Broadband TV Conference- Part 3: The Problem and Solution for WiFi Delivered Video Content -Why Can't We Watch Any Content, on Any Device in Any Room in the Home?

Introduction and Backgrounder:

The number of mobile devices in the home is exploding. Most "Pay TV" operators (like Comcast Xfinity, Verizon FioS, and AT&T U-Verse) are supporting multiple screen viewing as part of their "TV everywhere services." The content is mostly OTT VoD, video clips, or real time sporting events available by subscription, e.g. MLB.TV, NHL.com or ESPN3.

In almost all cases, the mobile device playing a video accesses the in-home WiFi network to deliver the streaming video content. That "second screen" will not likely use 3G/4G wireless access as such video watching would consume a good chunk of the mobile subscribers monthly data plan. Some second screens, like the Kindle Fire and iPod Touch, only use WiFi for wireless communications. Furthermore, there is no charge for WiFi home video distribution (other than the OTT subscriptions the user has with the video streaming provider, e.g. MLB.TV, Netflix, Amazon Prime, Hulu+, Apple TV, etc).

Most Wi-Fi home network implementations are optimized for best effort, peak data rate streaming. However, video is very sensitive to packet loss, latency and jitter, which results in artifacts on the consumers' second screens (How many times have you noticed the OTT video picture freezing or sharply degrading in quality? Or loss of lip synch?). In addition, whole-home WiFi coverage and a consistent signal becomes mandatory for a good "user quality of experience." Consumers will generally have their mobile devices, notebook PCs, STBs and TVs located in various nooks and corners of the home. They expect consistent video quality wherever screen they're watching anywhere in the home (or even in the back yard).

In addition to OTT streaming via WiFi in the home to notebook PCs and mobile devices, WiFi is sometimes used for delivering broadcast and on demand pay TV content. For example AT&T offers a "**Wireless U-Verse receiver**[1]" for watching SD and HD TV plus apps that are included in the residential subscriber's U-Verse TV package or bundle.

Note 1: The **U-verse Wireless Receiver** http://www.att.com/Common/about_us/pdf/uverse_wireless_receiver.pdf is a wireless STB which is connected to the TV using an HDMI or color cable. It uses the WiFi home network to connect to a WiFi Access Point (AP) that plugs into the U-verse Residential Gateway via an Ethernet cable. The WiFI AP is also a "video bridge," in that it extracts the TV content (SD/HD/apps) from the Residential Gateway, decodes it into the correct format, and delivers that content wirelessly over the in-home Wi-Fi network to the U-verse Wireless Receiver which plugs into the TV. The quality of SD/HDTV videos is expected to be a lot better than OTT video streaming, so would be adversely effected by any WiFi home network performance degradation.

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Fundamental Problem with WiFi Delivery of Video Content in the Home:

Consumers have been led to believe they can watch any video content on any TV/device, in any room of the home. AT&T has been advertising this claim repeatedly in their TV commercials for U-Verse TV (Have you seen the one where the Dallas Maverick's Mark Cuban invites players into his house to watch live basketball games on his tablet?). Google reports that 77% of consumers use mobile devices while watching TV each day. Touch screen mobile devices were said to have superior User Interfaces (UI's) for search and socializing. Therefore, many people use them for watching and sharing videos while at home.

Ideally, video reception quality should not vary much depending on location in the home, but it does. **AirTies** http://airties.com claims the user experience is not nearly up to expectations when watching WiFi delivered video content within the home. They say the primary bottleneck is poor WiFi performance - even with the latest IEEE 802.11ac silicon in the sending/ receiving WiFi enabled equipment/devices.

AirTies Presentation Overview:

Ozgur Yildirim, Vice President and General Manager - North America Business Unit- AirTies discussed this topic during his Broadband TV session on June 4. 2014. http://www.bbtvcon.com/agenda-june-4.html

Ozgur's excellent presentation included actual measurements in a typical home. He also discussed network level limitations of WiFi, including: range performance, capacity impact of mobile devices, interference from neighbors and streaming from DVR to 2nd TV. Finally, Ozgur presented a WiFi mesh-network home network solution to the problems inclusive of range extender/ boosters and other WiFi network enhancements. AirTies currently sells such a home network to Service Provider customers in Europe (see **Comment and Analysis section** below for further details on AirTies).

The prmary problems with WiFi distribution of video and audio content is that **it's difficult for the WiFi signal to pentrate walls or reach corners within a typical home.** *That was supposed to be fixed with IEEE 802.11n and now 802.11ac, but not according to Mr. Yıldırım.* Here's why:

1. In conventional WiFi, all wireless traffic to/from the Internet or between clients goes over a single WiFi Access Point (AP) which is embedded in a WiFi router, Video Bridge, or Residential Gateway. For "n" devices in the home, there are "n" point- to- point wireless links to the WiFi AP, which creates a star topology.

2. WiFi capacity degrades logarithmically over distance and walls (RF signals at 5GHz - used by 802.11ac- are prone to absorption by walls which effectively reduce signal levels, i.e. lower S/N ratio at the receiver.).

3. The slowest WiFi link pulls down the entire WiFi network capacity, which is shared amongst all the devices accessing that wireless network. Therefore, there is less effective bandwidth to distribute to mobile devices and personal digital recorders within the home as you add/use slower devices.

4. Your neighbor's WiFi signal was said to "consumer air time," which is something we hadn't heard before! Ozgur provided this explanation via email after the conference:

"WiFi uses “Carrier Sense Multiple Access” (CSMA) – only 1 user can transmit at any one time, while others must wait. Since they all “share” time and bandwidth this way, one “bad apple” device taking too long will hurt all others. "Airtime" is also shared with neighbors on the same channel. There are only 3 channels in 2.4 GHz – if you have more than two neighbors with WiFi home networks you share channels with them."

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Actual Tests of WiFi Home Network Performance under Various Conditions:

In an actual **wireless home networking test** in Istanbul, Turkey (headquarters of AirTies), sharing the WiFi aggregate bandwidth between three devices was said to reduce aggregate bandwidth/ total capacity by 65%. With a single device in the room, the WiFi capacity was measured to be 800M b/sec. When an iPad 4 (2X2 MIMO IEEE 802.11n), MacBook (3X3 MIMO IEEE 802.11ac), bridge (3X3 MIMO IEEE 802.11ac) the aggregate capacity dropped to 292 M b/sec in the same room.

Ozgur said that "much worse results would be obtained if the iPad was removed from the room." Ozgur provided this explanation via email to clarify that last statement:

"The iPad represents the legacy “slow” 802.11n client in the configuration described. It pulls down the entire network capacity- even within the same room. Recall that the single 802.11ac client got 800Mb/sec of WiFi capacity. If we were to put two 802.11ac clients in the same room, each clients would 400Mb/sec. But when the iPad is introduced as a legacy (802.11n) client that does not support 802.11ac, the total WiFi capacity went down to 290Mb/sec."

"Moving the iPad to a far location (with respect to the AP) in the home results in that (relatively slow) legacy client will get significantly slower due to poor WiFi reception. This results in the iPad taking much longer time to send packets which means much less time is left over for faster 802.11ac clients to access the home WiFi network."

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Worse, when moving one device upstairs, the total capacity was reduced to 92%, with an effective bit rate of only 68 Mb/sec. Wi-Fi link speed at the edge was said to be critical for performance in this case.

Almost as bad is "device- to- device" streaming performance -say from a Personal Digital Recorder/Network Attached Storage (PDR/NAS) to an iPad or other second screen. That reduces total WiFi capacity by 40% to only 320M b/sec. With three devices in the same room the capacity drops to 175M b/sec. If the PVR (using 3X3 MIMO and 802.11ac) is moved upstairs, it drops to 38M b/sec. [Remember, that total WiFi capacity is shared by all devices using that wireless network.]

A Solution for Mutli-Screen Video Streaming over WiFi Home Networks:

AirTies solution is a WiFi Mesh home network, which enables streaming video to multiple screens with much better video quality. That was said to outperform conventional Wi-Fi (with the star topology described above) by up to 10X. That WiFi Mesh configuration, along with conventional WiFi, is

illustrated in the figure below:

Ken PLS INSERT slide 16 here.

It connects each WiFi device/node to a WiFi AP and routes IP packets over the best path available at the time. Mobile WiFi devices connect to the closest AP at maximum capacity speed.

In conclusion, Ozgur said that such a "Wireless mesh network enables an ideal user experience. You can watch any content on any device, in any room, with premium (perceived) video quality."

Comment and Analysis:

AirTies sells their technology to OEM partners, including several European telco TV providers http://airties.com/about/customers/# One of their products is called the Air 4641- a dual pack Wireless Digital Bridge "to optimize wireless video delivery throughout the home." http://airties.com/solutions/video/ They also sell other products and solutions, such as a "wireless extender" http://www.airties.com/solutions/expand/# which extends a WiFi home network's coverage range and cleans up wireless signals (i.e. increases the signal to noise ratio).

This past March at **TV Connect 2014**, the company demonstrated HEVC adaptive bit rate video streaming, delivered over the public Internet to STBs, with **Envivio** (a provider of software-based video processing and delivery solutions) and **Octoshape** (a leader in cloud based OTT video streaming technology).
http://www.octoshape.com/airties-demonstrates-hevc-for-broadband-tv-with-envivio-and-octoshape-at-tv-connect-2014/

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In contrast to the WiFi mesh network solution proposed by AirTies, a WiFi semiconductor company named **Quantenna Communications Inc**. published a white paper in March 2013, titled "**Right Wi-Fi® Technology for Multi-Media Distribution."** http://www.quantenna.com/pdf/RightWiFi.pdf It details and recommends how to get the best performance from 5 GHz IEEE 802.11ac for muti-media/video distribution within the home without using a mesh network topology. There's no mention of a mesh network topology.

We thought this excerpt was especially noteworthy: "For mobile devices, power is the most important, next is cost and lastly performance. In contrast, for whole home video distribution and general access points, higher performance connectivity with continuous error free distribution is a must. Error free video in the presence of interference cannot be compromised."

References:

The Evolution of Wireless Home Networks, by Ece Gelal, Eren Soyak, Ozgur Yildirim of Airties

http://www.airties.com/images/legal/The%20Evolution%20of%20Wireless%20Home%20Networks.pdf

Interview with Burak Onat, AirTies Product Manager (multicast live video streaming demo with Octoshape) **http://www.screenplaysmag.com/2013/09/25/burak-onat-product-manager-airties/**