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Revolutionizing Video Delivery with Wireless Home Networking

**Motorola™ Mobility's VAP2400 Video Access Bridge Allows
Telcos and Cable Operators to Deliver Reliable, High-Quality
HD and SD Video over Wireless Throughout the Home**

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Join the Wireless Video Revolution

Broadband video services have traditionally been distributed throughout the home via cable connections. While residential subscribers have long since become accustomed to leveraging wireless technology to access voice and data services throughout the home, the quality of experience consumers expect from residential video services has thus far prevented telcos and cable operators from offering wireless in-home video distribution to residential subscribers.

No network operator wants to deliver services that fail to meet the expectations of subscribers – thereby increasing the number of support calls and truck rolls while lowering customer satisfaction levels – so previous efforts to transmit video signals throughout consumer homes have failed to capture consumer interest or drive market share. For years, the industry has attempted to develop the technology to deliver wireless video bridges, but no vendors have delivered technology with the quality and reliability required to provide the viewing experience that residential subscribers demand.

Motorola Mobility has analyzed this technology for years, testing multiple generations of set-top and home networking technologies to develop a new solution that provides concurrent transmission of high-quality, high definition (HD) 1080p resolution and standard definition (SD) video throughout the home to multiple televisions over a single wireless home network. Years of analysis and development have paid off in an innovative new solution. The VAP2400 Video Access Bridge transmits video content over the wireless 5 GHz spectrum in a home with a level of quality and reliability never before possible in commercial applications. This revolutionary design from Motorola makes it possible to create home networks that enable a full range of services and applications – including multi-room digital video recording (DVR) – without having to run cabling through the home. Highlights of the VAP2400 include:

- Support for multiple concurrent full HD 1080p and SD streams
- 4x4 multiple-input, multiple-output (MIMO) architecture
- Dynamic digital beamforming
- Advanced quality of service (QoS) capabilities to support applications that require low latency and zeropacket loss
- Full remote TR-069 management with self-install capabilities
- No subscriber home wiring required
- A secure, reliable, and easy-to-install solution for delivering high-quality video throughout the home

This whitepaper discusses the market opportunity for wireless delivery of residential video services throughout the home. It explains the revolutionary technology advantages in the Motorola VAP2400 solution that allow telcos and cable operators to swiftly capitalize on high consumer interest and the resulting revenue opportunity by securely delivering video over home 802.11n Wi-Fi® networks.

The Natural Shift to Wireless Video Delivery

Most of us remember when all of our home telephones were hard-wired to phone outlets on the wall. We generally had only one or two phones per household, and rarely added another phone because of the cost and hassle of running a new phone line into another room. Now, many of us have cordless phones that completely remove these legacy restrictions from our telephone “experience” and allow us to talk to our friends from any room in the house.

Similarly, many of us added broadband data service years ago and connected a single PC to a cable or DSL modem via Ethernet. Once we realized the advantages of broadband data compared to dial-up connections, some residential subscribers added Ethernet cabling to their homes, building residential local area networks (LANs) so they could gain broadband data access from different rooms throughout the house. A few years later – as wireless LAN standards rapidly evolved and commercial products swiftly became more viable – many of those residential LANs now lie dormant as home users have shifted to wireless LANs for utilizing residential best-effort data services throughout the home.

Meanwhile, video services continue to be primarily delivered throughout the home via cable, primarily because it provides the consistent reliability that consumers demand. Wireless in-home distribution of video has not been successful in the past because wireless home networks have been plagued by unreliable and spotty coverage, low data rates, intermittent outages resulting from interference and overall poor performance. Video is bandwidth intensive

and previous wireless solutions were not robust enough to deliver satisfactory viewing experiences.

Running cable throughout the home can be expensive and disruptive to the consumer. For carriers, IPTV installation times continue to run longer so installation costs continue to increase. HomePNA[®] standards provide specifications for distributing video over coax cables and phone wires, but result in issues with noise and electromagnetic interference – and in some cases new wiring is required. Category 5 cable traditionally used for Ethernet is another alternative for distributing video throughout the home, but it is comparable in cost and complexity to deploying coax.

Another alternative can be deploying Homeplug[®] powerline adapters and reusing the existing power outlets in the home, but in most cases the single and concurrent HD viewing experience is limited and this alternative is not friendly to surge protectors. It also runs the risk of interference from adjacent homes, and for network operators this alternative becomes support-intensive, particularly for deployments with multidwelling subscriber apartments.

Residential subscribers who want video in other rooms of their homes often avoid adding additional set-tops because of the cost and inconvenience of running coax or Category 5 cabling. Homeowners often want to avoid the disruption of drilling holes through walls to run cabling to additional rooms – or even additional floors – and renters want to avoid investing in building a wired network for their landlord's financial benefit. People want to watch TV throughout their homes, but they don't want the expense and inconvenience of running cables everywhere.

The VAP2400 solves this problem. Subscribers get crystal-clear HD video and digital sound with wholehouse coverage. And there are no wires to connect, no holes to drill.

Residential subscribers want the freedom to access video throughout the home – just as they want the freedom to access their data and voice services throughout their households. And cable operators and carriers want to build closer and longer-lasting bonds with subscribers by offering innovative products that distinguish their offerings in the marketplace. The ability to swiftly deliver high-quality, self-installed wireless video throughout the home can allow a service provider to not only gain a competitive advantage, but to also lower OPEX, increase revenues, and capture new market share by fulfilling a pent-up customer demand for access to video content throughout the home.

Capitalizing on the Business Opportunity to Deliver Wireless Video

Service providers want to extend IP connectivity and coverage throughout consumer homes so they can improve service delivery to subscribers while lowering costs. One way to do this is to help subscribers wirelessly transmit video signals throughout their homes. A wireless solution can:

- Enhance seamless service delivery to subscribers
- Enable installations in additional rooms without the need to run cabling
- Reduce installation time and allow for customer self-install
- Enable secure wireless communication for video content distribution throughout the home

A wireless video solution can significantly reduce installation time and enable service in additional rooms without running a wired connection. Through a technology collaboration with Quantenna Communications (now a division of ON Semiconductor), Motorola has included the latest video chipset into the VAP2400 and developed a solution that delivers a significant improvement over previous generations of this technology. Service providers can gain an edge over their competitors in the marketplace by allowing residential subscribers to easily add video content to additional rooms and additional floors throughout the home without the need to run cabling. By deploying the Motorola VAP2400 Video Access Bridge, telcos and cable operators can:

- Enable user self-installable deployment
- Allow for portable deployment throughout the home
- Improve customer support by enabling remote management of devices connected over the Wi-Fi network
- Provide multiple video feeds anywhere throughout the home – with the quality that users expect and demand

Increasing Revenues, Reducing Costs

Providing a wireless solution for transmitting video throughout the home not only creates opportunities to attract new customers and increase market share, it also significantly reduces the time to install or remotely activate new services, creating opportunities to increase revenues and reduce costs. This wireless video solution can also be bundled with higher tiers of service that include set-tops and gateways, creating opportunities for telcos and cable operators to provide premium services in a single bundle – simplifying the delivery of triple-play home networking solutions.

Because a wireless video solution can significantly reduce installation time and costs, network operators can realize a major cost advantage for deploying new services or deploying additional set-tops to existing subscribers. A VAP2400 wireless bridge enables TV coverage in additional rooms without the need to run additional cabling, and it can even be made available for customer self-install – further reducing installation costs.

Deploying the Motorola VAP2400 Video Access Bridge

VAP2400 Highlights

- Plug and play – no software configuration required
- 802.11n Wi-Fi standards based wireless connectivity
- Design based on Quantenna QHS710 silicon with 4x4 MIMO
- Four antennas enable X-Y-Z polarization diversity
- Better range from dynamic beamforming
- Operates in 5 GHz band to reliably support HD video
- Available with a single Ethernet port or with four Ethernet ports to support multiple devices in a room
- Supports TR-069 and remote firmware upgrades
- WPA2, WPA and WEP encryption supported for secure wireless connectivity throughout the home

The Motorola VAP2400 can transmit high-quality video content – HD and even 3D – over the wireless spectrum in a home with a level of quality and reliability never before possible in consumer devices. This revolutionary design makes it possible to create home networks that enable a full range of services and applications without having to run wires through the home. And because it is wireless, the VAP2400 is easy to set-up and ready to be self-installed by the customer, so there's no truck roll required.

The VAP2400 can be used as a controller connected to a gateway or set-top via Ethernet, and as a client providing wireless connectivity to a set-top in a room without Ethernet or Category 5 cabling. In addition, the Motorola VAP2400 incorporates an advanced smart-mode selection capability that allows the device to automatically configure itself in the customer network, further reducing the need for service provider support. It will analyze and detect the components of the residential network and select to work either in the controller mode or as a client.

A residential subscriber seeking to “bridge” television to an additional room can just connect a VAP2400 to an existing set-top via an Ethernet cable, plug in the power supply and have it serve as a controller. Installation of a VAP2400 typically takes less than three minutes. The subscriber could then go to the other room and install another VAP2400 as a client to the controller on a secure encrypted wireless link, connect it to an additional set-top and connect that set-top to a television. Up to three rooms can be added as HD clients over the wireless network in a typical household.

Since the VAP2400 is available with either a single Ethernet port or in a four-port Ethernet configuration, the subscriber can network-enable additional Ethernet devices in additional rooms – such as gaming consoles, video consoles, over the top video appliances, video cameras and Internet radios – by selecting the VAP2400 four-port configuration and plugging these devices into the RJ-45 Ethernet ports to connect them over the wireless network. Introducing the VAP2400 will drive down service provider operations costs while allowing network operators to improve customer satisfaction levels by offering consumers greater flexibility in where they enjoy their video programming throughout their homes.



Figure 1. The VAP2400 is Available in a Four-Port or a Single Ethernet Port Configuration

With the Motorola VAP2400, subscribers can swiftly and easily add video services to new locations throughout the home without worrying about cabling. Adding video to a master bedroom, a child's room or a study is no longer an ordeal – wireless video distribution removes a traditional obstacle to increased average revenue per subscriber (ARPU) levels by making it dramatically easier for subscribers to provision set-tops for additional rooms throughout the house. The primary applications of the VAP2400 are for:

- Delivery of IPTV, telco, fiber to the home (FTTH) and cable residential video services
- Supporting Wi-Fi-enabled IP as well as hybrid DVB-S and DVB-T set-top boxes
- Enabling multi-room DVR capabilities so that users can access recorded content throughout the home
- Delivering wireless access to over-the-top video content
- Enabling multi-room gaming over the home LAN
- Sharing home video content via a media server appliance

Motorola's innovative design and groundbreaking antenna technology allow the VAP2400 to deliver advanced QoS and support video applications that require low latency and zero packet loss.

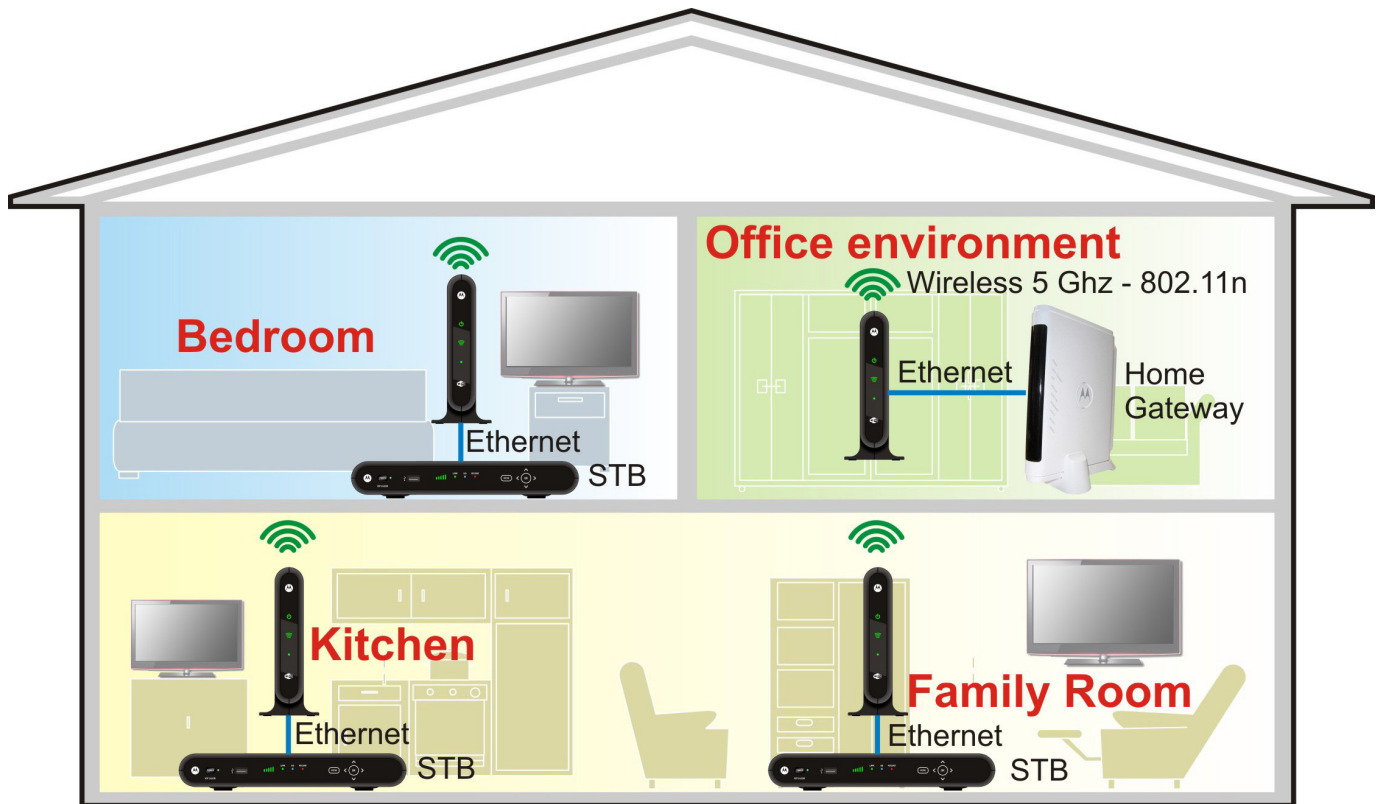


Figure 2. In This Example, a Telco Deploys a Home Gateway and a VAP2400 That Serves as a Controller to Provide Wireless HD Video to VAP2400 Clients in Three Rooms Throughout the House – without the Need to Run Any Cables

Technology Overview of the VAP2400

When deploying home networks, a recurring question is what kind of wireless technology is good enough for supporting multiple streams of HD video while also delivering the lowest cost of deployment. Although there are several wired options for delivering compressed video in home networks, they don't offer the same ubiquitous coverage and cost-effectiveness that this Motorola wireless video solution provides. The VAP2400 is built for video distribution in the home, and is capable of easily and economically reaching every corner of the home. It potentially replaces wired technologies to significantly extend home-networking coverage for a variety of consumer products, including TVs, residential gateways, set-top boxes and game consoles.

The Need to Design Reliable Wi-Fi for HD Delivery Throughout the Home

Wireless home networks frequently suffer from dead zones, unreliable bandwidth, poor coverage and signal interference, which impacts the high level of performance needed for video distribution. The reason for unpredictable and unreliable performance of existing 802.11 systems is the nature of wireless signal propagation and the fact that interference is pervasive in the unlicensed spectral bands where 802.11 operates. Specifically, the data rate and reliability of a Wi-Fi radio receiver improves as its received signal power increases and decreases as a result of interference. Wi-Fi signals propagating through a home or an apartment experience a number of effects with respect to received signal power and interference, such as:

- The received signal power falls off inversely with the distance between the transmitter and receiver. Locations in the home far from a wireless access point receive less signal power, and therefore cannot support the high data rates possible at close range.
- Signal reflections – also called multipath – from walls and other objects partially cancel the direct-path (line-of-sight) signal when their phases are not aligned. Multipath leads to fading and dead spots in various locations throughout the home.
- Interference from other wireless devices in the same or nearby frequency bands can saturate a receiver or cause excessive noise, thereby significantly degrading performance.
- Signals propagating through walls can experience significant power attenuation, depending on the wall material.
- Some apartment buildings have thin walls, which result in minimal signal loss. However, interference from neighboring apartments is not attenuated either, and that interference may preclude good performance or jam the receiver, leading to intermittent outages and many dropped packets.

These signal propagation characteristics give rise to the home networking dilemma: cutting the cord is highly desirable and Wi-Fi is pervasive and cost-effective, however, data rates and reliability in existing Wi-Fi products have not yet been good enough to provide a compelling solution for reliable wireless connectivity throughout the entire home.

Motorola's Innovative Solution – 4x4 MIMO and Digital Dynamic Beamforming

Given the difficulties of Wi-Fi signal propagation and interference, Motorola has integrated powerful complementary technologies to support intelligent high-speed performance and consistent, reliable delivery over Wi-Fi networks. Through a technology collaboration with Quantenna Communications, Motorola developed the VAP2400 solution that combines 4x4 multiple-input, multiple-output (MIMO) and dynamic digital beamforming to provide very fast data rates to every room in the home.

4x4 MIMO

Systems with multiple antennas at the transmitter and receiver – also referred to as MIMO systems – offer significant increases in data rates, range and reliability without additional bandwidth or transmission power. These benefits are obtained by exploiting the spatial dimension associated with the multiple antennas. Specifically, utilizing several antennas at both the transmitter and receiver can create multiple independent channels for sending multiple data streams. The number of independent channels or, similarly, the number of data streams that can be supported over a MIMO channel, is equivalent to the minimum number of antennas at the transmitter or receiver. Thus, a 2x2 system can support at most two streams, a 3x3 system can support three streams and a 4x4 system can support up to four streams, as illustrated in Figure 3. Some of the independent streams can be combined through dynamic digital beamforming and MIMO receiver processing, as shown in the red oval in Figure 3, which results in increased reliability and range.

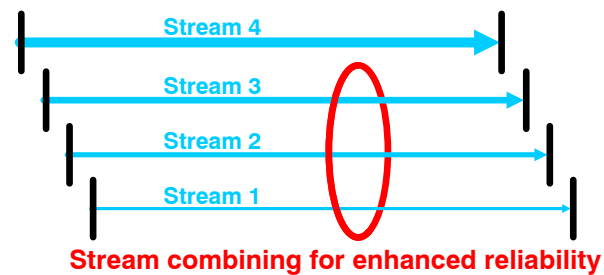


Figure 3. A 4x4 MIMO System Supports Up to Four Independent Data Streams. These Streams Can Be Combined Through Dynamic Digital Beamforming and MIMO Receiver Processing (in the Red Oval) to Increase Reliability and Range

The reliability increase is shown in Table 1, which illustrates the probability of supporting one or two data streams at the maximum data rate in 2x2, 3x3 and 4x4 systems. By using several antennas at both the transmitter and receiver, MIMO systems create multiple independent channels for sending multiple data streams, and a 4x4 MIMO system can support up to four independent data streams. As Table 1 indicates, a 4x4 MIMO system with dynamic digital beamforming and MIMO receiver processing supports two maximum-rate data streams 99 percent of the time. Other configurations are less reliable, since they have fewer antennas and thus fewer extra spatial dimensions that can be combined.

Table 1. Reliability of 2x2, 3x3 and 4x4 MIMO in 802.11n B Channels

MIMO Configuration	2x2	3x3	4x4
% of Channels Supporting 1 Maximum Rate Data Stream	99.5%	100%	100%
% of Channels Supporting 2 Maximum Rate Data Stream	4.4%	68.1%	99%

Dynamic Digital Beamforming

Extra antennas at the transmitter, above the minimum required to support multiple data streams, are not very useful without dynamic digital beamforming. Dynamic digital beamforming applies optimal complex weights to each transmit antenna to steer the energy of the antenna array in the independent spatial directions associated with the different data streams while simultaneously avoiding interference for two data streams.

This optimal weighting requires channel estimation at the receiver, and explicit feedback of the weights or channel estimates from the receiver to the transmitter. Implicit transmit beamforming where the weights are based on metrics such as minimizing packet error rate can also be used. However, it is much less effective than basing the weights on explicit channel measurements.

A 4x4 MIMO configuration supporting two data streams provides two extra transmit antennas for beamforming, which allows significant focusing of the energy in two directions. This feature not only improves reliability, but also reduces interference with coexisting systems, since steering energy in the direction of the desired receiver moves it away from other locations. For transmission of two data streams, a 3x3 system has significantly lower reliability since there is only one extra antenna to focus energy in the two required directions, and a 2x2 system exhibits negligible transmit beamforming performance gain since there are no extra antennas beyond the minimum needed. While dynamic digital beamforming gains with any number of receiver antennas, it is most powerful in a 4x4 configuration with MIMO receiver processing optimized with respect to the transmit beamforming weights.

MIMO receiver processing combined with dynamic digital beamforming optimally steers the data streams between the transmitter and the receiver. This steering provides increased throughput, reliability and range, and the performance improvement increases with the number of extra receiver antennas beyond the minimum needed to support the transmitted data streams. To ensure the highest levels of consistency and reliable wireless connectivity in any home – regardless of its size, layout or construction – the VAP2400 relies on 4x4 MIMO and dynamic digital beamforming. The 4x4 MIMO system provides enough extra antennas to allow for substantial performance gains from dynamic digital beamforming and MIMO receiver processing. Dynamic digital beamforming uses explicit channel estimates to focus energy in the best directions to support transmission of multiple data streams with high channel gain and low interference, while enabling consistency over longer distances.

This focusing of energy also reduces interference to other wireless devices. Complementary MIMO receiver processing provides maximum receiver antenna gain in the directions of the incoming data streams and can null out interference. The combination of 4x4 MIMO with dynamic digital beamforming is adaptive, which means it can constantly adjust Wi-Fi performance based on real-time events.

Business Advantages of Offering the VAP2400

Video service providers can increase revenue and profits by offering high-value wireless video delivery capabilities throughout the home. Network operators can increase ARPU levels by making it easier for residential subscribers to provision more set-tops to add video delivery to more rooms – while avoiding the disruption of running cable throughout their homes. In addition, with the VAP2400 service providers can:

- Provide whole-home wireless coverage – The VAP2400 allows network operators to provide full coverage to the home. It is the first product developed to meet the performance standards necessary to transmit video via a wireless connection throughout the home.
- Ensure flexible integration with all standards-based set-tops and gateways – Network operators can increase operational efficiency by ensuring flexible integration with existing infrastructure. The VAP2400 is compatible with set-tops and gateways, and supports use with Motorola set-tops and gateways as well as third-party devices.
- Streamline network management – It enables centralized management of remote devices via Motorola's EDGE™ Service Assurance Software Suite, and Motorola's HomeCenter – one of the products within the award-winning EDGE Service Assurance Software Suite – which can be used by subscribers for multiscreen self-help for devices connected on the home wireless network. The VAP2400 also includes a standards based TR-069 implementation to allow the service provider to integrate the solution to existing management systems with full remote upgrade, diagnostics, and statistics data collection capabilities.
- Benefit from market disruption through product innovation – The VAP2400 is a revolutionary product that is changing the landscape for the delivery of video content throughout the home. Network operators that capitalize on this watershed moment can be first to market with high-value wireless video solutions that potentially drive revenue growth and customer satisfaction for years to come.
- Minimize truck rolls – Pulling cable throughout the home is time-consuming and expensive. Network operators can dramatically reduce installation costs and minimize truck rolls by offering the VAP2400 to subscribers.
- Reduce costs, increase revenues – The VAP2400 allows network operators to reduce the costs of installation while creating opportunities to increase average set-top deployment ratios within subscriber households. It also creates opportunities to offer premium service bundles for wireless distribution of residential video services.

VAP2400 Benefits

- Breakthrough wireless video bridge technology from Motorola, available to network operators and packed with full remote TR-069 management capabilities
- The first true beamforming 4x4 solution in the market
- Whole-home coverage for delivery of high-quality video content to multiple screens
- Effortless support for multiple HD and SD streams within the home
- Coverage for larger houses, including support for multiple concurrent HD streams through multiple walls
- A carrier-grade wireless video delivery solution with low latency and zero packet loss
- A secure, reliable and easy-to-install solution
- Seamless setup with auto-detection and autoprovisioning capabilities
- A seamless replacement for wireline solutions
- Full remote management capabilities without any extra expenses to the network operator
- A flexible and futureproof solution that can be integrated into set-tops and gateways in the future
- No holes to drill, no walls to paint, and no ugly cables running throughout the home

Summary

Video delivery within the household has long been tied to the limitations of residential cabling infrastructure. Nobody wants to disrupt their homes by having cabling pulled, but everybody wants the flexibility to be able to view video content wherever they want to enjoy it within their homes. Residential subscribers will value the mobility of their video services within their homes, just as they now value the mobility of their voice and data services within their homes.

Telcos and cable operators revolutionizing video delivery with home wireless networking will be able to gain a competitive advantage over those service providers slow to adopt this emerging technology solution. Motorola's VAP2400 Video Access Bridge allows carriers and cable operators to deliver reliable, high-quality HD and SD video over Wi-Fi throughout the home so they can increase revenues and margins while driving down costs and attracting new customers with high-value services.

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For More Information

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