Effective DVB-H Coverage

In order for DVB-H networks to provide effective and robust coverage in support of mass consumer adoption of mobile TV services, operators need to take a fresh look at network design and implementation.

Mobile TV holds great promise for both the TV broadcasting and mobile communications industries. For broadcasters it presents an opportunity for finding a new audience and new uses for valuable content, while for mobile operators it is a way to increase revenues in saturated markets.

For this promise to be fulfilled, however, a sizable investment in DVB-H network infrastructure will have to be made. It is important, therefore, to understand the physics and economics of the network needed for the support of mobile TV services.

From Analog TV, to DVB-T, to DVB-H

In order to fully understand the factors impacting DVB-H network deployment it is useful to briefly go back to the legacy analog TV network as deployed starting way back in the first half of the 20th century. That network employed very high power transmitters, with high power amplifiers (HPAs) in the tens of kilowatts and antenna elevations of hundreds of meters. At the receiving end of the link, the reference home receiver assumed for network planning used a directional rooftop antenna installed 10m above the ground. With such an antenna it is typically possible to receive the signal at a distance of tens (30-50) km from the transmitter, which translated to the coverage radius and the basis for transmitter and frequency planning.

The transition to digital terrestrial TV – specifically DVB-T in Europe and many other parts of the world – while revolutionary in many respects, was engineered to largely preserve the then-existing network planning principles: transmitters were still assumed to be high power and far between, and the home user was still assumed to need a rooftop aerial for proper reception in large parts of the coverage area.

Still later, the DVB forum developed the DVB-H standard with the vision of allowing mobile TV networks to leverage the existing DVB-T infrastructure in order to reach the mobile receiver with a modest incremental investment in network infrastructure. Thus, DVB-H is a close derivative of DVB-T, and the standard was designed to support the multiplexing of DVB-H and DVB-T programs over a common multiplex: this would allow operators to use spare capacity on their DVB-T multiplexes to add DVB-H programming in a way that would be transparent to the legacy home receivers, but would still be useful for the new DVB-H devices.

If only it was that easy.

DVB-H services are targeted at hand-held devices, most commonly properly equipped cellular phones. Such devices are very different from the home receiver described above: they have small antennas with a much lower gain, and are usually used at lower elevations, with no line of site to the transmitter, occasionally in motion and even more often inside buildings. Combined, these factors translate to a 30-40 dB deficiency in gain relative to the reference DVB-T receiver. Such a huge gap means DVB-H network planning needs to be drastically different from that of DVB-T.

DVB-H Network Planning

The first step in closing the coverage gap described above is by proper choice of signal parameters. DVB-T/H offers a wide range of signal modulation and coding options, which allows the network designer to trade off power with bandwidth efficiency. In a typical DVB-T network, the generous link parameters allow the use of a highly bandwidth-efficient modulation and coding parameter set, at the expense of power efficiency: capacities upwards of 20 Mbps are typically achieved for a single UHF channel, allowing the transmission of either multiple standard definition (SD) or one High Definition (HD) together with several SD programs over a single multiplex.

A mobile TV network is an entirely different ballgame: achieving realistic network economics starts with choosing a drastically different power vs. bandwidth balance. In fact, most DVB-H network designs go to the extreme in power efficiency at the inescapable expense of bandwidth, bringing channel capacity down to about a quarter of DVB-T's – or around 5 Mbps. This departure from common DVB-T practice is the major reason why in reality DVB-H services beyond the trial stage do not share capacity with DVB-T, relying rather on dedicated carriers.

Unfortunately, proper choice of signal parameters alone is not enough to offset the difference in link parameters described above: unavoidably, additional transmission sites are needed in order to achieve continuous service coverage. This is similar to the situation in the cellular network, with one important difference: additional cellular base-stations improve signal strength but, just as importantly, increase network capacity through greater frequency reuse. Mobile TV's is a broadcast network – an identical signal is output by multiple transmitters covering a large area – and signal strength is therefore the only relevant consideration.

With this in mind, it stands to reason that the most economical network plan would use the smallest possible number of transmitters, each with the highest possible power. This, however, is true only in theory: in practice, various regulations limit the power of the signal that can be output from any single transmission site, addressing electromagnetic compatibility, zoning and safety concerns. For example, the HPA power output of Third Generation cellular base-stations located in dense urban areas is limited in many countries to 20-50W. While the working parameters of DVB-H transmitters are somewhat different, they are limited in a similar way. In more open areas, higher output powers and taller antenna masts are permitted, but will still be much smaller than those of the big DVB-T sites.

So, how do you provide good coverage with such small transmitters? Very simply, you use a relatively large number of them, deployed relatively densely. For example, simulations and experience from field deployments show that with a medium power amplifier (200W) and a medium height mast (40m) you can expect to achieve a 95% probability of indoor coverage over an urban area within a radius of approximately 1.5 km from the transmitter. Covering a 100 km^2 city with such transmitters would require 15 similar sites. Farther away, in more open areas, transmitters can in most circumstances have higher power; propagation conditions also are usually better, together contributing to a lower density of sites.

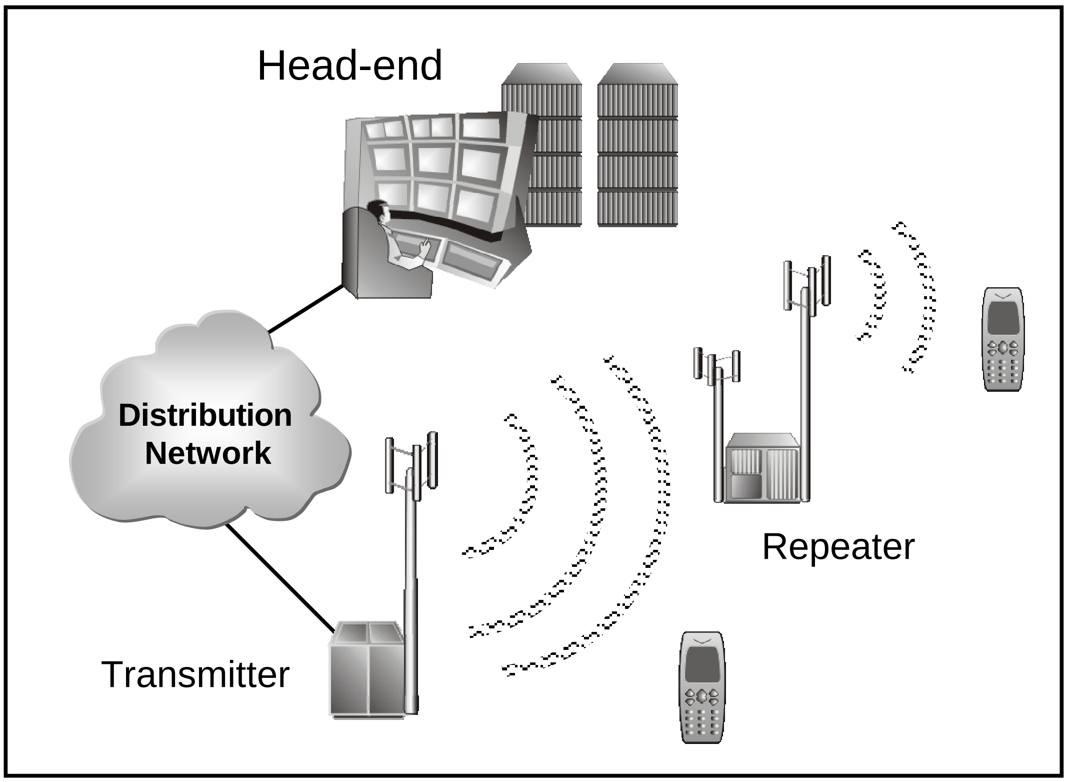
Finally, co-locating new low-power DVB-H transmitters with cellular base stations is an obvious way to reduce network cost: while the two networks use separate electronics, other infrastructure such as power, masts, connectivity etc can be shared.

Transmitters and Repeaters

Low power DVB-H sites come in two major varieties – transmitters and repeaters.

A transmitter is functionally similar to the legacy high-power site: it receives the content for transmission from the head-end over a distribution network, which is typically satellite or telecom based, and uses it to modulate the DVB-H carrier.

A repeater, on the other hand, receives the DVB-H signal – the same signal picked up by the end user's device – from a nearby transmitter, and amplifies and re-transmits it in order to cover an under-served area.



A DVB-H transmitter site will typically include the following functions:

An appropriate interface terminates the distribution network: for satellite distribution this means a satellite dish and a cable run to an indoor satellite receiver. For a wireline telecom network this is an Ethernet, SDH, PDH or similar interface.

The received data is optionally demultiplexed, or groomed, in order to extract the relevant content. That content is then input to the DVB-H modulator and from there to the HPA, which feeds the transmitting antenna.

DVB-H networks will most often work in Single Frequency Network (SFN) mode. Using SFN mode, adjacent transmitters that cover a contiguous area and deliver the same content can transmit on the same RF channel, thereby economizing on valuable spectrum resources: provided their outputs are synchronized to within one microsecond, the receiver – by taking advantage of the design of the DVB-H signal – is able to operate satisfactorily even in locations where it receives the transmissions of multiple sites (which might otherwise interfere with each another). Synchronizing the SFN transmitters is usually done by GPS, and the transmitter should therefore include a GPS receiver and related synchronization unit.

Repeaters are conceptually simpler: their function is to receive the DVB-H signal, filter and then amplify it for output to the transmitting antenna. Some repeater products can perform frequency translation: they receive a signal on one channel and convert its frequency for output on another channel. This variation, however, is not useful in typical DVB-H networks: multiple channels are not likely to be available, and are even less likely to be useful in networks with a large number of repeaters. DVB-H deployments will therefore most likely use what's called on-channel Repeaters.

Simple on-channel repeaters of the kind just described are useful for indoor coverage enhancement in malls, transportation terminals etc. However, an additional complication is involved when they need to provide outdoor coverage: for their "on channel" operation, such repeaters need to include a receiving antenna, a signal amplification chain and a transmitting antenna generating a signal on the same frequency as the received signal. Unless the receive and transmit antennas are properly isolated from each other, the feedback signal from the latter to the former will cause the entire chain to oscillate. The required isolation level is often difficult to achieve when both antennas are located outdoors at relatively close proximity, especially as they are typically broad-beam. To mitigate this difficulty use is made of an echo-canceling repeater: such a repeater digitizes the input signal and then performs echo cancellation in order to offset as much as possible the output-to-input feedback signal path. The algorithms used are similar to those used to cancel out speech echoes in long-distance telephone circuits.

Transmitters and repeaters each have their advantages and disadvantages, and the optimal choice of technology depends on the specific circumstances:

A transmitter can be placed at any location that is within reach of the distribution network. With satellite, this is practically almost anywhere. A repeater, on the other hand, needs to be within good reception range – essentially within line of sight – of a transmitter, and is therefore limited to service extension over a modest distance.

Repeaters rely on a feeder signal that's freely available over the air. Transmitters require a distribution network, with its associated cost of set-up and operation. However, with satellite distribution, which seems to be the method of choice for DVB-H networks, those are minimal even for a relatively small network of a hundred sites.

The hardware cost of an echo-canceling repeater is comparable to that of a transmitter with a similar output power.

The output signal of a properly engineered transmitter is optimal in terms of minimal noise and distortion. A repeater, on the other hand, cannot cancel out noise and distortion introduced into its feeder signal: those impairments add up at its output, limiting performance somewhat.

The service availability of a transmitter is dependent on that of the distribution network it connects to. On the other hand, the failure of a transmitter will bring down all the repeaters that rely on it for signal feed.

To summarize:

	Transmitters	**Repeaters**
Location	Almost anywhere	Within line of sight of a transmitter
Bandwidth cost	Distribution network's	None
Equipment cost	Similar	
Signal integrity	First rate	Somewhat degraded
Service availability	Dependent on feeder network	Dependent on feeding transmitter

Current DVB-H network deployments generally favor transmitters over repeaters for wide area coverage, limiting the use of repeaters to spot coverage of indoor locales: at a similar hardware cost, and with the cost of distribution not being a major factor to the equation, transmitters offer much higher flexibility in site placement and superior signal quality.

Conclusion

DVB-H network deployments typically start out by relying on a small number of legacy high power sites. Eventually, however, the bulk of network infrastructure cost will be spent on a much larger number of low power transmitters. This presents a new challenge as well as a new opportunity to the broadcasting industry: answering the challenge by coming up with a cost effective and highly functional offering for this new set of requirements will translate to an exciting opportunity in an entirely new product category.