Qualcomm® snapdragon™

QUALCOMM® SNAPDRAGON™ INTEGRATED FABLESS MANUFACTURING

Executive Summary

The new mobile age has brought with it a new approach to solve the performance and power efficiency problems of modern processors. As a leader in the mobile industry, Qualcomm Technologies, Inc. (QTI) implemented the Integrated Fabless Manufacturing (IFM) model to address the changes in the evolving mobile ecosystem to deliver the best user experiences. IFM allows Qualcomm Technologies to work closely with selected foundries, test and assembly vendors to provide cutting edge solutions that can be manufactured in high volume while also meeting the performance, power, size, and cost requirements of the mobile industry.

Technical Engagement

The QTI IFM builds tight technical interfaces among all parties in the semiconductor development cycle. As a technology leader in the mobile ecosystem, QTI collaborates closely with the foundries and other services, on virtually every aspect of the implementation, including the design rules and design trade-offs. QTI collaborates with the foundries to define the features and capabilities of the future process generations. This close interaction gives QTI an input into design targets, like transistor gate leakage, and into backend features. In addition, because Snapdragon™ processors are custom designs, unlike other competitors, QTI works with the foundries to also customize the standard cell libraries used during the manufacturing processes. This foundation IP design gives QTI more control over the implementation of the design, enabling even greater performance and power optimization. The IFM ecosystem also extends its reach to include Electronic Design Automation (EDA) and Outsourced Semiconductor Assembly and Test Services (OSATS) companies as well.

Although QTI is fabless, it is still invested in advancing manufacturing technology. QTI helps drive and influence semiconductor innovations through alliances and cooperation with industry organizations. In 2013, QTI became a core member of the CMOS Program at the global semiconductor research program, IMEC, to extend the group's collaboration into advance CMOS process technologies. Prior to QTI's core membership, the two organizations collaborated for several years on 3D stacking technologies. Also in 2010, QTI became the first integrated, fabless chip manufactures to join SEMATECH, also with the intent to advance CMOS scaling and collaborate on new technologies.

Flexible Foundries

IFM uniquely positions QTI to adjust demand across foundries and select the most cost effective process nodes for the various components of a mobile system chipset.

In a modern day mobile device, there are multiple chips required to deliver a full solution. Beyond the normal applications processor and modem, there is also the Radio Frequency front end (RF), audio codec, and the Power Management Integrated Circuit (PMIC).

For both technical and cost reasons, various process nodes are needed to fabricate these different components. In a Snapdragon SoC, the main application processor and modem, which are the most power and performance sensitive, are on the leading edge process node. The engineering requirements of the RF and PMIC chips are more optimally met on process nodes generations behind the leading edge. Currently,

the RF is manufactured to 65nm and the PMIC to the 180nm.

These diverse process nodes require access to various fabs and the ability to work with the processes of each. QTI has the tools, processes, and the technical expertise established to work with different foundries at different process nodes to accomplish this system level optimization The flexibility to select which process node these chips are manufactured allows QTI to optimize for performance and cost for these different functions. [Figure 1]

Incentivized to amortize the latest facility, the traditional Integrated Device Manufacturer (IDM) is often limited to the latest process node and the previous generation. When new fabs and process nodes are brought online, the initial ramp will typically have lower yields and higher costs. This forces the IDM to create chips which will not significantly benefit from the latest process technology and do so at a higher cost. Aggregation of industry volume is the most economical way to optimize ROI for many of these process nodes.

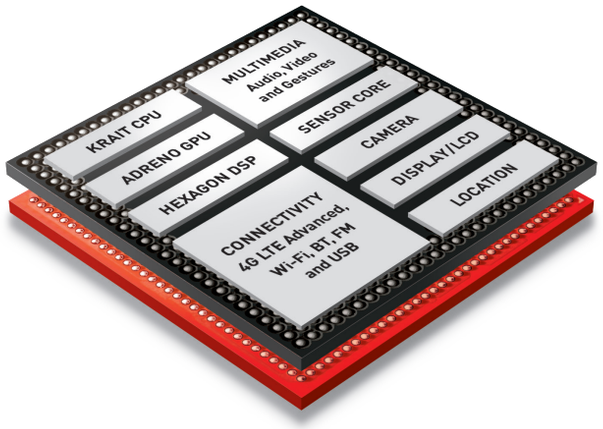
In addition, the smaller process nodes are physically incapable of either sustaining the power output needed for the PMIC, or the tailored transistor width required for the RF chips. The engineering constraints force IDMs or their customers to seek 3rd party solutions in order to acquire all of the necessary smartphone IP blocks.

The flexibility to choose between foundries is also beneficial to a fabless company. Through IFM, QTI can adapt to the increases in demand by sourcing from various foundries. Conversely, there is an added penalty of an idle, multi-billion dollar factory from over estimating demand. The traditional IDM primarily manufactures their own parts, so it must have enough demand for their product to fill the fabs to capacity.

For example early in 2013, as the PC market hit its worst decline in history, Intel was burdened with idle and underutilized fabs. In the Q4 earnings calls, the Intel CFO admitted the fab utilization was near historic lows at below 50% capacity. If fabs are not in use, they are not making the IDM any money, and an idle or underutilized fab after a multi-billion dollar investment is an expensive proposition.*

Without a fab to fill, QTI is not penalized further if manufacturing slows. In addition our foundry partners are more able to combine multiple sources to optimize capacity. Recently a major IDM has also become a foundry for external designs due to this pressure.

Figure 1



Fabless Cost Benefits

Moore's Law began in 1965 by Gordon Moore, where he noted the number of transistors on an integrated circuit was doubling approximately every two years. Nearly 50 years later, as Moore

* http://www.telegraph.co.uk/finance/newsbysector/mediatechnologyandtelecoms/electronics/10172763/PCs-suffer-longest-sales-decline-in-history.html
http://seekingalpha.com/article/1119201-intels-ceo-discusses-q4-2012-results-earnings-call-transcript?part=single

himself pointed out recently, "It can't continue forever. The nature of exponentials is that you push them out and eventually disaster happens."

The advancements in process technology led to much of the innovation during the PC era. Smaller transistors resulted in more complex processors at higher frequencies. Although the impact is not as significant as the early days of semiconductors, there is still performance gain associated with smaller transistors.

Today, the economics of Moore's law are changing. As the manufacturing of smaller transistors becomes more challenging the cost of tools and investment in research and development increases. Added complexity and expense means the cost per transistor will no longer decrease as it did historically. [Figure 2]

While advancing Moore's Law is still technically achievable, it is less economically reasonable. The cost of the building and operating fabrication plants has increased significantly with the complexity of the process nodes at 22nm and beyond. Observe Intel's capital expenditures from 2010 to 2012. [Figure 3]

While this rising CapEx has hurt IDMs, it has benefited the foundry business. Foundries are able to aggregate the industry demand, and source from more customers and more volume to amortize the fab costs.

Industry data shows the power behind IFM over IDM, as fabless companies have out-grown IDMs by nearly 4x, while foundries have grown by 6x over the last 15 years. During that same time period, a quarter of the value within the semiconductor industry now resides within fabless companies. (Bernstein). [Figure 4]

The fabless model does have to contend with the stacked margins between the foundry and

Figure 2

Relative Cost per Gate (log scale)

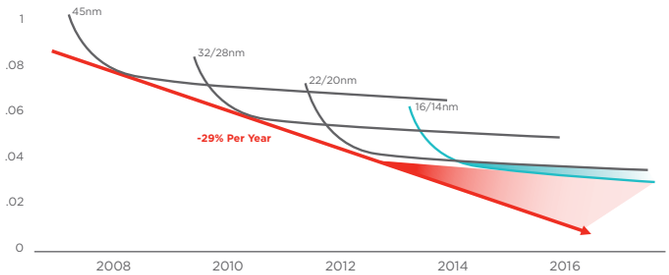


Figure 3

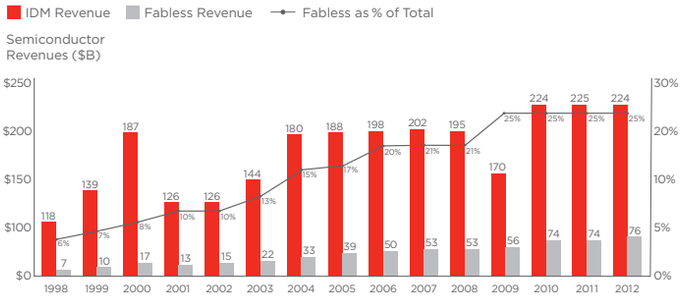
Capital Expenditures 2010–2012

Company	2010 ($M)	2011 ($M)	11/10% Change	2012 ($M)	12/11% Change	2013 ($M)	13/12% Change
Intel	5,207	10,764	107%	11,000	2%	13,000	18%
Top 10 Total	32,492	48,023	35%	45,425	-5%	47,800	5%
Others	18,303	18,042	-1%	13,150	-27%	12,035	-8%
Top Cap Spending	53,795	66,065	23%	58,575	-11%	59,835	2%

*Includes company's share of joint-venture spending.

Figure 4

Fabless vs. IDM Growth



1998–2012 CAGR: Fabless: 18% IDM: 5%

the chip design company. However, this inter-dependent relationship means it is in the best interest of both parties to conduct fair negotiations in pricing to ensure mutual success and profitability.

Integration

From 1970 to 2000, the transistor was the driving force behind lower power, better performance, and reduced costs. In the mobile era, relying on a smaller transistor is not enough to drive innovation. QTI's IFM allows us to focus on creating a better, faster, and more efficient smartphone through architectural innovation while IDMs continue to invest and dedicate significant financial resources into creating a smaller transistor.

Connectivity is a vital component for any mobile device, and thus is a vital component to the user's experience. For example, QTI invested time and resources developing its LTE solutions. QTI was the first with RF360 Front End Solution, enabling a single, global design for LTE. QTI was the first to commercially enable LTE-Advanced phones with carrier aggregation, designed to double the previous generation LTE speeds. [Figure 5]

These continued investments in the essential communication aspect of any mobile device have resulted in QTI releasing its 3rd implementation of LTE, while IDMs are still developing their first. [Figure 6]

In mobile, integration is one of the primary methods to reduce costs, increase performance, and improve battery life. The focus on smaller transistors is a remnant of the CPU centric PC-era. To fit in the small mobile form factors, mobile SoCs are pushed to absorb as many components as possible into a single die, including CPU, GPU, DSP (Digital Signal Processor), ISP (Image Signal Processor), multimedia, and connectivity. Even a major IDM will

Figure 5

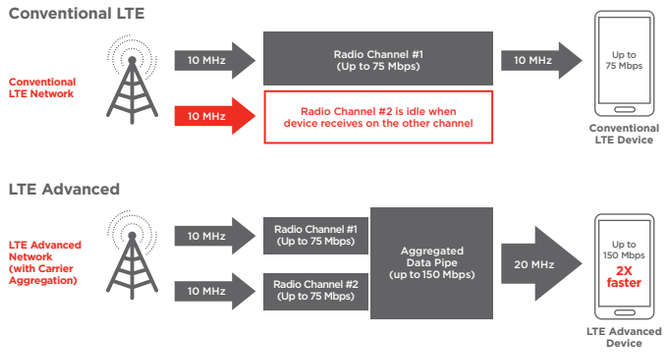
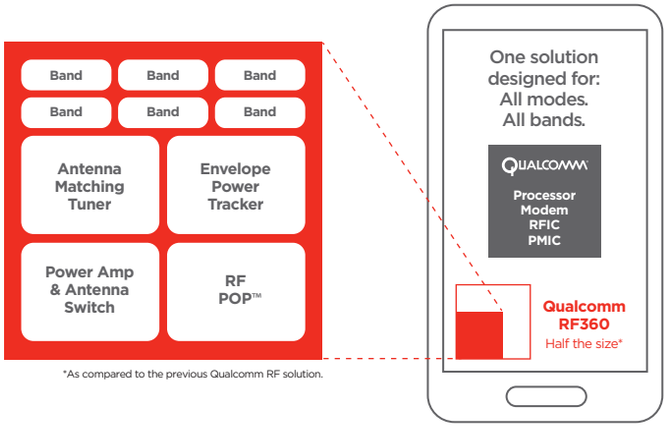


Figure 6



now outsource manufacturing to an external foundry in order to deliver a SoC with integrated communications.

QTI not only has overcome the engineering challenges of integrating all of these components into a single chip, but it also owns and customizes designs specifically for mobile applications. Other IDMs only control two or three of the components, needing to rely on commoditized, 3rd party designs or architectures for the remaining pieces.

Summary

The Integrated Fabless Manufacturing model positioned QTI ideally in the new age of mobile

computing. IFM enables QTI to produce modern processors which are optimized for price, performance, and power efficiency, through sourcing multiple foundries at various process nodes as well as integrating and owning all components on the SoC.