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Supplier BullsEye Analysis™

802.11ac Wi-Fi Chipsets

February 2015

EJL Wireless Research

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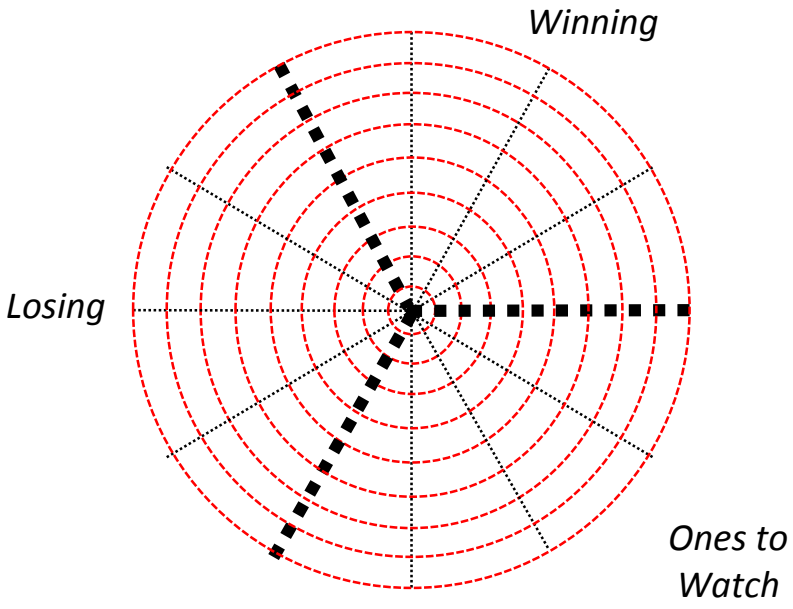

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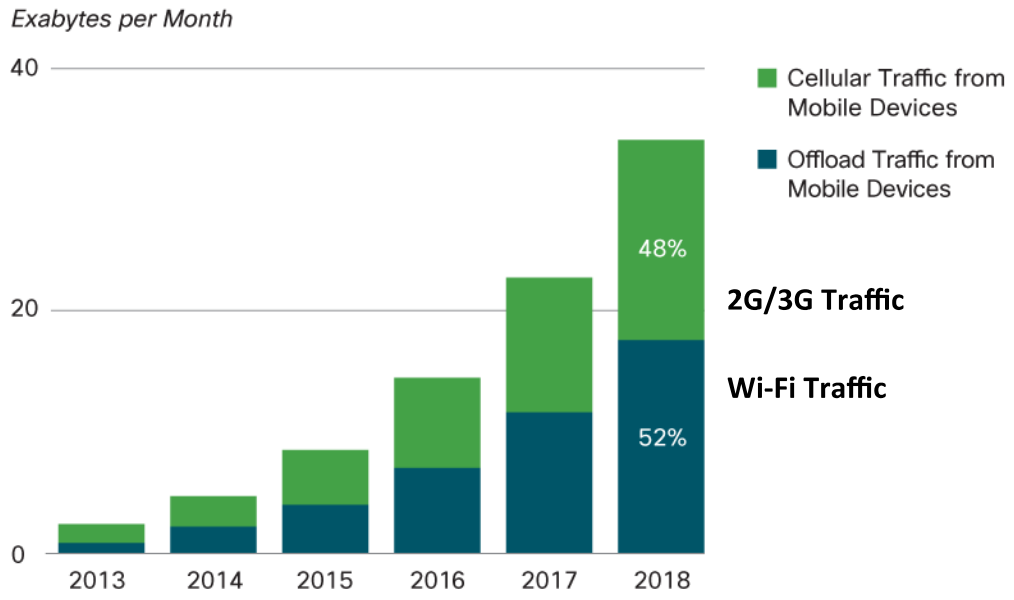
EXECUTIVE SUMMARY

Wi-Fi Ascending – Now More Than Ever

According to the oft-cited Cisco Visual Networking Index, by 2018, Wi-Fi becomes the most important air interface (and possibly the most important broadband wireless communications interface bar none):

Exhibit 1: Global IP Traffic by Local Access Technology



Source: Cisco VNI Mobile (January 2015)

2x2 MIMO 802.11ac is now a standard feature in new smartphones, phablets, tablets and notebook computers. We believe that in 1H15 2015, new iOS and Android radio firmware will turn on Multi User MIMO (MU-MIMO) functionality in smartphones, potentially quadrupling Wi-Fi throughput as 11ac Wave 2 Access Points are deployed.

At the International CES 2015 event in early January 2015, all eight of the semiconductor suppliers analyzed in this report made announcements regarding their IEEE 802.1ac product portfolios. The battle for new design wins and subsequent market share had shifted and become significantly more complex.

- Qualcomm and Broadcom are in a horse race now for Wave 2 consumer gateway and enterprise access point design wins. Broadcom has strong Wave 1 design win momentum, while Qualcomm has a product maturity advantage.

- Marvell has a strong new Wave 2 chipset offering, a deep Ethernet packet processing experience, but few existing 11ac design wins. We believe Marvell is the dark horse in the 2015 race for Wave 2 chipset market share.

- Quantenna has the most market experience with Wave 2 802.11ac radios. As evidence of their technical prowess, they demonstrated an 8x8:8 “Wave 3” (EJL

Wireless Research designation) solution at CES 2015. We believe the company is an attractive acquisition for a strong embedded processing semiconductor company.

- For a small venture-backed company, Celeno has an impressive set of design wins. An acquisition by their set top box design partner Intel would enable Intel to increase their "share of wallet" in consumer cable modem WLAN gateway systems.

- MediaTek has stepped up with a Wave 2 radio and powerful Wi-Fi networking SoC, and while late to the game, they offer a complete smartphone chipset portfolio, providing client side leverage for their Wi-Fi access point chipset solution.

- Intel has taken an early market lead with IEEE 802.11ad WiGig. The question remains whether they will see consumer interest and PC OEM uptake of this new short range 60 GHz air interface in 2015.

- Realtek faces a serious threat from Broadcom's new single chip 2x2 11ac product family. 2015 will be a critical year for Realtek's future in Wi-Fi silicon.

Intent

This Research Report is intended as a companion to EJL Wireless Research's recent report "Wi-Fi Blasts Ahead with 11ac Wave 2 Chipsets", published in December 2014.

This Research Report analyzes eight 802.11ac Wi-Fi equipment chipset suppliers (three radio only and five radio plus Wi-Fi networking processor SoC) using objective commercial and technical performance fitness evaluation criteria. Alphabetically, these suppliers are:

- Broadcom Corp
- Celeno Communications (radio only)
- Intel Corp (radio only)
- Marvell Technology Group
- MediaTek, Inc.
- Qualcomm Technology, Inc.
- Quantenna Communications, Inc. (radio only)
- Realtek Semiconductor Corp

This research report does not cover products from Airoha, Intersil or Lantiq, as none of these companies offers 802.11ac radios or companion networking processors SoCs. Redpine Signals was removed from this report, as the company has no known 802.11ac equipment design wins.

EVALUATION CRITERIA RATIONALIZATION

Criterion 1 – Complete 802.11ac Wave 1 or Wave 2 Chipset (Radio plus Wi-Fi Networking Processor SoC)

With a very small number of exceptions, enterprise and carrier Wi-Fi access point OEMs (and their ODM partners typically in Taiwan) are unwilling to mix radios and networking processor SoC in their system designs. There are numerous compelling reasons for this industry dynamic. First, complete "homogeneous" (single supplier) chipset suppliers optimize system performance for their own radio and networking SoC (plus one or two third-party RF front end designs), and these suppliers are generally unwilling to optimize system performance for system designs that include competitor silicon and software (this optimization process generally requires release of proprietary firmware or software source code, for example). This means the equipment OEM must optimize a "mixed supplier" chipset themselves. To make matters worse, the chip suppliers will typically hold back on application engineering support to customers attempting to integrate and optimize a "heterogeneous" (multiple supplier) chipset, both because of ambiguous technical accountability, and to apply business leverage on the equipment OEM to abandon the heterogeneous design, and adopt the supplier's complete homogeneous chipset. Additionally, the semiconductor suppliers will typically provide more attractive pricing for a complete chipset design win than for discrete radio or networking SoC chips.

The R&D and sustaining engineering support resources required by the equipment OEM to integrate and optimize a heterogeneous chipset are much higher than using a complete reference design from a single supplier. Clearly there would have to be a major technical benefit (much higher performance, much lower power, much smaller form factor) to a heterogeneous chipset to justify the higher marginal manufacturing cost and the much higher development and support costs. There is little or no compelling evidence of any "breakthrough level" technical benefit in the publically available test results published by access point equipment OEMs using heterogeneous chipsets.

The particular criterion is "binary": complete radio plus Wi-Fi networking processor SoC suppliers receive four points; and radio only suppliers receive one point. There are no intermediate point scores between one and four. One point is awarded to radio only suppliers because in all cases they have reference design relationships with Wi-Fi networking processor SoC suppliers such as Lantiq, Freescale and Intel.

Due to this industry dynamic, suppliers who can offer complete 802.11ac chipsets (radio plus networking SoC) have an overwhelming commercial advantage over those suppliers who offer discrete radios or discrete networking processor SoCs, and thus this criterion is ranked #1 in the EJL Wireless Research Wi-Fi Chipset Supplier BullsEye Analysis.

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