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# Delivering Total Mobile TV

Combining Streaming and Broadcast for a  
Complete Mobile Television Solution

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## Table of Contents

<b>TABLE OF CONTENTS</b> .....	<b>3</b>
<b>INTRODUCTION</b> .....	<b>4</b>
Abstract .....	4
Define Mobile TV by its Use Cases .....	4
<b>DELIVERING BASIC MOBILE TV</b> .....	<b>5</b>
Viewing TV .....	5
Scheduled Recording .....	6
Key Points of This Section .....	7
<b>BETTER TOGETHER: STREAMING &amp; BROADCAST COMBINED SERVICE</b> .....	<b>8</b>
Advantages of a Combined Service .....	8
Exclusively Combinational Use Cases .....	9
<b>BEST PRACTICES FOR DEPLOYING TOTAL MOBILE TV</b> .....	<b>10</b>
Deliver the Use Cases First, Then Introduce Broadcast .....	10
Get Intimately Involved in the ESG and TV Client UI Design .....	11
Abstract Your Total Mobile TV Solution from the Technology .....	12
<b>CONCLUSION</b> .....	<b>12</b>

## Introduction

### Abstract

Wireless carriers streaming on-demand clips and live mobile TV to their subscribers today are looking to incorporate mobile broadcast/multicast technologies such as DVB-H, FLO, DAB-IP, BCMCS and MBMS into their offerings as a means of dramatically reducing media-centric data traffic on their networks.

But mobile broadcast is not designed to address the “Long Tail” distribution pattern of digital media consumption (see inset). All mobile broadcast technologies have hard limits as to the amount of content and channels they can carry and must tradeoff selection for ubiquity which results in a “one-size-fits-all” offering to subscribers.

Combining streaming with mobile broadcast offers the best of both worlds to the mobile operator and their subscribers; a vast selection of content and functionality delivered via the most efficient route. Using these highly complementary technologies together will even deliver advanced features and functionality to subscribers that would not otherwise be possible.

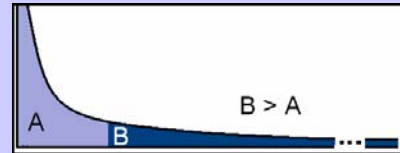
This article will help wireless carriers plan for the inclusion of mobile broadcast into their streaming Service Delivery Platform by presenting the pros and cons of both broadcast and streaming, demonstrating the options available for delivering the most popular mobile TV use cases, illustrating new use cases where broadcast and streaming are better together, and providing some best practices for designing a Total Mobile TV solution that provides wireless carriers with ultimate flexibility and a future-proof foundation.

### Defining Mobile TV by its Use Cases

The wireless industry seems to use the term “mobile TV” interchangeably to describe the delivery of live or on-demand streaming, live mobile broadcast technologies, and pushed or downloaded clips to mobile devices (Even though these answers all represent distinctly different delivery mechanisms, service offerings, and demands on the carrier infrastructure). But as we’ll see in the next section, there are multiple ways to deliver mobile TV for the most common use cases, so we’ll define mobile TV not by how it gets to the user, but rather by the television-viewing use cases it enables.

#### The Long Tail and Digital Media Distribution

The Long Tail generically refers to Power-law distribution graphs where the area under the tail of the curve (B) which represents events that individually occur less frequently, can cumulatively outweigh the “popular” data in the head of the curve (A).



This phenomenon has been observed in various online enterprises, but perhaps most noticeably on digital media services such as RealRhapsody where new content is constantly added and the top 500,000+ tracks are streamed *at least* once each month.

To get a perspective of how deep into the tail that is, consider that the typical “big box” retailer only carries 40,000 tracks at any given time.

The low storage and distribution cost of digital media makes it economically viable to offer the less popular content in the tail.

For more information see “The Long Tail” by Chris Anderson, *Wired*, Oct. 2004

## Delivering Basic Mobile TV

We asserted above that we want to deliver services built on the use cases they enable, not the underlying technology and that there are multiple ways to deliver content for the same mobile TV use cases. To prove this we only need to look at variations of the two most common use cases for Mobile TV: The passive viewing experience and personal video recording. For each use case we'll examine the possible content types, the ways in which the content is ingested into the wireless carrier's service delivery platform (SDP), the time at which the content is delivered, the time when it can be viewed and the routes by which that content can be delivered.

### Viewing TV

Let's examine the most basic use case for mobile TV which is to passively view content. Table 1 below compares and contrasts common variations of this scenario.

Use Case	Content	Ingestion	Delivery-Time	View Time	Delivery Route
On Demand	A la carte clips	Prior	On-Demand	Shifted	- Unicast Stream
Scheduled Rebroadcast Carrier-originated "channel" style program viewing	Clips/feeds assembled and put into program rotation on a carrier created playlist to create a channel format.	- Prior - Live	Live	Live	- Unicast Stream - Unicast Stream fed into Mobile Broadcast system
Live Broadcast	Typically live feed from traditional broadcaster	Live	Live	Live	- Unicast Stream - Mobile Broadcast

Table 1: TV Viewing Use Case Variations

#### On Demand

In true on-demand (as opposed to near-on-demand where the user signs up to catch the next scheduled viewing) the user gets their media delivered immediately, and can often control the playback with VCR-like functionality to start, stop, pause, fast-forward and rewind the video. On-demand content is ingested well prior to actual demand. Since on-demand means the user starts/stops playback when they feel like it, on-demand is time-shifted and can only deliver individual clips via unicast streaming/progressive download.

#### Scheduled Rebroadcast

A scheduled rebroadcast creates a "live" broadcast programming feed by putting together individual clips and live content provider feeds into a playlist/carousel to simulate a live channel format in which all users viewing the channel join the programming in progress and cannot control the playback or selection of content on the channel. Content can be ingested ahead of time or live from feed at time of rebroadcast. Scheduled rebroadcast is delivered via a unicast stream directly to a streaming handset or as the input source to a live broadcast/multicast system.

## Live Broadcast

The basic use case for viewing a live mobile broadcast is a direct parallel to viewing a traditional network television broadcast. Just as it is with scheduled rebroadcast above, the user can only watch programming in real-time as it is delivered from the content feed and cannot control playback at all. The content is a live feed, typically from a traditional broadcaster received in a broadcast format such as MPEG2, but can also be a live feed received from a scheduled rebroadcast unicast stream. Live broadcast feeds are delivered immediately as they are ingested and transcoded. The live media is then delivered as a stream to unicast users via a scheduled rebroadcast system (which is how most carriers do live mobile TV today) or via a mobile broadcast system either as an in-band multicast on the carrier data network, or as an out-of-band broadcast over a separate radio or satellite network to a separate receiver in the handset.

## Personal Video Recording

Next we'll examine simple PVR recording and time-shifted replay use case variations. To illustrate the differences in delivery routes, all of our scenarios assume the existence of a scheduled recording functionality called from a "Season Ticket" or "Wishlist" feature which finds the desired programming and puts it in the Playback List. Table 2 illustrates variations on this theme.

Use Case	Content	Ingestion	Delivery-Time	View Time	Delivery Route
Handset-recorded Season Ticket /Wishlist	Any	Any	-Live -On Demand	Shifted	- None. Handset client archives received content on the fly just like a home PVR
Season Ticket /Wishlist-in-the-Sky	Any	Any	On Demand	Shifted	- Unicast Stream
Season Ticket /Wishlist Scheduled Push	Clips	Prior	Prior and Scheduled	Shifted	- Clip-casting via Broadcast/Multicast - OMA DCD - RSS scheduled pull

Table 2: Scheduled Recording Use Case Variations

## Handset-recorded Season Ticket/Wishlist

The Handset-recorded Season Ticket/Wishlist use case is directly analogous to functionality found in the average home PVR system connected to satellite or cable TV. In this scenario, there are no requirements placed on the SDP other than to originate the content. The burden is on the handset to provide all PVR functionality, schedule recordings, archive the incoming content and update the Playback List. Although handset-recording is the easiest for carriers to architect, it's actually the least practical to deliver because it requires handsets to have not only a mobile broadcast receiver, but multiple gigabyte hard disks for storage. This would substantially drive up the subscriber's upfront investment (or alternately, the carrier's customer acquisition cost) and would greatly limit the addressable market.

## Season Ticket/Wishlist in the Sky

Conversely, the Season Ticket/Wishlist in the Sky variant of the PVR use case puts the least requirements on the handset and shifts the “recording” and “storage” to the carrier’s SDP. In reality, the Season Ticket/Wishlist lives in the network, and just creates a link in the Playback List to the segment that was originally delivered. This means only one copy of the clip (per supported A/V format) is maintained and streamed by the SDP. In this scenario the type of content and ingestion time do not play a role, the delivery is on-demand and the playback is time shifted. Playback is analogous to the On-Demand Viewing use case above, so the only way to deliver the media in this scenario is via unicast streaming.

## Season Ticket/Wishlist Scheduled Push

The Season Ticket/Wishlist Scheduled Push scenario is a hybrid of the In-The-Sky and Handset recorded scenarios. The main difference is that rather than all content listed in the Playback List being delivered on-demand, some subset of the content is silently pushed to the handset in the background or in off-peak hours. In this scenario the type of content and time of its ingestion into the SDP do not play a role. The playback is time-shifted but the media is stored locally on the handset, which provides the least startup delay.

Push delivery is achieved by “pushing” a copy of the original media file to the user. There are many technology options for performing push delivery, and even more on the way. The mobile broadcast network can do this most efficiently for the most popular content and this is often referred to as “Clip-casting”. Forward Error Correction (FEC) is utilized by the broadcast network to minimize the effects of lost data in forward link only transmission (See “Push Delivery & FEC” inset).

The tradeoff for pushing files over broadcast vs point-to-point parallels the tradeoff of content selection in Live Broadcast vs. On-Demand Viewing. The content in the Long Tail cannot be reached with broadcast push and will require smaller multicast groups or point-to-point connections to be pushed.

## Key Points of This Section

Let’s sum up the key points of delivering the basic mobile TV use cases before moving on. We’ve just shown that

- ◆ You can deploy at least one variation of each basic use case for live mobile TV using either streaming or mobile broadcast alone.
- ◆ Mobile Broadcast is a much more efficient way to deliver the most popular content.
- ◆ But the most popular content typically represents less than 20% of what users want at any moment in time, and they can’t access the other 80% of content they desire in the Long Tail *without* support for on-demand streaming.

Now that we’ve seen how streaming and broadcast are both necessary to deliver the basic functionality of Mobile TV, let’s take a look at what becomes possible when streaming and broadcast are integrated into a single combinational service.

### Push Delivery & FEC

In multicast and broadcast, the connection is forward-link-only (meaning one-way, towards the handset) and there is no means to retransmit missing packets. While an RTP stream can continue to be delivered and played after packet loss without FEC, other forms of pushed files are much more vulnerable to corruption. For this reason all broadcast and multicast technologies provide some sort of forward error correction (FEC) which has the net effect of spreading around the original contents of any single packet to minimize the impact of loss of any given packet. Some forms of FEC have additional error resilience capabilities such as data redundancy and probabilistic reconstruction of the lost data.

## Better Together: Streaming & Broadcast Combined Service

We've shown how streaming and mobile broadcast must co-exist in the wireless carrier's SDP just to deliver the basic use cases of mobile TV, and now we'll explore the advanced capabilities of moving *beyond* parallel deployments to a unified combinational service where mobile broadcast and streaming work together in concert.

### Advantages of a Combined Service

#### Maximum Channel Selection with Limited Overhead

Even though mobile broadcast/multicast solutions will deliver between 15 and 30 channels of video (depending on the bitrate), 30 channels is still well less than the average cable or satellite basic offering users have come to expect in their homes. Just as those most basic home offerings quickly gave rise to premium movie channels and custom packages of additional channels (not to mention on-demand), it's quite reasonable to expect the same sort of evolution in customer demand for mobile TV as it reaches the mainstream user. Given the fierce competition in wireless and the precedent set by satellite and cable, this evolution is likely to occur even faster than it did in the battle for the home television audience.

But this situation doesn't mean a wireless carrier must lower video quality to try and cram a 100 or more channels onto the limited broadcast spectrum. Looking again to cable and satellite, a trend toward "narrowcasting" has developed, where channels increasingly honed their programming to address a niche demographic. If we assume that the narrowcasting model will transfer to mobile since much of the content is from the same providers, it's quite reasonable to expect that as more and more niche channels are added, the distribution of channel consumption will start to show a tailed pattern of distribution similar to that shown below in Figure 1.

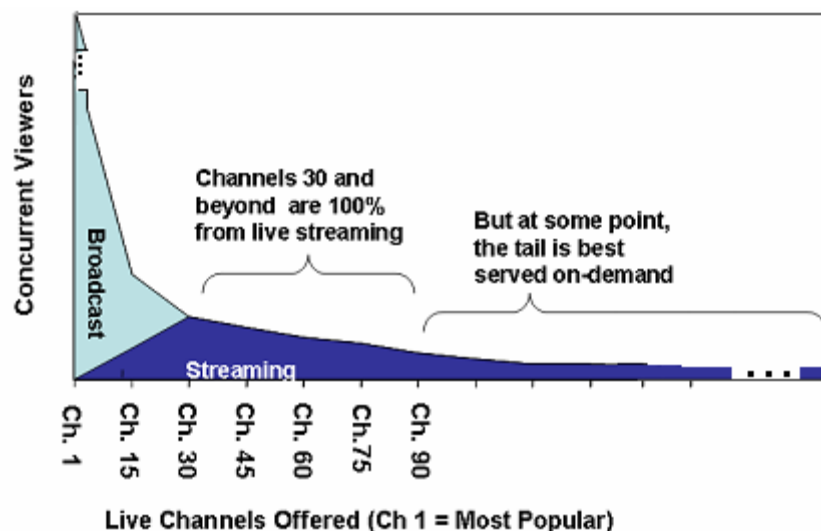


Figure 1: A Theoretical Long-ish Tail of Live Channel Offerings

After the 15 to 30 most popular stations are served by mobile broadcast, there are still a lot of niche channels left in the tail that can be addressed by multicast or unicast streaming with the remainder served as on-demand clips.

## Streaming the Broadcast Channels to Non-Broadcast or Out of Coverage Area Users

But what about those subscribers that you serve now on your current streaming mobile TV SDP today--The ones that just bought a brand new EV-DO or HSDPA phone and the other new subscribers that don't want to invest in a broadcast-capable terminal? What happens when your subscribers step out of the mobile broadcast coverage area, but are still on the 3G network?

These non-broadcast customers will need to receive the broadcast channels as multicast or unicast streaming. (This is a variation on the Schedule Rebroadcast use case above where the mobile broadcast feed is also the source of the streaming rebroadcast.) In Figure 1 above we illustrate this by showing streaming reaching legacy subscribers on Ch 1- Ch 30 which are now primarily serviced by broadcast.

## Federated Electronic Programming/Service Guides

Bringing together live channels across multiple sources brings with it the opportunity to federate the various electronic service guides (ESG) displaying the live channel programming lineups into a single guide so the underlying implementation is invisible to the mobile TV user.

This orchestration could be performed by the channel surfing application on the handset reading in the various ESG feeds on startup (either by obtaining them on the fly or by reading in previously pushed files) but this practice leads to sections of data being out of date, places multiple points of failure on the user's handset, and overall, makes a uniform interactivity strategy difficult to manage for a wireless carrier. Instead, unification of the ESG feeds should occur in the carrier's SDP to avoid these pitfalls. The SDP approach can also provide additional capabilities such as custom queries that can filter the program guide, search its contents, apply style and branding, and above all allow personalization by the user.

## Exclusively Combinational Use Cases

Now let's explore some examples of features/use cases that can only be accomplished when the streaming and mobile broadcast infrastructures are integrated in the SDP.

### Pause/Rewind Live TV

Unless you provide users handsets that have gigabytes of extra file storage, they won't be pausing, or rewinding a live broadcast without the aid of streaming. More accurately, they won't be able to resume from where they left off because the broadcast transmission continues on without them. But when you combine the broadcast offering with streaming, you can pause, rewind and resume from without needing tons of extra device storage. Upon pause, the TV client simply initiates a steaming session to the on-demand version of the channel or show, and indexes directly to the time code where the broadcast was abandoned. Connection times can even be masked by pre-establishing the companion session with the streaming server and playing out of the client buffer if resumed/rewound while waiting.

### Private Rebroadcast / Watch It Now

Without combinational service, selecting a program in the future only allows the user to schedule a recording or channel change and selecting past programs may not even be an option. By combining streaming with the live broadcast, future and past programs could be viewed on-demand immediately (potentially as a premium service) by delivering a unicast stream of the desired content.

## Interactive Vote/Rate/Chat and Other Datacasting While Streaming

While the ability to build interactive presentations that play and respond to mobile streams, present contextual advertising, display/navigate an ESG and more has been possible for some time via SMIL 2.0, most forms of mobile broadcast bring with them a unified interactivity model incorporating datacast, usually over IP, to the handset over broadcast, multicast and unicast alike.

A top level TV client application on the handset could easily take advantage of this IP-Datacast infrastructure for live and on-demand streaming (without requiring SMIL authoring) to bring the user equivalent interactivity experiences whether watching broadcast or unicast.

### Datacasting

The term datacasting comes from traditional broadcasting and is used to describe data sent over the airwaves that is not inherently related to the medium. Stocks, news, traffic and weather are typical examples of datacast. Datacasts do not need to be relevant to the media playing, but often are and increasingly support some form of user interactivity. Examples of interactive datacasts include voting/rating, gaming, shopping, chat, and the ESG itself.

## Best Practices for Deploying Total Mobile TV

In this section, we'll outline some best practices for incorporating mobile broadcast into your streaming service delivery platform.

### Deliver the Use Cases First, Then Introduce Broadcast

Chances are your 3G data network isn't yet bursting at the seams due to the demands of streaming live mobile TV and is safe for the near future. Use this grace period to model the end-to-end service operation and functionality as you ultimately envision it, and deliver your vision now with streaming over your existing 2.5 or 3G network. Then when you are ready to introduce broadcast, it's just another delivery mechanism. Each incoming media request is simply serviced via the least cost route.

- ◆ **Don't wait for mobile broadcast to arrive to expand your mobile TV offering.**

While mobile broadcast will be available in some countries as early as the end of 2006, others won't clear the spectrum until 2012. In many countries where spectrum has been awarded, confusion abounds as to what business model the license recipients will offer (or be compelled to offer by the government). In some cases the same basic channel package will be offered to all carriers, in others the number of available channels will be divided among all carriers wishing spectrum. You can't afford to wait for the dust to settle before delivering a compelling mobile TV offering to your subscribers.

- ◆ **Deliver at least 15-30 channels as live streams at the rate and codec you plan to evaluate for mobile broadcast.**

Modeling your live mobile TV service on IP streaming will help you make usage predictions relevant for *your* network that best serve *your* subscribers. If you eventually plan to offer more than 30 channels, you will still be using this infrastructure to deliver live channels even after you incorporate broadcast.

- ◆ **Plan to Incorporate IP-Datacast/ESG and interactivity as early on as possible.**

Offer an orchestrated ESG service for your live streaming channels and on-demand video today. Then when it comes time to introduce broadcast, there is no disparity in user interactivity experience between the broadcast and streaming channels.

- ◆ **Consider deploying in-band multicast solutions such as MBMS or BCMCS prior to going out-of-band.**

By deploying MBMS or BCMCS, you will be able to utilize in-band multicast for the live channels, and even if you choose not to use in-band for mobile TV it's highly likely you will need to leverage in-band multicast for other kinds file delivery such as home screen branding, anti-virus updates, service announcements, and more.

If you are one of the operators fortunate enough to have the unpaired spectrum required to do TD-CDMA, you may get enough channels out of MBMS to never have to go with an out-of-band broadcast solution.

Other operators without this spectrum will eventually need to go out-of-band to deliver the high-demand channels, but either way in-band multicast will be a key component in your SDP, so there is no need to hold off on this deployment decision.

## Get Intimately Involved in the ESG and TV Client UI Design

The user experience with your service is paramount; don't leave this to the vendor or system integrator to design for you.

- ◆ **Invest resources in storyboards, prototypes and usability.**

Even if you choose an off the shelf TV/ESG client, you'll still want to know exactly what each individual use case and variation your users will experience.

- ◆ **Standardize on one player for all forms of video.**

It's a poor and counterintuitive user experience to be surfing the ESG and select a channel or an on-demand clip only to have one player start for on-demand content, another for broadcast, and another for a different MIME type.

A single media engine that can accommodate all of the media codec and format types that will be delivered via your TV service also makes a valuable contribution to the quality of the end-user experience.

- ◆ **Unify the selection and viewing experiences...**

Even if you are able to use just one video player, it's still a clumsy experience to users that have been navigating cable and satellite ESGs their whole lives to have to go to a separate application for the mobile TV ESG, and then have the TV viewing client pop up as a separate player, which then has to be closed to view the ESG again. The ESG and TV Viewing Experiences must be able to be viewed from the same application.

- ◆ **...But still be flexible enough to accommodate affinity applications**

There will undoubtedly be applications that create a filtered view of the ESG and on-demand video to create interactive rich media affinity applications. An example of an affinity application is a football portal application for the avid sports fan that can present an alternate, filtered view of the ESG and on-demand content to only show football games, display only football-related news, push a fixture results ticker over the datacast, present player statistics, and more. The wireless SDP must provide access to the datacast, ESG and interactivity data as APIs to enable such applications.

## Abstract Your Total Mobile TV Solution from the Technology

Now that you've put the mobile TV technology behind the scenes for the user; give your Service Delivery Platform the same benefit. With proper abstraction, you'll be able to deliver the same service offering regardless of geography, billing arrangement, content provider, or terminal capabilities.

- ◆ **Insist on IP for both the datacast *and* the broadcast.**

One of the best ways to future-proof your service offering (and possibly the *only* way to have a centralized multi-national SDP strategy) is to insist that all broadcast traffic is delivered over IP. Early on, there were some performance advantages when channel switching using broadcast formats that omit IP "overhead" such as FLO, but DVB-H vendors have since recalibrated the time-slicing algorithms and packet sizes to decrease time between packets and narrow the performance gap in channel acquisition.

If you are a multi-national carrier, you may not get the same spectrum or even access to the same broadcast technology from nation to nation, and you will have to work with what's available to you to deliver a consistent, centralized, service offering across nations. Standardizing on IP is the only way to do that.

## Conclusion

In this article we've defined mobile TV by the use cases it comprises, and shown how out-of-band broadcast, IP multicast and IP unicast streaming complement each other in the use cases they can deliver and in the areas of the Long-Tailed digital media distribution curve for which each is best suited. We've also shown how these technologies can be combined to yield additional features and use cases for a Total Mobile TV solution that becomes more than the sum of its component technologies.

We've discussed best practices for building an abstracted Total Mobile TV architecture in your service delivery platform built on IP which leverages streaming, IP-Datacast, and a unified TV/ESG client to deliver live interactive TV to your subscribers *today*, and how and when to incorporate IP multicast and out of band broadcast as least cost routes to address increasing demand for the most popular channels and clips while at the same time, providing continued access to the content archive which grows the Tail each day.

You're now poised to deliver a Total Mobile TV solution that provides you with ultimate flexibility and a future-proof foundation.