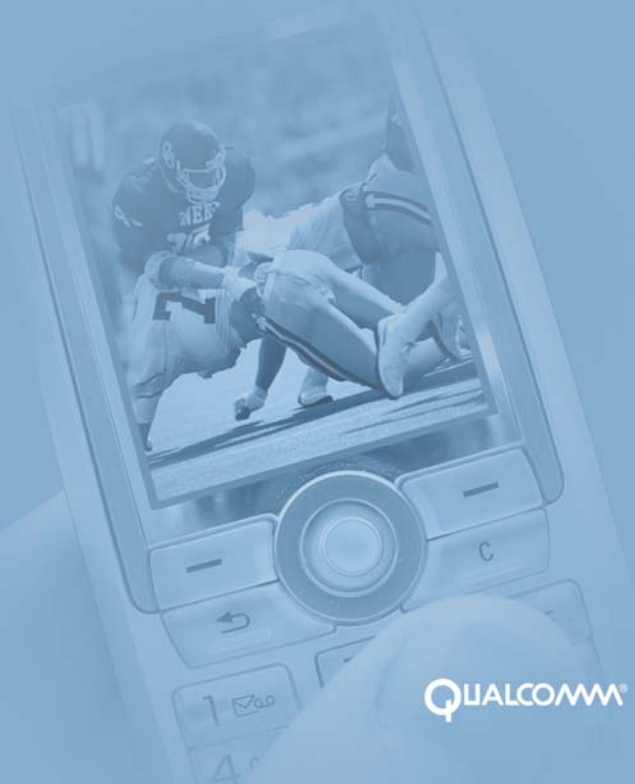
MediaFLO™

Revolutionizing Multimedia

FLO™ Technology Brief



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Introduction

Imagine a world where consumers are able to have live television or radio, news or soap opera summaries, highlights from their favorite sports teams, live feeds of their local weather and traffic, or real time stock ticker of their portfolio – delivered to their wireless mobile devices at all times. Wherever they go and whenever they want it.

No more missing their favorite show while waiting in the airport, or on the train. No more missing their favorite baseball game, or their favorite radio talk show. The ability to stay tuned in to everything you care about - when you care about it. No more waiting for data connections to retrieve information. *Instant On* - access it immediately, right there, right now.

Where Have We Been?

The world of multimedia delivery continues to change. Broadband delivery of multimedia content has been offered to consumers for decades – initially based on analog technologies, but more recently has begun migrating over to digitized formats in order to offer a broader set of content to subscribers (video, music, web pages, games, etc). Today, the most common distribution path is via the traditional cable, broadcast, and satellite distribution models which service the majority of current consumer demand for multimedia content.

Over the past decade, while media was transformed into digital formats, computing devices matured, and bandwidth into the home continued to increase, multimedia access through the portal of the computer skyrocketed. The wired Internet has moved to more data-intensive forms of multimedia such as streaming video, interactive graphics like Macromedia Flash, and scores of mechanisms for the delivery of digital audio.

The mobile Internet is evolving in the same way. What was once a 9.6 kbps circuit switched data network has evolved to networks like those based on CDMA2000 1xEV-DO with data rates to a cellular device comparable to landline broadband connections. There has been an explosive growth in device capability, especially for mobile cellular phones. The amount of computing power, memory, and high-end graphics functionality has accelerated the development of new and exciting wireless services. However, some services, like consumer multimedia, remain challenging for operators to deliver to these new devices due to the disparity between the cost of delivery and the expected revenue. Services which are technically possible may not necessarily be profitable.

Introducing FLO Technology

QUALCOMM embarked on an analysis of this proposition by applying system design principles starting from a clean sheet of paper. The design constraints revolved around the construction of a system that would deliver volumes of high quality video (and other multimedia) content to millions of mobile subscribers in a very efficient and profitable fashion.

QUALCOMM's solution for effectively delivering multimedia content to mobile devices is forward link only (FLO) technology. The FLO technology is an orthogonal frequency division multiplexing (OFDM)-based air interface designed specifically for multicasting a significant volume of rich multimedia content cost effectively to wireless subscribers. It takes advantage of multicasting technology in a single-frequency network to significantly reduce the cost of delivering identical content to numerous users simultaneously. Unencumbered by legacy terrestrial or satellite delivery formats, FLO offers superior mobility, minimum power consumption, and maximum spectral efficiency.

Mobility Matters

Wireless consumers expect continuous connection over the cellular network for a voice call, even while they are mobile. Whether walking down the street, riding a bus, or commuting to work on a train, the consumer expects the same from his multimedia service. A wide range of device speeds relative to the network may be encountered. Public ground transportation in some countries can sustain speeds to 200 km/hr. At the other end of the spectrum is the leisurely stroll or the morning ferry ride. It is reasonable to expect all speeds in between these two extremes, and for the user to expect a level of ubiquity with his mobile service. To optimize the user experience in a mobile environment, the FLO technology uses the latest advances in coding and interleaving. By using layered or hierarchical modulation and source coding, a more graceful degradation of service is realized, and better in-building penetration is achieved.

Power Efficiency

FLO devices are primarily cell phones: multipurpose devices that serve as telephones, address books, Internet portals, gaming consoles, etc. Out of all of these functions, the most important remains the ability to make and receive phone calls. Because all applications on a cell phone share common resources – most important of which is battery power – a service that exhausts that power will not be broadly adopted. Power can be exhausted by inefficient use of local resources (like the screen) or just as easily by inefficient use of network connectivity; therefore, FLO strives to optimize power consumption through intelligent integration on the device and optimized delivery over the network. The FLO technology simultaneously optimizes power consumption, frequency diversity, and time diversity. 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 device can achieve comparable battery life to a conventional cellular phone; i.e., a few hours of viewing time and a few days of stand-by time per battery charge.

No One Likes to Wait

An annoying element of any consumer service is prolonged delays in acquiring a service or selecting a channel. For years digital television has worked at keeping channel surfers happy. Channel change delays of 3, 4 or 5 seconds are unacceptable. Delays of these magnitudes make for a very frustrating user experience, an issue that the FLO technology recognizes and addresses head

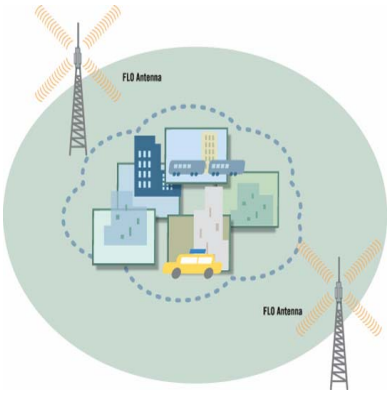
on. Designing a multicast system for handheld receivers involves tradeoffs between spectral efficiency, coverage, power consumption, and user experience. As earlier stated, FLO is built from the ground up with these issues in mind. By optimally balancing these tradeoffs to create the most robust experience, FLO can speed up program channel acquisition, which is paramount to creating an acceptable “channel surfing” experience so users can quickly peruse available content. The FLO design provides an experience targeted at less than 2 second acquisition time, rivaling the digital television experience.

The constraint of using an existing physical layer designed for digital television (DTV) reception prevents other multicast technologies, such as digital video broadcast-handheld (DVB-H), from achieving the optimal tradeoff. For example, in order for DVB-H to achieve acceptable time diversity and power consumption it must compromise channel selection time. By sending data once every 4 seconds, the user must regularly wait several seconds to acquire a new channel.

Network Economics

When considering the delivery of high quality content to a large number of users, the network economics need to be clearly understood and analyzed. In the cellular domain the benchmark data point is: what is the cost per byte? In order to determine the cost per byte, the required capacity has to be understood. An appropriate service model for video delivery to a mobile device is quarter video graphics array (QVGA) at 30 frames-per-second (fps) plus stereo audio. QVGA resolution is reasonable from the handset cost perspective, and the resolution is consistent with the human visual system relative to the dimensions of a handset display held in the user’s hand.

Compression technologies such as H.264 (312 kbps) and AAC+ (48 kbps) can support a high quality program channel at 360 kbps average. As a point of comparison, a single voice circuit user consumes a peak rate of 13 kbps, while the average bit rate may be 4 kbps. Nominally, a single video user is consuming approximately 100 times the data as a voice call, but may generate only approximately one quarter as much revenue. Clearly, the cost per byte delivered needs to be an order of magnitude less than a voice cellular network.

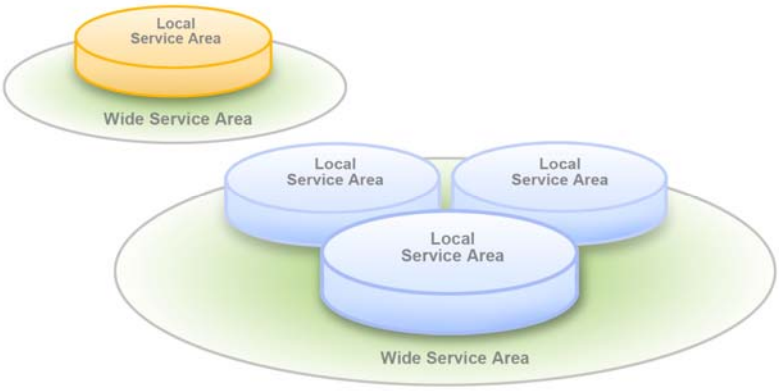


The FLO Technology is designed for markets where dedicated spectrum is available and where regulations permit high-power transmission from a single tower or a small number of towers. Given spectrum availability, FLO can be deployed across wide area regions using a network of transmitters, typically spaced about 60 km apart. Because an entire major metropolitan area can be covered with 2-3 towers providing excellent coverage including in building penetration, the capital and operating expense of deploying and managing a FLO network are tremendously reduced compared to traditional WWAN packet data networks or alternative multicast technologies. Comparing network deployments such as traditional cellular with that of FLO result in a 30x or greater increase in the number of sites needed to cover the same region.

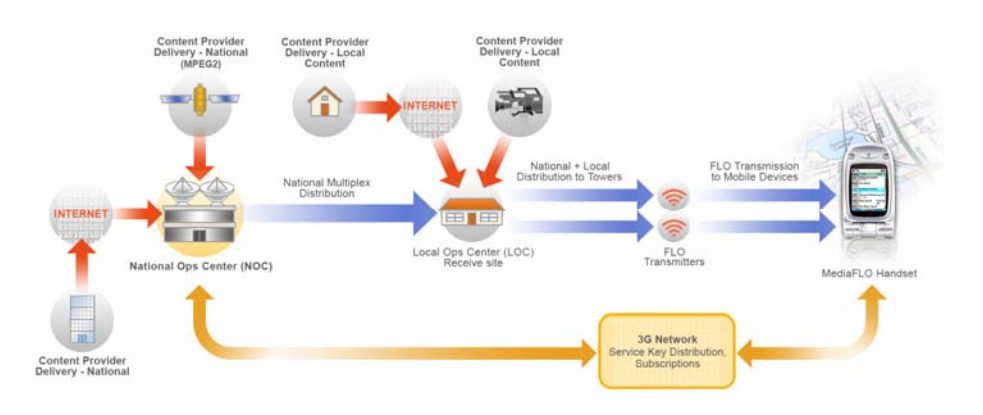
Service Areas

The FLO technology supports the coexistence of local and wide area coverage within a single RF channel. By utilizing a single frequency network, the need for complex handoffs for coverage areas is non-existent. The content that is of common interest to the subscribers in a wide area network is carried by the local area signals and synchronously transmitted by all of the transmitters within the local-area network of that particular market. This segmentation between wide

area and local area supports more targeted programming, local advertising business models and the ability to blackout and retune as required.



The figure below shows one example of how the FLO technology may be deployed. In this example, content that is representative of a linear real-time channel is received directly from content providers utilizing existing infrastructure. Non real time content (clips, etc) may be received over the Internet. The content is then reformatted into FLO packet streams and redistributed over a single frequency. This distribution point for the FLO packet streams is facilitated with the help of the MediaFLO Media Distribution System (MDS).



The transport mechanism for the distribution of this content may be over satellite, fiber, etc. At one or more locations in the target market, the content is received and the FLO packets are converted to the FLO waveform and radiated out to the devices in the market. If any local content is provided, it is combined with the wide area content and radiated out as well. Devices in the market that are authorized and subscribed for the service may receive the content. A 3G cellular network is part of the deployment as well. This can be utilized to deliver content, provide interactivity and facilitate user authorization to the service.

Suitable bands for operation

The frequency bands suitable for multicast distribution are not too dissimilar from those utilized for unicast wireless IP and voice. These range from 450 MHz to 2 GHz. The range of power levels vary by band. In order to maximize coverage area per cell and minimize the cost per byte, higher power levels than are licensed for voice applications are desired. Current technology and licensing practice allows power levels up to 50 kW ERP in the upper UHF bands.

Frequencies above 1 GHz are relatively inefficient, and the power levels needed are generally not allowed above the upper UHF frequencies, thus requiring more transmit sites. As the required number of transmit sites increases, the cost per byte rises, and economic efficiency declines.

An End-to-End Solution

The FLO technology meets all of the necessary requirements for multicasting vast amounts of multimedia to the most number of people. Its multiplexing scheme enables lower power operation while maintaining rapid service acquisition time, assuring quality of service, and providing mobility at all user speeds. FLO's powerful coding schemes provide good coverage with a fewer number of transmitters, supporting a lower cost per user byte than any alternative multicast technology available. Additionally, its local area and wide area support within one RF channel provide operators with a flexible platform for constructing the appropriate content offering in their target markets.

The combination of the FLO technology and the MediaFLO Media Distribution System creates an end to end System for operators to provide real-time multicasts of video and audio streams, Clipcast™ media, Clipcast data, and IP datacasting to their subscribers at a significantly lower cost. This System provides operators with the foundation to bring revolutionary new services to market, allowing them to differentiate and pave the way for making high quality media and information readily available to the mobile masses.

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