Consultation Paper
On
Issues Relating to
Mobile Television Services

Submission by
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Introduction

Mobile TV is a fast evolving market of potentially great value. The service can deliver a wide range of multimedia entertainment, news, and other beneficial content to people on the move, assistance in emergencies, educational programs, and more. It enables efficient broadcast delivery of high quality video and audio signals and using less infrastructure as compared to traditional cellular networks of similar capacity. It is as valuable for users as for India's IT, telecom, and broadcast industries. A strategic policy approach can provide lasting leadership for India in an important area in which it has several core strengths.

Mobile digital television signals can be received by mobile or portable devices or equipment (mobile phones, laptops, PDA, etc). This service can be provided by radio through different technologies, which may be either terrestrial (cellular, broadcast) or satellite waves (broadcast).

Just like different cellular technologies which are now available, there are several technologies in use for mobile TV services. These technologies include EV-DO, HSPA, DVB-H, MediaFLO, DAB and several others – newer version of existing technologies as well as entirely new ones- can be expected in future. In much the same way as other cellular technologies like CDMA and WCDMA are fuelling aggressive growth through a healthy competition dynamics enabled by enhanced services and affordable handsets, competition between different mobile TV technologies will undoubtedly help meet stakeholder's needs especially the consumer. As mobile TV is still in a nascent stage of its development, services will undoubtedly evolve and technologies will help to create effective solutions for the delivery of video content to consumers in ways that are most appropriate, cost effective and appealing. Much will depend on overall operator economies and spectrum availability besides technology superiority. Hence, it is critical that TRAI does not force a premature choice of technology and delivery mechanism for mobile TV content and services, and allow the operators to choose technologies that deliver value to consumers and make commercial sense.

Regulators can help this process by ensuring fair and robust market competition and undertake all possible steps to mitigate potential risks and prevent market abuse. However, experience worldwide and in India has shown that early regulation of new markets, especially controls on entry, can stunt their growth, restrict services, raise prices and hurt quality. Fair and effective competition, both in competing technologies and among competing operators, is a regulator's best method of protecting the interests of consumers. .

The success in facilitating competition among wireless mobile TV technologies will inevitably depend upon various commercials factors and spectrum availability. Regulation will have an important role in creating a robust framework and incentives for stakeholders to invest in this new market. A critical task for regulators will be to devise and implement spectrum allocation procedures, including quantum and price of spectrum.

It is easy to see that if spectrum needs are met adequately, huge benefits can follow through competition between contending technologies. However, arbitrary pricing and allocation of spectrum can distort the very economics of the business by making some technologies less/more competitive for reasons unrelated to their core strengths. A clear, market-based and transparent process, such as an auction, for allocating and pricing spectrum, is therefore key to the creation and success of mobile TV services that meet user aspirations and are commercially sustainable.

Apart from spectrum allocation, promoting infrastructure sharing (both passive and active) can help improve business viability of mobile operators significantly without compromising competition in the market place. All obstacles – whether stemming from regulators or from central or stage government rules about infrastructure - will need to ensure that unnecessary costs in duplicating infrastructure are avoided. It should be a priority for regulators to work with related agencies in this regard. An incentive-based procedure that rewards infrastructure sharing in line with FM & USO auctions should be created. This will not only increase business viability, but will also help extend mobile TV services across the country and in rural areas.

In short, India can greatly benefit from a framework which encourages different delivery options and favours unrestricted competition between technologies and operators. Any attempts at mandating technologies for mobile TV will hurt India's long term interests and economies as well as consumers. Promoting certain technologies through pre-emptive deployments by public sector agencies should be avoided as it will not only damage the competitive dynamics of the market, but also will distort the mobile TV market by creating preferences for a single technology option, thereby impacting mobile telephony growth. Several stakeholders in the market e.g. vendors, content producers etc- could be hurt by market distortion that a large player can cause by virtue of a premature call on technology.

Before undertaking a point-by-point response to the questions raised in TRAI's consultation paper, Qualcomm would like to clarify that TRAI's consultation paper incorrectly suggests that MediaFLO technology for mobile TV is proprietary in nature. Qualcomm will like to state that MediaFLO is based on global open standards with extensive standardization already taken place.

The International Telecommunication Union - Radiocommunication Sector (ITU-R), recently recognized FLO as an ITU-R recommended technology for the broadcasting of multimedia and data applications for mobile reception on handheld devices. FLO technology underlying MediaFLO has already been standardized by TIA (Telecommunication Industry Association).[1] In addition, European Telecom Standards Institute (ETSI) standardization is under active consideration[2].

FLO technical specifications are supported by the FLO Forum (www.floforum.org), an open international organization with over 90 leading wireless and broadcast industry companies from all regions of the world[3] committed to promoting global standardization of MediaFLO technology. The FLO Forum objective is to enable an open and wide ecosystem to meet the varied requirements of a growing standards based, multi-vendor environment. FLO Forum

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[1] TIA has approved the following technical standards: TIA-1009 (Radio interface), TIA-1102 (Receiver minimum performance specification), TIA-1103 (transmitter minimum performance specification), TIA-1104 (Test application protocol) and TIA-1120 (transport specification).

[2] In May 2007, ETSI approved a new work item, "Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast," aimed at the publication of an ETSI technical specification making a normative reference to the TIA-1099 standard[3]. This is a similar approach as that taken by ETSI DVB-H in the TIA.

[3] The FLO Forum is a rapidly growing international organization and includes today 27 companies based in Asia, 24 in Europe and 31 in North America. FLO Forum members span the entire Mobile TV value chain with 14 semiconductors, 9 device manufacturers, close to 60 infrastructure vendors or application developers and 11 operators (wireless carriers and/or content providers)

initiatives include the definition of necessary interface standards that will significantly lower the barriers to entry for alternative suppliers to offer compatible solutions in a modular fashion. The FLO Forum works collaboratively and on a consensus, contribution-driven basis to generate technical specifications for submission to global standards and regulatory bodies as highlighted above. In particular, it is in charge of developing technical specifications related to the service, content and user requirements, the radio interface, baseband to protocol stack API, the Open Conditional Access, multimedia applications (interactivity, rich media, etc.), as well as equipments testing and certification for transmitters and devices. As today, 5 FLO Forum specifications have been ratified by TIA[4] and more are already available to the FLO Forum members and will be made available to international standard bodies

The process for the standardization of MediaFLO and its open ecosystem are therefore no different than other competing technologies for mobile TV. Consequently, we would urge TRAI to clear any confusion caused by the statement in its document and to ensure that all mobile TV technologies are treated at par and allowed to compete robustly in the market place.

Finally, we will like to state that MediaFLO is a mature technology. MediaFLO technology has already been deployed nation wide in the U.S.A, and its services are available to the consumers through Verizon Wireless - the largest CDMA operator in the U.S.A. Additionally, AT&T (aka Cingular Wireless) – the largest GSM operator in the U.S.A – has announced launching MediaFLO services to its customers. Further, MediaFLO has a strong and growing ecosystem that can be leveraged across the world. Please reference Annexure I for further details on the MediaFLO ecosystem.

Qualcomm’s responses to the questions posed in the consultation paper are provided below.

1. Whether the technology for mobile television service should be regulated or whether it should be left to the service provider.

The technology for the mobile television service should not be regulated and the technology choice be left to the service provider. Any perceived benefits to be realised from adopting a single technology standard are only possible after all market stakeholders of the value chain have signalled which technology is superior in meeting user needs, more cost effective, efficient, safe, secure, meets the business requirements, addresses wide consumer choices and whether the presence of multiple technology standards could hurt consumers interest leading to wastage of scarce resources like spectrum, or cause unacceptable inefficiencies. In case of mobile TV services, various access options exist and are supported by multiple technologies simultaneously in several countries. Therefore, it is highly likely that multiple mobile TV technologies will coexist together seamlessly in the market place.

The Mobile TV market is starting to mature. There are few commercial deployments in major countries wherein different technologies, such as MediaFLO, DVB-H, T-DMB, and ISDB-T one segment, have been already commercially deployed. As for any existing service such as traditional TV broadcasting, mobile telephony (GSM or CDMA) or other wireless networks, the

[4] See TIA 1099; TIA 1102; TIA 1103; TIA 1104; TIA 1120

path for mobile TV growth and success is not unique; hence settling on one standard will be against user interest as well as against sound regulatory practices.

India's experience with competition between cellular technologies (CDMA, GSM) in the wireless telephony has demonstrated the huge benefits that users can derive from healthy competition in the market. It has also demonstrated that a host of factors – viz. price, excellence, availability, support etc- influence market stakeholder's decision to deploy a particular technology for a specific purpose and ultimately meet consumer needs in terms of cost, choice of terminals, etc. The need to ensure choice in the market is therefore critical.

In this scenario, it would be extremely risky and unwise to tie India to a single standard prematurely, whatever it may be. In regulatory terms, there are no immediate concerns – beyond those for conventional TV- that are specific to mobile TV markets. Effective competition in the mobile TV space- between technologies, operators, and vendors- is crucial for developing a competitive mobile TV industry.

2. If the technology is to be regulated, then please indicate which technology should be chosen and why. Please give reasons in support of your answer.

As mentioned in answer to Q1, there are huge benefits from allowing the service providers to choose their own technology including healthy competition, increased innovation, sustainable ecosystem which leads to tremendous benefits to the consumer in terms of costs, choice, etc. Hence, there are no grounds to mandate a specific technology standard.

3. What will be the frequency requirement for different broadcast technological standards for terrestrial and satellite mobile television transmission in India?

Terrestrial transmission in the UHF band is recognized as the prime spectrum for mobile TV due to its good propagation characteristics, better antenna performance, superior mobility performance, and good in-building penetration characteristics. Within the UHF, Band V (esp. the 700 MHz range) is particularly viewed by the industry as the most optimum compromise between propagation and handheld antenna characteristics while traditional TV services benefit from lower UHF with greater propagations but without antenna design limitations. Encouraging such band segmentation as much as possible will further facilitate potential interference between fixed and mobile TV services (regardless the mobile TV technology).

As already mentioned earlier, choice of technologies and access options is best left to the market. However, typically satellite based transmission is unlikely to be used on a standalone basis and is likely to be supplemented with terrestrial networks as satellite transmission suffers from the antenna size (gain) requirement and the poor in-building coverage, leading to loss of quality.

In addition, UHF in India as in many part of the world follows an 8 MHz channelization (as opposed to 1.5 MHz or 5 MHz for alternative spectrum bands) thereby provide an efficient bandwidth for the provision of a compelling mobile TV programming line-up, by supporting larger number of TV channels. For terrestrial TV transmission, India has already adopted an 8 MHz channel plan for the UHF Bands. It is evident that mobile TV technologies need to coexist with the existing services provided by Doordarsan. Mobile TV technology standards like DVB-H and MediaFLO are designed with flexibly to operate on an 8 MHz channel structure. Hence, it is suggested that India should adopt an 8 MHz channel structure for mobile TV for UHF bands.

Finally, Qualcomm believes that mobile TV technologies enables maximal efficiency use of UHF frequency bands by deploying nationwide single frequency networks (SFN). SFN configuration has many advantages for mobile TV, including limiting spectrum operating range in the terminals (greater antenna design and performance, efficient and cheaper filtering components, etc.) thereby increasing handset performances – hence network cost. SFN deployment can also translate with improved network planning in terms of coverage, frequency handover, and interference requirements (no co-channel interference). These considerations are detailed in the Radio Spectrum Policy Group Opinion on the Digital Dividend[5].

4. Which route would be preferable for mobile TV transmission – dedicated terrestrial transmission route or the satellite route? Should the mobile TV operator be free to decide the appropriate route for transmission?

Qualcomm believes that the choice of technologies and access options is best left to the market to decide. However, as pointed out by the consultation paper, satellite transmission suffers from the antenna size (gain) requirement and the poor in-building coverage. For India, with dense population and multi-story concrete buildings, any mobile TV service that uses satellite transmission will need to be supplemented by terrestrial transmissions.

5. How should the spectrum requirements for analogue/ Digital/ mobile TV terrestrial broadcasting be accommodated in the frequency bands of operation? Should mobile TV be earmarked some limited assignment in these broadcasting bands, leaving the rest for analog and digital terrestrial transmission?

As described in question 3 above, we believe that Band V (and in particular the 700 MHz range) would largely benefit mobile TV deployments. Furthermore, based on the frequency allocation

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[5] RSPG OPINION ON EU SPECTRUM POLICY IMPLICATIONS OF THE DIGITAL DIVIDEND

outlined in the consultation paper, UHF Band IV can not be made available since it is completely occupied by Doordarshan. Also, Doordarshan will need additional spectrum for migration to digital transmission. We recommend that Doordarshan be provided contiguous spectrum adjacent to their currently occupied UHF Band IV. The spectrum following this allocation needs to be earmarked for mobile TV services.

6. In the case of terrestrial transmission route, how many channels of 8 MHz should be blocked for mobile TV services for initial and future demand of the services as there are nearly 270 TV channels permitted under downlinking guidelines by Ministry of Information and broadcasting?

Qualcomm believes that a compelling service offering will require a minimum of 25 channels with a provision to double the number of channels. Based on this each system operator will require 2 RF carriers of 8 MHz each. Assuming there are 3 system operators, a total of 6 UHF RF channels (6 x 8 MHz = 48 MHz of spectrum) will be required. Such allocation will further increase mobile TV competition in the India market. Regulators worldwide have recognized that the digital dividend could constitute a total amount of ~100 MHz. Therefore a roadmap should be clearly laid out for making available more spectrum for increasing capacity of the existing operators and accommodating new operators in future. .

7. Whether Digital Terrestrial Transmission should be given priority for the spectrum assignment over mobile TV, particularly in view of the fact that the mobile TV all over the world is essentially at a trial stage.

No. The case for digital terrestrial transmission – market for which is admittedly more mature than for mobile TV- is substantially weakened by the fact that DTT is a monopoly with little quality programming and is struggling to compete with satellite-based services of the private sector that is barred from terrestrial TV. Unless, the field is levelled for all players, priority for DTT will distort markets further and hurt consumer interest. Mobile TV is a new opportunity and an appropriate regulatory framework will provide incentives to invest and provide consumers with new mobile multimedia services offerings – India is particularly well positioned to benefit from such new markets.

8. **Whether the frequency allocation for the mobile TV should be made based on the Single Frequency network (SFN) topology for the entire service area or it should follow Multi Frequency Network (MFN) approach.**

As described above in question 3, the aim of SFNs is efficient utilization of the radio spectrum, allowing a higher number of radio and TV programs in comparison to traditional multi-frequency network (MFN) transmission. An SFN may also increase the coverage area and decrease the outage probability in comparison to an MFN, since the total received signal strength may increase to positions midway between the transmitters. SFN also simplifies guard band requirements and network planning. Most of the terrestrial mobile TV networks around the world are being designed as SFNs. Qualcomm recommends use of SFN topology for India.

9. **Whether frequency spectrum should be assigned through a market led approach – auctions and roll out obligation or should there be a utilization fee?**

Qualcomm believes that the spectrum allocation procedure should be market based and follow a national licensing process, to enable transparency and fair competition. It will have sufficient incentives for operators to roll out services countrywide. If gaps are still found, an incentive based roll out obligation may be a more effective way to expand coverage.

"Use it or lose it" must govern all spectrum allocation. There should be built-in disincentives for hoarding spectrum and not utilizing it.

10. **What should be the eligibility conditions for grant of license for mobile television services?**

The eligibility conditions must be minimal though predictable and transparent. Spectrum bidders require certainty in order to balance their risk and investments. Small innovative players may have an important role in this relatively new and evolving market. Rules must ensure that this is possible and encouraged.

If spectrum is allocated on market-based criteria, it will automatically rule out frivolous players. A security clearance and a background check to rule out previous criminal activity can be considered.

11. Whether net worth requirements should be laid down for participation in licensing process for mobile television services? If yes, what should be the net worth requirements for participation in licensing process for mobile television services?

No comments.

12. What should be the limit for FDI and portfolio investment for mobile television service providers?

Same rules can be applied as applicable for telecom business.

13. What should be the tenure of license for the mobile television service providers?

No comments.

14. What should be the license fee to be imposed on the mobile television service providers?

No comments.

15. Whether in view of the high capital investment and risk associated with the establishment of mobile television service, a revenue share system would be more appropriate?

As already mentioned in the introduction, success of mobile TV services in the country will depend upon a regulatory framework which minimizes high capital investments thereby making mobile TV business case viable. Hence, Qualcomm recommends the adoption of a similar model for infrastructure sharing as has been done for FM services. Since, it might not be possible (due to spectrum constraints) for the cellular players to have their own independent networks; active infrastructure sharing should also be allowed and promoted.

16. Whether any Bank Guarantee should be specified for licensing of the mobile television service providers. If yes, then what should be the amount of such bank guarantee? The basis for arriving at the amount should also be indicated.

No comments.

17. Whether the licenses for mobile television service should be given on national/ regional/ city basis.

The most appropriate license design for mobile TV should be a single national license rather than a set of regional licenses. It will bring additional incentives to provide a national service in India while planning an appropriate and possibly staged roll-out based on market demand and requirements.

Annexure – I

MediaFLO Ecosystem

FLO is an open, global standard which is standardized by FLO Forum - an international organization focused on promoting the standardization of FLO technology. The FLO Forum comprises more than 90 international organizations that represent various parts of the Mobile TV value chain. Through the collaborative efforts of these organizations, several specifications, including the FLO Air Interface specification have been standardized by FLO Forum via TIA and effort is underway to standardize via other standards organizations. Some of the published standards include:

- *TIA-1099 (FLO Air Interface Specification)*
- *TIA-1102) – Minimum Performance Specification for Terrestrial Mobile Multimedia Multicast FLO Devices*
- *(TIA-1103) - Minimum Performance Specification for Terrestrial Mobile Multimedia Multicast FLO Transmitters*
- *(TIA-1104) – Test Application Protocol for Terrestrial Mobile Multimedia Multicast FLO Transmitters and Devices*
- *(TIA-1120) – FLO Air Interface Specification Transport Protocols*

In addition, the International Telecommunication Union recently recognized FLO technology in an ITU-R Recommendation BT.1833 for the broadcasting of multimedia and data applications for mobile reception on handheld devices[1]. Finally, the European Telecom Standards Institute (ETSI) standardization of FLO is under active consideration[2]. As a result of standardization, a strong ecosystem has emerged for MediaFLO. The various ecosystem partners are described in the following paragraphs.

FLO Transmitters

FLO transmitters are nothing but the commercially available digital broadcast transmitters with appropriate exciter components capable of generating FLO waveform. There are several

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[1] http://www.itu.int/rec/R-REC-BT.1833/en

[2] In May 2007, ETSI approved a new work item, “Forward Link Only Air Interface Specification for Terrestrial Mobile Multimedia Multicast” http://webapp.etsi.org/WorkProgram/Report_WorkItem.asp?WKI_ID=25905

transmitter vendors on the FLO Forum who are committed to the development of FLO specifications and products. Majority of the leading transmitter vendors including Rohde and Schwarz, Harris, Thomson, Teamcast, etc. have either demonstrated FLO based transmitter products or have commercially announced the availability of FLO transmitters.

FLO Receiver chipsets

In addition to Qualcomm, several organizations have supported the development of FLO receiver chipsets. Organizations such as Newport Media, Siano and Telechips have publicly announced their commitment to the development of FLO chipsets and they are at various stages of development. FLO chipsets from Qualcomm are already being used in the commercial handsets offered by Verizon Wireless.

FLO Handsets

Several commercial handsets are available from leading handset OEMs such as LG, Motorola and Samsung. Verizon Wireless is already selling the following MediaFLO-enabled phones by Samsung, LG Electronics and Motorola.

LG
VX-9400

Samsung
SCH-u620

Motorola
MOTORIZR Z6tv

Verizon Wireless has also announced the availability of the following handset from LG in the November 2007 timeframe.

AT&T (Cingular Wireless) has announced its support for the MediaFLO technology and is expected to announce the availability of GSM/UMTS MediaFLO-enabled handsets for its consumers towards the end of 2007

Additionally, Kyocera, Pantech Curitel, Sharp Corp, Amoi have publicly demonstrated MediaFLO-enabled handsets. Samsung has also demonstrated a MediaFLO-enabled UMTS handset.

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Introduction

In recent years, the wireless industry has seen explosive growth in device capability, especially in relation to mobile cellular phones. Ever-increasing computing power, memory, and high-end graphic functionalities have accelerated the development of new and exciting wireless services. However, some of these services, while technically possible, are challenging to implement because of the unfavorable ratio that exists between the cost of delivery and the expected revenue.

A case in point is the simultaneous delivery of large amounts (Mbytes) of consumer multimedia content to vast numbers (millions) of wireless devices. Delivery of this type of content is technically feasible over today's existing (unicast) networks, such as 3G networks. However, market analysis indicates that demand for this type of content, which is similar to that which is available on traditional broadcast services, commands a lower price than other on-demand, Internet-like, bi-directional data services. This leaves operators without a long-term viable business case for offering such content.

The appeal of video and multimedia is enormous, as evidenced by the $87 billion that consumers in the U.S. spent on these services in 2004 alone. For network operators, the challenge has become: "How can large-scale delivery of high-quality multimedia to wireless devices be implemented profitably?"

FLO technology was designed specifically for the efficient and economical distribution of the same multimedia content to millions of wireless subscribers simultaneously. It actually reduces the cost of delivering such content and enhances the user experience, allowing consumers to "surf" channels of content on the same mobile handsets they use for traditional cellular voice and data services. In designing FLO technology, QUALCOMM has effectively addressed key challenges involved in the wireless delivery of multimedia content to mass consumers. Unencumbered by legacy terrestrial or satellite delivery formats, FLO offers better performance for mobility and spectral efficiency with minimal power consumption.

This paper provides a brief overview of FLO Technology and its key air interface characteristics.

The User Experience

Before providing a general system and technical overview, it is useful to provide a high-level description of what a user will experience. As currently envisioned, today's wireless operator will offer to consumers a service powered 'behind-the-scenes' by a MediaFLO System based on FLO technology.

For example, a FLO-based programming lineup that utilizes 30 frames-per-second (fps) QVGA (a Quarter Video Graphics Array or 240x320 pixels) with stereo audio includes 14 real-time streaming video channels of wide-area content (ex: national content) and 5 real-time streaming video channels of local market-specific content. This can be delivered concurrently with 50 nationwide non-real-time channels (consisting of pre-recorded content) and 15 local non-real-time channels, with each channel providing up to 20 minutes of content per day. non-real-time content can be delivered in the background seamlessly and made available for viewing in accordance with a provided program guide. The allocation between local and wide-area content is flexible and may vary during the course of the programming day. The delivery of non-real-time content allows immediate access to music, weather or news summaries by topic while real-time streaming services support live events such as sports. In addition to wide-area and local content, a large number of Internet Protocol (IP) data channels can be included in the programming line-up. Such channels may include (but are not limited to) traffic information, financial information or local weather updates.

The ability to change channels quickly is considered a key user requirement. Equally important is watch time, which is designed to be comparable to talk time, if not longer, so as not to compromise the functionality of the mobile device.

The MediaFLO Service is designed to provide the user with a viewing experience similar to a television viewing experience by providing a familiar type of program -guide user interface.

Users simply select a presentation package, or grouping of programs, just as they would select a channel to subscribe to on television. Once the programs are selected and subscribed to, the user can view the available programming content at any time.

In addition to viewing high quality video and audio content and IP data, the user may also have access to related interactive services, including the option to purchase a music album, ring tone, or download of a song featured in a music program. The user may also be able to purchase access to on-demand video programming, above and beyond the content featured on the program guide.

The Media FLO system, based on FLO technology, is able to deliver such a rich variety of content choice to consumers while efficiently utilizing spectrum as well as effectively managing capital and operating expenses for the service provider.

FLO System Architecture

A FLO system is comprised of four sub-systems: the Network Operation Center (which consists of a National Operations Center and one or more Local Operation Centers), FLO Transmitters, 3G Network, and FLO-enabled devices (also known as MediaFLO Handsets). The schematic diagram in Figure 1 shows an example of the FLO network.

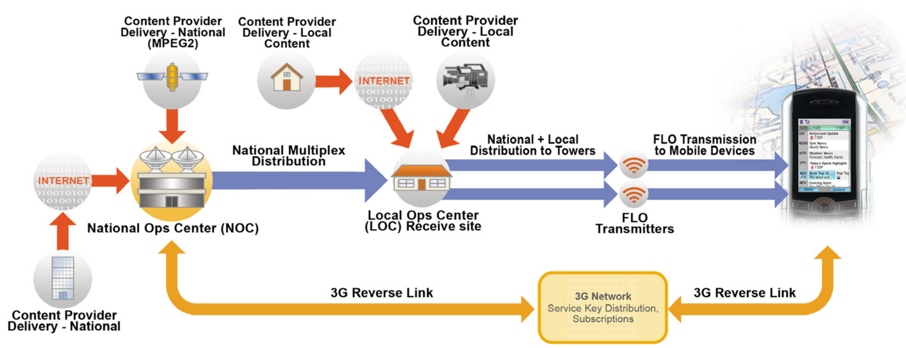

Figure 1 Example of FLO Network

Network Operation Center

The Network Operation Center consists of the central facility(s) of the FLO network, including the National Operations Center (NOC) and one or more Local Operation Centers (LOC). The NOC can include the billing, distribution, and content-management infrastructure for the network. The NOC manages various elements of the network and serves as an access point for national and local content providers to distribute wide area content and program guide information to mobile devices. It also manages user-service subscriptions, the delivery of access and encryption keys, and provides billing information to cellular operators. The Network Operation Center may include one or more LOCs to serve as an access point from which local content providers can distribute local content to mobile devices in the associated market area.

FLO Transmitters

Each transmitter transmits FLO waveforms to deliver content to mobile devices.

3G Network

The 3G network belongs to the wireless operator(s) and supports interactive services to allow mobile devices to communicate with the NOC in order to facilitate service subscriptions and access key distribution.

FLO-Enabled Devices

FLO-enabled devices can receive FLO waveforms containing subscribed content services and program-guide information. FLO-enabled devices are primarily cell phones, which are actually multipurpose devices that serve as telephones, address books, Internet portals, gaming consoles, etc.

Of all the various cell phone functions, the most important remains the ability to make and receive phone calls. Because all applications on a mobile device share common resources—the most important of which is battery power—a service that wastes that power will quickly fail. FLO has been designed specifically to optimize power consumption through intelligent integration on the device and optimized delivery over the network.

FLO System Overview

Content Acquisition and Distribution

In a FLO network, content that is representative of a linear real-time channel is received directly from content providers, typically via a C-band satellite in MPEG-2[1] format (704 or 720 x 480 or 576 pixels), utilizing off-the-shelf infrastructure equipment. This is the most common format utilized by programmers, making it relatively simple for content providers to interface with a FLO System. The use of a standard definition as a source content provides sufficient resolution to allow for efficient transcoding to H.264[2] QVGA resolution supported by the FLO network.

Non-real-time content is received by a content server, typically via an IP link, and then reformatted into FLO packet streams and redistributed over a Single Frequency Network (SFN). This distribution of the FLO packet streams is facilitated by the MediaFLO Media Distribution System (MDS). This non-real-time content is delivered according to a pre-arranged schedule.

The transport mechanism for the distribution of this content to the FLO transmitter may be via satellite, fiber, etc. At one or more locations in the target market, the content is received and the FLO packets are converted to FLO waveforms and radiated out to the devices in the market via FLO Transmitters. If any local content is provided, it will be combined with the wide area content and radiated out to the target market.

Only those devices that have subscribed to the service may receive the content, which in turn can be stored on the mobile device for future viewing, in accordance with a service program guide, or as a linear feed of content, delivered in real-time to the device. This content may consist of high-quality video (QVGA) and audio (MPEG-4 HE-AAC[3]) as well as IP data streams. A 3G cellular network, such as 1XEV-DO, UMTS, or HSDPA, is required to provide control functions to support interactivity and facilitate user authorization to the service. Equally important, the 3G network provides a basis for interactivity, including purchase and download transactions.

1. Motion Picture Experts Group (MPEG). MPEG-2 is a compression standard that allows the coding of studio quality video for digital TV, high-density CD-ROMs and TV-broadcasting.
2. AVC/H.264 – Advanced Video Compression – standardized by ITU and ISO/IEC for enhanced compression performance
3. High Efficiency AAC (HE AAC) audio profile is specified in "ISO/IEC 14496-3:2001 / AMD 1:2003" and is accessible through the ISO/IEC website. The performance of the HE-AAC profile coder is documented in the publicly available formal verification test report WG 11 (MPEG) N 6009.

Power Consumption Optimization

FLO technology simultaneously optimizes power consumption, frequency diversity[4], and time diversity[5]. Other similar, but less efficient, systems optimize one or two of these parameters but ultimately compromise the others. FLO has a unique capability that allows it to access a small fraction of the total signal transmitted without compromising either frequency or time diversity. As a result of these considerations, it is expected that a FLO-enabled mobile device can achieve comparable battery life to a conventional cellular phone; that is, a few hours of viewing and talk time and a few days of stand-by time per battery charge.

The FLO air interface employs Time Division Multiplexing (TDM) to transmit each content stream at specific intervals within the FLO waveform. The mobile device accesses overhead information to determine at which time intervals a desired content stream is transmitted. The mobile device receiver circuitry only powers up during the time periods in which the desired content stream is transmitted; at all other times it is powered down. The receiver ON/OFF duty cycle is expected to be relatively low or immaterial, depending on the media content size and data rate used.

FLO technology minimizes program channel acquisition time. In most cases, it is under two seconds. Mobile users can channel surf with the same ease as they would using digital satellite or cable systems at home.

Wide- and Local-Area Content

FLO supports the coexistence of local and wide-area coverage within a single Radio Frequency (RF) channel.

The content that is of common interest to all the subscribers in a wide-area network is synchronously transmitted by all of the transmitters. Content of regional or local interest can be carried in a specific market. This per market control is a key feature, offering the ability to blackout and retune based on any contractual obligations associated with specific programming.

4. Frequency diversity provides immunity in a fading environment where a signal spans a wide spectrum and usually does not all fade at the same time.
5. Time diversity: transmission in which signals representing the same information are sent over the same channel at different times – it's often used over systems subject to burst error conditions and at intervals longer than an error burst.

Layered Modulation

To provide the best possible quality of service, FLO technology supports the use of layered modulation. This means the FLO data stream is divided into a base layer that all users can decode, and an enhancement layer that is decoded in areas where a higher Signal to Noise Ratio (SNR) is available. The majority of user devices will be able to receive both layers of the signal to deliver 30 fps video quality. The base layer has superior coverage compared to an un-layered mode of similar total capacity, and it can deliver 15 fps video quality. The combined use of layered modulation and source coding allows for graceful degradation of service and the ability to receive in locations or at speeds that could not otherwise have reception. For the end user, this efficiency means that a FLO network can provide better coverage, offering higher quality services like video, which require significantly greater bandwidth than other multimedia services.

As previously described, FLO systems use H.264 for real-time media. The H.264 encoding is extended H.264 compliant for non-layered applications, and the base layer is H.264 extended compliant in applications in which a layered codec is applied.

FLO Air Interface

FLO Air Interface Protocol Reference Model

The FLO air interface protocol reference model is shown in Figure 2. The FLO air interface specification covers protocols and services corresponding to OSI[6] Layers 1 (physical layer) and Layer 2 (Data Link layer) only. The Data Link layer is further subdivided into two sub-layers, namely, Medium Access (MAC) sub-layer, and Stream sub-layer.

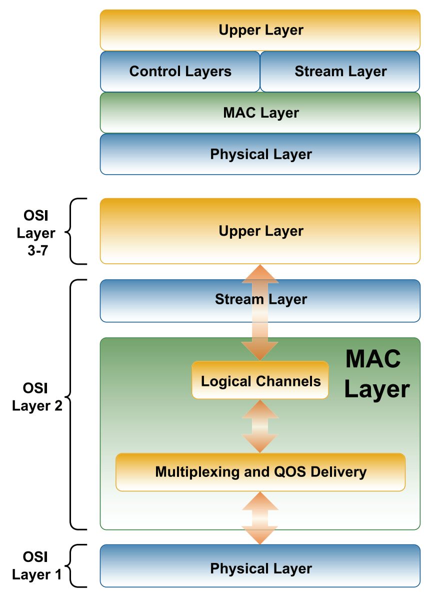

Figure 1 Example of FLO Network

Key Features of Upper Layers

- Compression of multimedia content
- Access control to multimedia
- Content and formatting of control information

The FLO air interface specification does not specify the upper layers to allow for design flexibility in support of various applications and services. These layers are only shown to provide context.

Key Features of Stream Layer

- Multiplexes up to three upper layer flows into one logical channel
- Binding of upper layer packets to streams for each logical channel
- Provides packetization and residual error handling functions

Key Features of Medium Access Control (MAC) Layer

- Controls access to the physical layer
- Performs the mapping between logical channels and physical channels
- Multiplexes logical channels for transmission over the physical channel
- De-multiplexes logical channels at the mobile device
- Enforces Quality of Service (QOS) requirements

Key Features of Physical Layer

- Provides channel structure for the forward link
- Defines frequency, modulation, and encoding requirements

6. International Standard Organization's Open System Interconnect (ISO/OSI) model.

FLO Air Interface Fundamentals

OFDM Modulation

The FLO technology utilizes Orthogonal Frequency Division Multiplexing (OFDM), which is also utilized by Digital Audio Broadcasting (DAB)[7], Terrestrial Digital Video Broadcasting (DVB-T)[8] , and Terrestrial Integrated Services Digital Broadcasting (ISDB-T)[9]. OFDM, as depicted in Figure 3, can achieve high spectral efficiency while effectively meeting mobility requirements in a large cell SFN.

The smallest transmission interval corresponds to one OFDM symbol period, as shown in Figure 3.

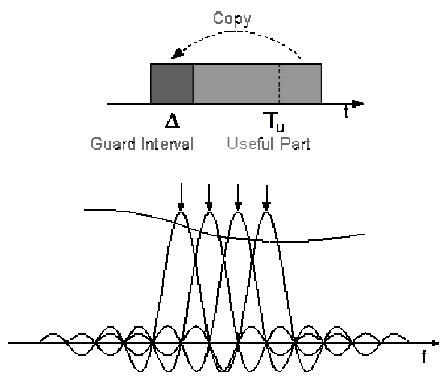

Figure 3: OFDM Symbols

OFDM can handle long delays from multiple transmitters with an appropriate length of cyclic prefix; a guard interval added to the front of the symbol (which is a copy of the last portion of the data symbol) ensures orthogonality and prevents inter-carrier interference. As long as the length of this interval is greater than the maximum channel delay, all reflections of previous symbols are removed and the orthogonality is preserved.

A number of design tradeoffs must be considered when developing an OFDM-based system. These decisions will be governed by the way the system is intended to be used, including the degree of mobility, the data rates required, the services to be supported, the number of users to be supported, and the environment in which the

7. Digital Audio Broadcasting (DAB) system also referred to as Eureka 147 and defined in ETSI EN 300 401: "Digital Audio Broadcasting (DAB); DAB to mobile, portable and fixed receivers."
8. Terrestrial Digital Video Broadcasting (DVB-T) as defined in ETSI EN 300 744: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television."
9. ISDB family includes System C of Recommendation ITU-R BT.1306, System F of Recommendation ITU-R BS.1114 and IDSB-S of Recommendation ITU-R BO.1408.

system will be used. The most fundamental tradeoff is the basic sub-carrier, or tone characteristics, which involves selection of the number of tones, as well as the cyclic prefix duration.

A key factor in the design of OFDM systems is the size of the transform: the number of separately modulated sub-carriers in each symbol. The FLO physical layer uses a 4K mode (yielding a transform size of 4096 sub-carriers), providing superior mobile performance com-pared to an 8K mode, while retaining a sufficiently long guard interval that is useful in fairly large SFN cells. Robust performance can then be maintained to greater than 200 km/hour. Beyond 200 km/hour, degradation is graceful, creating minimal impact to the overall performance. This is supported by the FLO pilot structure (used for channel estimation), which enables receivers to handle delay spreads greater than the cyclic prefix.

OFDM is a modulation technique in that it enables user data to be modulated onto the tones, or sub-carriers. For each OFDM symbol duration, information-carrying symbols are loaded on each tone. The information is modulated onto a tone by adjusting the tone's phase, amplitude or both. In the most basic form, a tone may be present or disabled to indicate a one or zero bit of information. Either quadrature phase shift keying (QPSK)[10] or quadrature amplitude modulation (QAM)[11] is typically employed. The FLO air interface supports the use of QPSK, 16-QAM[12] and layered modulation techniques. Non-uniform 16-QAM constellations (two layers of QPSK signals) with 2 bits applied per layer are utilized in layered modulation.

Physical Layer Characteristics

Rapid channel acquisition is achieved through an optimized pilot and interleaver structure design. The interleaving schemes incorporated in the FLO air interface simultaneously assure time diversity. The pilot structure and interleaver designs optimize channel utilization without annoying the user with long acquisition times.

10. QPSK is a form of modulation in which a carrier is sent in four phases and the change in phase from one symbol to the next encodes two bits per symbol.
11. QAM is the encoding of information into a carrier wave by variation of the amplitude of both the carrier wave and a 'quadrature' carrier that is 90° out of phase with the main carrier in accordance with two input signals.
12. In 16 QAM 4 different phases and 4 different amplitudes are used for a total of 16 different symbols.

FLO transmitted signals are organized into super frames. Each super frame is comprised of four frames of data, including the TDM pilots, the Overhead Information Symbols (OIS) and frames containing wide-area and local-area data. The TDM pilots are provided to allow for rapid acquisition of the OIS. The OIS describes the location of the data for each media service in the super frame. The structure of a super frame is shown in Figure 4.

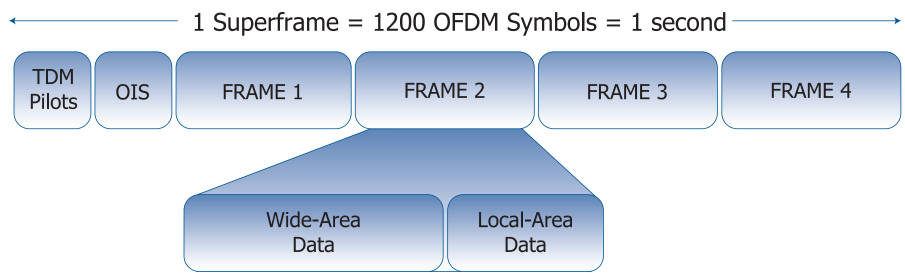

Figure 4: FLO super frame structure

Each super frame consists of 200 OFDM symbols per MHz of allocated bandwidth (1200 symbols for 6 MHz), and each symbol contains 7 interlaces of active sub-carriers. Each interlace is uniformly distributed in frequency, so that it achieves the full frequency diversity within the available bandwidth. These interlaces are assigned to logical channels that vary in terms of duration and number of actual interlaces used. This provides flexibility in the time diversity achieved by any given data source. Lower data rate channels can be assigned fewer interlaces to improve time diversity, while higher data rate channels utilize more interlaces to minimize the radio's on-time and reduce power consumption. The acquisition time for both low and high data rate channels is the same. Both frequency and time diversity can be maintained without compromising acquisition time.

FLO logical channels are used to carry real-time (live streaming) content at variable rates to obtain statistical multiplexing gains possible with variable rate codecs (Compressor and Decompressor all in one). Each logical channel can have different coding rates and modulation to support various reliability and quality of service requirements for different applications. The FLO multiplexing scheme enables device receivers to just demodulate the content of the single logical channel it is interested in to minimize power consumption. Mobile devices can demodulate multiple logical channels concurrently to enable video and associated audio to be sent on different channels.

Error correction and coding techniques

FLO incorporates a turbo inner code[13] and a Reed Solomon (RS)[14] outer code. Each turbo code packet contains a Cyclic Redundancy Check (CRC). The RS code need not be calculated for data that is correctly received, which, under favorable signal conditions, results in additional power savings.

As described earlier in the System Overview section, FLO technology supports the use of layered modulation. A given application may divide a data stream into a base layer that all users can decode, and an enhancement layer that users with higher SNR can also decode. Due to the multicast-only nature of the FLO waveform, the majority of devices will receive both layers of the signal, with the base layer having superior coverage and equivalent total capacity mode.

Outer and inner coding is performed independently for the base and enhancement layer, providing adjustment to the relative thresholds of each layer and adjusts the ratio of bandwidths.

Bandwidth Requirements

The FLO air interface is designed to support frequency bandwidths of 5, 6, 7, and 8 MHz. A highly desirable service offering can be achieved with a single Radio Frequency channel. In some regions, the 5 MHz allocations provided for Time Division Duplex (TDD) applications may also be applied to mobile media distribution.

FLO's air interface supports a broad range of data rates, ranging from .47 to 1.87 bits per second per hertz. In a 6 MHz channel, the FLO physical layer can achieve up to 11.2 Mbps at this bandwidth. The different data rates available enable tradeoffs between coverage and throughput.

13. Turbo codes are a class of recently-developed high-performance error correction codes finding use in deep-space satellite communications and other applications where designers seek to achieve maximal information transfer over a limited-bandwidth communication link in the presence of data-corrupting noise.
14. Reed-Solomon codes are block-based error correcting codes with a wide range of applications in digital communications and storage.

Transport Mechanism

FLO incorporates effective means for transporting packets based on content type. IP is used when IP has a quantifiable advantage such as in the delivery of non-real-time content or data (text and graphics). Real-time streaming media is delivered directly to a sync layer that is designed to minimize the impact of lost packets in streaming media. One FLO design objective is to maximize efficiency by eliminating cascading multiple protocols. This results in more capacity being available for media and minimizes power consumption, since receiving fewer total bits conserves power. The FLO transport protocol stack is illustrated in Figure 5 below.

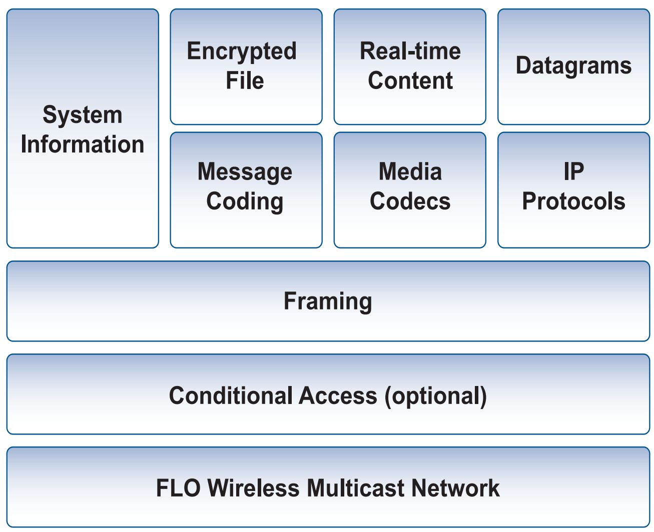

Figure 5: FLO transport protocol stack

Candidate Frequency Bands

FLO can be deployed in a number of frequency bands utilizing various bandwidths and transmit power levels. The relative performance of a given modulation mode is defined by the choice of modulation, turbo, and RS code rates.

The frequency bands suitable for multicast distribution (including FLO technology) are similar to those used for unicast wireless IP and voice. These range from 450 MHz to 3 GHz. The characteristics of these bands for transmission to a device are well understood. A significant difference for video reception is that the device is not placed against the head but held in the hand. This improves the performance in the PCS bands (1900 MHz) by 1-2 dB and in the cellular bands (800 MHz) by 3-4 dB.

For instance, the range of allowable transmission power levels in the United States (U.S.) varies by band, as determined by the Federal Communications Commission (FCC). To maximize coverage area per cell and minimize the cost-per-bit delivered to the user, the design of a network supporting multimedia services benefits from higher power levels than those typically licensed for voice applications. In the U.S. the FCC assigned licenses for 698-746 MHz in 6 MHz blocks for a variety of broadcasting, mobile and fixed services, with a maximum transmit power of 50 kW Effective Radiated Power (ERP).

For each of these bands, the nominal cell diameter supported by a 50kW ERP transmitter 300 meters high is shown in Table 1. The path losses are based on the Okumura-Hata suburban model[15]. It is assumed that an additional external antenna is not desirable or acceptable on the device.

The example of frequency bands from the United States provided in Table 1 shows the bands' relative performance, without consideration of the applied technology. The following assumptions are made:

- Average antenna gain is approximate and includes hand loss.
- Noise Figure is 8 dB.
- Transmit height is 300 meters.
- Receive height is 1 meter.
- Coverage is calculated at 16 dB SNR.
- Propagation model is Okamura Hata suburban.

Frequency (MHz)	ERP (kW)	Average Gain Including Hand Loss	Coverage Area	Area Relative to 716 MHz	Regulation
716	50	-5.4dBi	1937 km2	1	LP UHF TV
788	1	-5.3dBi	153 km2	1/13	Public Service
1672.5	1.2	-4.2d Bi	73 km2	1/26	PCS Like
1992.5	1	-4.1dBi	51 km2	1/37	PCS
2130	1	-4.0dBi	47 km2	1/41	New 3G
2352.5	1.2	-3.9dBi	48 km2	1/40	WCS
2595	1.2	-3.8dBi	43 km2	1/45	LBS/UBS/MBS

Table 1: Potential Frequency Bands for Multimedia Distribution

15. Okumura model was first specified in "Field Strength and Its Variability in VHF and UHF Land-Mobile Radio Service," by Yoshihisa Okumura, et.al., Review of the Electrical Communications Laboratory, Vol. 16, No. 9-10, September-October 1968. Okumura/Hata model is further described in "A Report on Technology Independent Methodology for the Modeling, Simulation and Empirical Verification of Wireless Communications System Performance in Noise and Interference Limited Systems Operating on Frequencies between 30 and 1500MHz", TIA TR8 Working Group, IEEE Vehicular Technology Society Propagation Committee, May 1997.

FLO is being deployed in a 6 MHz block of the lower 700 MHz in the US. This spectrum, as regulated by the FCC, offers significant advantages in terms of coverage per transmitter, which translates to significant infrastructure cost savings. Lowering the average height of the transmit sites to 100 meters decreases the coverage by approximately a factor of 3. The higher frequency bands may require a greater SNR than 16 dB assumed in Table 1 due to the increased Doppler [16].

Comparison with Other Mobile Multicast Media Technologies

A number of technologies address, at least partially, the requirements of mobile multimedia. These technologies are mostly variants or derivatives of an existing digital television broadcast format. This section compares these formats to the dedicated mobile multimedia multicast solution provided by FLO technology. The formats are listed in Table 2.

Format	Description
ISDB-T	Origin: DTV packet data technology (Japan) Modulation/Coding: OFDM, convolutional, Reed-Solomon
T-DMB	Origin: Derivative from European DAB, modified for multimedia (Korea) Modulation/Coding: OFDM, convolutional, Reed-Solomon
S-DMB	Origin: Proprietary format, primarily from Toshiba (Japan) Modulation/Coding: CDM, convolutional, Reed-Solomon
DVB-H	Origin: Derivative from DVB-T (Europe) Modulation/Coding: OFDM, convolutional, Reed-Solomon
FLO	Origin: QUALCOMM packet data technology (USA) Modulation/Coding: OFDM, turbo, Reed-Solomon

Table 2: Mobile Multimedia Format

All formats utilize OFDM except S-DMB, which is Code Division Modulation (CDM). They also utilize Convolutional coding and Viterbi decoding [17], with the exception of FLO, which has a more modern and efficient turbo code. All formats utilize a concatenated Reed Solomon code(s).

16. The Doppler effect is the apparent change in frequency or wavelength of a wave that is perceived by an observer moving relative to the source of the waves.
17. Convolutional codes are widely used to encode digital data before transmission through noisy or error-prone channels. During encoding, k input bits are mapped to n output bits to give a rate k/n coded bitstream. At the receiver, the bitstream can be decoded to recover the original data, correcting errors in the process. The most popular algorithm for maximum-likelihood decoding is the Viterbi Algorithm.

Various factors impact the performance of a mobile multimedia format. The most significant of these are listed in Table 3 (information on non-FLO formats are based on public sources, including those listed in the References section). FLO has effectively addressed all of these key factors, outperforming all competitive formats in the mobile handheld environment, and providing key power saving features. FLO delivers 3-5 db better performance than any other comparable technology. This is because FLO technology was designed first and foremost for the delivery of mobile multimedia rather than being a subset or modification of an existing broadcast format.

Format	Frequency Diversity	Time Diversity	Stat Mux Gains[a]	Time Domain Power Reduction[b]	Frequency or Code Domain Power Reduction[b]	Performance Relative to FLO at 1 bps/Hz
ISDB-T	Poor 430kHz	0.5 sec.	None	No	Yes	-3 to -4 dB
T-DMB	Fair 1.5MHz	<<0.25 sec.	Poor	No	No	-3 to -5 dB
S-DMB	Excellent 25MHz	3.5 sec.	Good	No	Yes	N/A[c]
DVB-H	Good 5-8MHz	~0.25 sec	None	Yes	No	-3 to -4 dB
FLO	Good 5-8MHz	~0.75 sec.	Good	Yes	Yes	0 dB

Table 3: Technical Parameters and Performance

a. This refers to the gains realized by encoding real-time media under bit control of a statistical multiplexer that allocates bandwidth according to content need utilizing variable bit rate video and or audio codecs.

b. Selective access to desired content (if the format is designed such that a device can access the desired data of interest and turns its receiver off) is critical to power efficiency and a key feature to a successful design. Selective access may be achieved in both time and frequency domains.

c. S-DMB cannot achieve one bit per second per Hz.

The technical performance of a format is only one aspect of the user experience.

Additional User Experience Features

Table 4 lists a number of significant features of the individual formats and the implications for the user.

Format	Average Channel Switching Time	Video Watch Time With 850 mAhr Battery	Per Channel QOSa	File Download	Local- and Wide-Area in Single RF Channel
ISDB-T	~1.5 sec.	unknown	Yes	No	No
T-DMB	~1.5 sec.	~2 hours	Possibly[b]	Possibly	No
S-DMB	~5.0 sec.	~1.2 hours	No	No	No
DVB-H	~5.0 sec.	Goal ~4 hours Demo ~2 hours with 1600 mAhr battery	No	Possibly	No
FLO	1.5 sec.	Goal ~3.8 hours (at 360kbps)	Yes	Yes + integrated Clip Casting solution with memory management, conditional access and subscription model	Yes

Table 4: Service Experience and Features

a. Quality of Service in a multicast context is the ability to adjust the Packet Error Rate (PER) on a per-application / service basis. This optimizes capacity for a service mix that includes multiple application types e.g. media, games, software downloads

b. Unequal error protection may be applied at the stream level

The correct balance of technical performance parameters is reflected in the user experience. The ability to change channels quickly is always important to the user. Watch time should be comparable to talk time, if not longer, so as to not compromise the functionality of the device. The capacity of the system is optimized when per application QOS is available in a network. A mix of both real-time and non-real-time media provides the best overall user experience. The delivery of non-real-time content allows immediate access to content such as weather or news summaries by topic while real-time streaming services support live events such as sports. The ability to support both wide-area and local content within a single RF carrier allows an operator to maximize the value of the available spectrum through the flexible allocation of channels.

Additionally, the use of layered modulation, as described the System Overview section, is a unique feature of FLO technology. It provides better coverage (up to 3 db incremental gain) and services of high quality, especially video, which requires significantly more bandwidth than other multimedia services.

Implications to Service Providers

The selection of a multicast technology can have a strong influence on the costs of providing services. A number of factors help determine the cost:

- Number of infrastructure sites that are required.
- Total spectrum required to support a defined channel line up.
- Total number of transmitter assemblies required to achieve a service line up.

Table 5 shows the relative costs of utilizing the various technologies listed in Table 2. This comparison assumes that each system has the same link margin, which forces the capacity constraints. The table attempts to target 20 real-time services at 300kb/sec per service; however, due to structural limitation, some formats cannot achieve the desired link margin at the specified bit rate. In those cases, the product of average bit rate and number of services is held constant.

Format	Channels Per Transmitter	Infrastructure Costs for 20 Channels	Channels per MHz	Required Spectrum for 20 Channels
ISDB-T	13 channels, 6 MHz ~ 230kbps each	~2X	~2	12 MHz (26 lower quality channels)
T-DMB	3 channels, 1.5 MHz ~ 250kbps each	~4-6X	~2	10.5 MHz
S-DMB	~20 channels, 25 MHz	Broadcast satellite plus terrestrial repeaters	<1	25MHz
DVB-H	9 channels, 6 MHz ~ 300kpbs each	~2X	1.5	12MHz
FLO	20 channels, 6 MHz ~ 300kbps each	Reference (1X)	>3	6MHz

Table 5: Required Infrastructure for Comparable Service

This analysis shows that, due to the superior efficiency of the FLO air interface in the areas of Packet Error Rate (PER) performance, protocol efficiency, and the application of layered service and modulation, FLO technology can deliver equivalent or superior service with roughly half the spectrum and less than half the infrastructure. The implications for the user and operator are significant relative to the cost and breadth of services that can be delivered.

Conclusion

With FLO technology, the broad delivery of wireless multimedia services is now more economical, more efficient, and more accessible than ever before. FLO technology was designed from inception to meet global market demands for wireless multimedia services. The result: wireless subscribers can now have greater access to better multimedia services.

QUALCOMM's development and implementation of FLO technology via a single frequency FLO Network provide the critical link between technical feasibility and economic viability, offering wireless operators an excellent delivery mechanism for providing multimedia content to their subscribers. FLO technology is designed to work in combination with the existing cellular data network to drive additional demand through new innovative services—resulting in higher revenues.

MediaFLO™

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