality	Hosting services
Audio listening functionality	Apps
Curation	Apps; directories
Exclusive content	Apps; directories
Analytics	Apps; directories; hosting services
Dynamic and targeted advertising	Apps; directories; hosting services

▲ **Table 1. A list of podcasting features, sorted roughly from most interoperable (top) to most anti-interoperable (bottom).**

Nevertheless, at least one independent attempt at creating new RSS tags has gained some adoption—an initiative called Podcasting 2.0 led by Dave Jones and Adam Curry, who along with Dave Winer helped design and popularize the RSS feed podcasting standard (Jones, 2021b). Jones and Curry have published an extension of the initial RSS podcasting standard that included many new features, like adding transcripts, soundbite previews, chapters, license information, donation links, and even an experimental feature that allows listeners to automatically donate a set amount of cryptocurrency to podcast creators per minute listened to (Jones, 2021a).

To this date, no major podcast directories (e.g., Apple or Spotify) have adopted the Podcasting 2.0 additions to the RSS standard. Instead, Jones, Curry, and others created a podcast directory called the Podcast Index to support feeds and podcasts that use these new standards. They have also made it easier to get new apps and hosting services to integrate Podcasting 2.0 standards, by designing it in a way that one can adopt as many or as few features as desired. Of the few dozen apps and hosting services that have adopted Podcasting 2.0, far more have added chapters and transcripts than, say, soundbites (Podcast Index, n.d.).

File hosting functionality

Podcast RSS hosting services, such as BuzzSprout, Podbean, and Libsyn, also offer their own local innovations, allowing podcast creators to make different tradeoffs between cost, reach, and analytics. These features build on top of the interoperable podcasting ecosystem without providing new open data or functionality others can leverage. The main features many podcast hosting services have incorporated are the ability to schedule releases and automatically submit podcasts to directories. Some also have features that affect the listener experience, like private podcasts, chapter markers, and automatic audio mastering. Podcast hosting services' primary source of income is charging podcast creators per hour of audio hosted or gigabyte of bandwidth used. In general, many of these features bolster interoperability by providing new data apps and hosting services that can be leveraged. However, some offer features, such as analytics and advertisement insertion, that do the opposite, creating separate walled gardens of data.

Audio listening functionality

Besides the standard play/pause/skip buttons, applications include a range of features that support listening functionality: some examples include organizing podcasts, queuing episodes on a playlist, altering audio speed or quality, or looking through statistics about a user's listening habits. Some podcasting apps bring their innovation in adjusting the functionality of "legacy" podcasting applications to novel interfaces, allowing listeners to optimally listen to podcasts on new devices. For example, Overcast created an "Alexa Skill" that is dedicated to podcast consumption; Castro offers adapted podcast listening to be optimal for Apple Watch devices. These functions are unique within each platform and are created to allow users to customize their ideal listening experience. By doing so, they improve the ease of use for users, giving them a competitive advantage. However, these features are usually local to the application itself, and neither bolster nor impede interoperability.

Curation

Many podcasting apps offer a range of innovations around content discovery and recommendation, to help listeners find new content. Some podcasting apps offer "human-picked" editorial selections of podcasts that listeners may enjoy. Others use their own collected data about what people listen to and consume to determine what podcasts should be recommended or cross-list their choices from other sources, like the now-defunct Twitter API. Others make personalized recommendations using

algorithms, based on a user's listening history—for instance, listeners who liked X may also like Y. Recommendations can also be based on more personal information that the platform can collect, as does Spotify. Some apps have even gone so far as to create their own small social networks for recommending content. For example, Castbox offers community feeds through which users can comment on, like, or recommend their favorite podcasts.

For end-user listeners, finding a podcasting app whose recommendations system aligns with their interests can significantly improve their ability to discover and enjoy new podcasting content. However, it also may lead to the over-saturation of the market by a few popular podcasts, or lead to other attention-economy negative knock-on effects, such as polarization, spread of inflammatory or misleading content, or misuse of personal user data (Einhorn, 2021). There are also transparency concerns: most apps are opaque about how they recommend content to listeners and leave them with a lack of control over what they see and consume. Nevertheless, curation does not particularly affect interoperability, since it does not impede or improve the ability to transfer data across systems.

Exclusive content

The most common model seen among podcast apps with their own bespoke, private directories is an attempt to host exclusive podcast content to draw in new users to sign up for services. Directory managers, often with their own apps and hosting services, pay some podcasters to host exclusively on their platforms, usually celebrities with large followings, or podcasts that are already successful and well-known. For example, Spotify acquired Joe Rogan's podcast, and Luminary exclusively hosted Lena Dunham's podcast "The C-Word." These podcasts are not available to listeners who use other podcast apps.

The question of whether exclusive content undermines interoperability is not straightforward. Paywalled content does not require a larger technical architecture that fundamentally undermines the ability to transfer data; a podcast can be exclusive to one directory but still be served via RSS. However, large exclusive content deals can be used to remove valuable podcasts from other directories; this can create market concentration around a few companies that can afford to acquire the most popular shows, such as Spotify making Gimlet Media and The Joe Rogan Experience exclusives to its platform (Einhorn, 2021).

Analytics

Some podcasting apps and hosting services allow podcasters to track their user demographics and personal listening habits. Hosting services are limited in how they can do this, since they can only track the number of downloads, along with imprecise geography and device information, from IP addresses. In contrast, companies that run both apps and directories, like Apple and Spotify, can offer far more specific statistics about listeners and listening behaviors. For example, with in-app analytics, they can track where listeners tend to stop listening to an episode or which parts they skip through, which in turn podcasters can use to improve their output to hold more listeners (Mignano, 2021). Some companies can obtain even more analytics data by cross-checking information against other personal data they have collected on users—this is especially true for actors that have many sources of user data, such as Apple or Google.

Robust data on listener behavior and demographics is key for actors in the podcasting space to build ad networks and increase revenue (Sullivan, forthcoming). This data is so essential that the Interactive Advertising Bureau has released guidelines for what constitutes an ad impression, to improve accuracy and consistency, which most companies that offer podcast ads now adhere to. For instance, when Apple's watchOS Podcasts app began requesting duplicate downloads, the IAB required certified ad networks to filter out downloads that came from Apple Watch (IAB, 2020).

It is up for debate whether analytics should be considered an anti-interoperable feature. Although it provides data that is not transferable from one system to another, it is not clear to what extent that impedes switching services. Analytics offered by companies that vertically integrate their apps and directories, like Spotify and Apple, may prompt more data-driven podcasters to encourage their listeners to consume podcasts on platforms where analytics are available (Fourcade & Healy, 2017).

Dynamic and targeted ads

Many of the podcast hosting services that offer analytics also allow some form of dynamic or targeted ads. As opposed to "baked-in" ads, where the podcast audio file remains static (e.g., the host of a podcast records an ad read as part of the episode), dynamic ads can be inserted and swapped out at the time the user downloads the episode. In practice, this works by swapping out the URL for the episode file a user is served in their RSS feed. With dynamic ads, podcasters and podcast networks can sell ad space and host an ad for a certain number of downloads or, for a certain duration, even on older episodes of a podcast. As in web advertising, dynamic ad insertion has led to

an ecosystem of supply-side advertising platforms, where podcasters can list available ad space on their podcasts, and demand-side platforms, where companies who want to run ads can find those podcasts.

From 2019 to 2021, dynamically inserted ads—rather than baked-in ads—grew from 48% of podcast revenue to 84% (IAB, 2022). However, as discussed in the previous section, podcast hosting services are limited in targeting these ads according to the RSS data they have on listeners. Companies such as Spotify and YouTube that run podcast indexes, hosting services, and apps have an advantage here, too. They can collect much more ad-relevant information and offer that to advertisers. For instance, they can identify when users listen to ads (as opposed to skipping them), or can use additional personal information to target ads more precisely (such as through Spotify's Megaphone platform (Megaphone, n.d.)).

Dynamic and targeted ads may create new opportunities for podcasters to monetize their podcasts, but they also expose end-user listeners to the larger mechanisms of surveillance capitalism and all of the privacy and polarization dangers that come with it. Furthermore, podcasters may be limited in how much value they can capture from dynamic and targeted ads, because many intermediaries also need to capture value for the system to work, including supply-side platforms, demand-side platforms, and hosting services. Finally, a platform with its own directory and apps, such as Spotify, may discourage podcasters from taking the time to make their content available on other platforms, where they cannot capture the same advertising revenue. Spotify (per this example) might pay podcasters for an exclusive arrangement or even insist on one.

Overall, dynamic and targeted ads are particularly anti-interoperable because they often entail one company running multiple services — apps, directories, and hosting — to create all the data flows necessary to serve ads and observe their performance. Not only are the mechanisms of advertising un-interoperable, but they shepherd podcasters into walled gardens, preventing them from being part of the larger podcasting ecosystem.

Discussion

The case study of podcasting reveals important lessons about the relationship between interoperability and innovation. In this section, we discuss those lessons more broadly and draw discussion points pertinent for policymakers.

In our analysis, we found that no one stakeholder or type of stakeholder can lay exclusive claim to innovating in the podcast space. While some have attempted to cast the podcasting ecosystem as stagnant, our findings reveal that there have, in fact, been several innovations in the nearly two decades of podcasting. Innovations have come from small podcasting apps, medium-sized podcast hosting services, large vertically integrated podcast indexes that also run their own applications, and everyone in between. Those innovations have varied widely in their relations to interoperability too—some have improved existing interoperable systems, others merely leverage them, and still others have sought to replace them with their own non-interoperable infrastructures.

As a result, innovation in the podcasting ecosystem is in itself very diverse. Innovations target both podcast listeners (e.g. audio-listening functionality, transcripts) and podcast creators (e.g. file hosting, device adaptation, analytics). They also facilitate the two-sided marketplace of podcasters and interested listeners seeking one another (e.g. through discovery and recommendation) and create new ways for podcasters to increase revenue from the podcasts they create (e.g. exclusive content, advertisements, cryptocurrency donations).

However, interoperable and anti-interoperable features are not introduced evenly by all actors. As a general rule, more interoperable features (such as Podcasting 2.0 RSS features and file hosting features) are more commonly introduced by smaller companies and organizations, and anti-interoperable features (such as analytics, exclusive content, and dynamic and targeted ads) are introduced more often by larger ones. Our analysis reveals a bifurcated ecosystem. On one side are smaller apps and services that leverage interoperable systems and compete using smaller, local features, and on the other side, larger, more vertically integrated, publicly traded technology companies. The latter use the interoperable podcasting ecosystem to bootstrap their own products but also seek to seize market share by introducing their own features. Eventually, they end up dominating the interoperable infrastructure with their own self-preferencing alternatives.

Interoperable and anti-interoperable features also offer different scales of change. Interoperable innovations (and local innovations alike) are more often geared towards smaller quality-of-life changes that encourage users to choose one platform over another. While it is possible to roll out large, transformative innovations in an interoperable way, such as ones that allow new business models, media types, and interactions, they are difficult to coordinate towards mass adoption. Some of the reasons include technical costs, their disadvantages for early adopters, and the required buy-in from many actors, each with their own motivations (Eghbal, 2020). Furthermore, large companies are unlikely to adopt new interoperable features if they are not able to capture commercial value or competitive advantage through this implementation. For instance, many end-users would benefit from bigger companies adopting aspects of the Podcasting 2.0 standard, but few have or are likely to since the commercial benefits would be marginal at best.

In contrast, anti-interoperable features can lead to very large innovations and paradigm shifts and have significant incentives for companies. But often, platform intermediaries are the only ones who capture the value generated by those innovations, leaving less value for listeners and podcasters to enjoy. For instance, exclusive content may help a small group of high-profile podcasters who get large exclusive deals to act as bellwethers, but may also hurt listeners' access to podcasts they could have enjoyed and even drive audiences away from smaller podcasters. Similarly, targeted advertisements may help some podcasters profit, but most of the value will go to platforms, and users will gain very little, and arguably at the price of their privacy.

Further, while anti-interoperable features could eventually lead to more significant paradigm shifts within the podcasting ecosystem, these features also risk market concentration. Concentration would mean fewer companies facing less competition, making it easier for them to serve their own interests even further while deprioritizing the interests of listeners and creators. For example, systematic self-preference of original podcasts by a company could threaten the diversity of voices in podcasting. In contrast, more interoperable features, while more incremental and slow in implementation, could promote an open digital environment and access to all.

Conclusion

The fact that the podcasting ecosystem is fundamentally an interoperable one is less the result of top-down design and more the artifact of internet companies' early 2000s attitudes towards maximizing interconnectivity. Since the advent of podcasting, many online media ecosystems that became mainstream later on — microblogging, on-demand video streaming, social media — were designed from the start as closed systems, concentrating power in those companies that were able to achieve mass adoption and protect their market position with network effects. But the existence of interoperability in the podcast ecosystem raises debates; about the possibility of mandating or encouraging, through policy, adoption of interoperability in currently non-interoperable systems; about the extent to which it is desired; and about whether such post-hoc interoperability could create a more diverse, competitive technical ecosystem.

Podcasting offers a rare case study into how interoperable and anti-interoperable innovation differs, which helps illuminate complexities and considerations that should be taken into account when designing interoperability policy. First, the fractured nature of podcasting sheds light on the fact that interoperability is not a binary. No technical ecosystem is entirely interoperable or non-interoperable; all are, in some way, a mix of both. Despite podcasting being seen as a canonically interoperable system, a closer look into its features reveals that individual apps, hosts, and directories each introduce their own local and anti-interoperable features to create unique offerings and compete with one another, which can benefit users by offering them distinct choices.

Second, the case study of podcasting reveals that conversations about whether interoperability "helps" or "hurts" innovation are reductive. Instead, interoperability affects what kind of innovations are easier or more likely, and how value from those innovations can be captured by different actors. When considering mandating interoperability, policymakers should determine whether the desired outcome is innovation with a foundation of open access and an open internet structure, which will likely be slower and more incremental, or more paradigm-shifting innovation, but which also risks winner-take-all dynamics. Each may have its own time and place, and may in part depend on how mature the industry is, and what kind of technological development is needed.

"Technology is politically significant in its own right," writes Langdon Winner. "...the machines, structures, and systems of modern material culture . . . embody specific forms of power and authority" (2020). By altering the design of technology, interoperability policy inherently affects how power and wealth are allocated. Policymakers should not avoid confronting the effects of these designs under the rhetoric of promoting innovation. Instead, they should address these effects head-on, fostering an environment where innovation aligns with the broader goals and visions for technology and society.

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