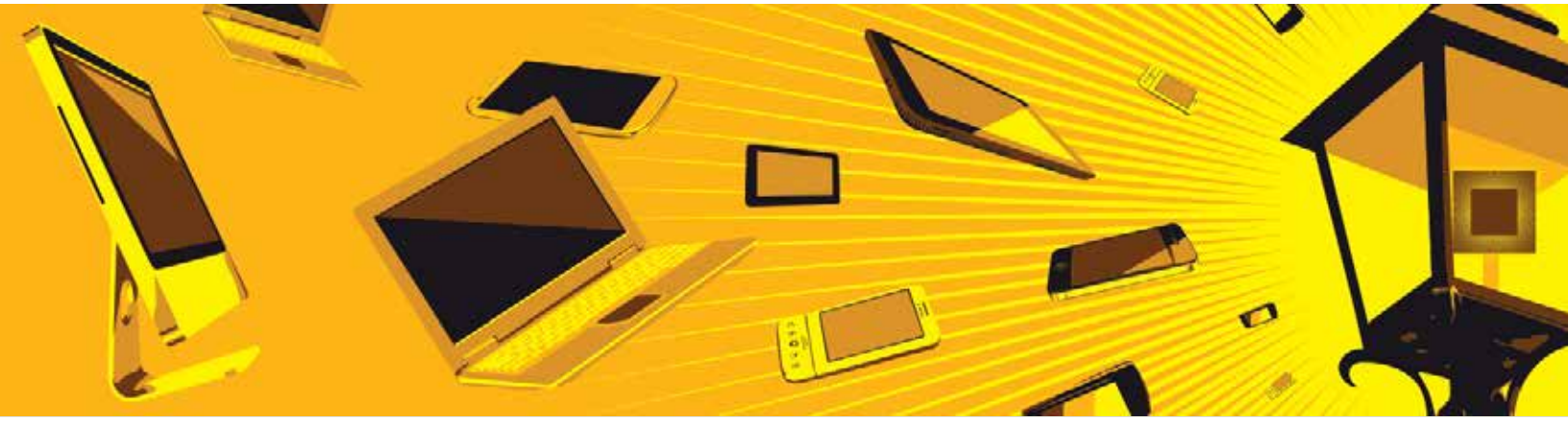


Semiconductors for wireless communications: Growth engine of the industry

Over the last three years, the market for wireless semiconductors has undergone tectonic shifts, with new operating systems and high-performance smartphones taking the stage. The disruption creates opportunities for new players and changes the game within the industry.

Harald Bauer, Felix Grawert, and Sebastian Schink

The market for the semiconductors that power wireless communications is undergoing dramatic changes. Based on data from Strategy Analytics, the estimated overall industry growth rate will average 6 percent from 2011 to 2015. A large share of that growth will be attributable to two categories: smartphones and connected devices such as iPads. These account for more than half of total units shipped, and each category is growing at more than 25 percent per year. Today, mobile application processors operate at 5 to 10 percent of a typical laptop's computing power, yet that gap is rapidly narrowing as smartphones run applications from mobile video to mobile games, and their energy consumption is lower than a laptop's by a factor of 10 to 30 times. Despite the clear opportunity, the increased performance and the rapid shift from traditional handsets to mobile computing devices pose a number of challenges for chip makers (Exhibit 1).

Challenge 1: Tectonic shifts in market share

The shift to smartphones and connected devices comes with significant market-share gains for players that have offered devices in these categories from early on. Apple and Samsung were able to increase their market share to a combined 27 percent in 2011—and to capture more than 80 percent of industry profits at the

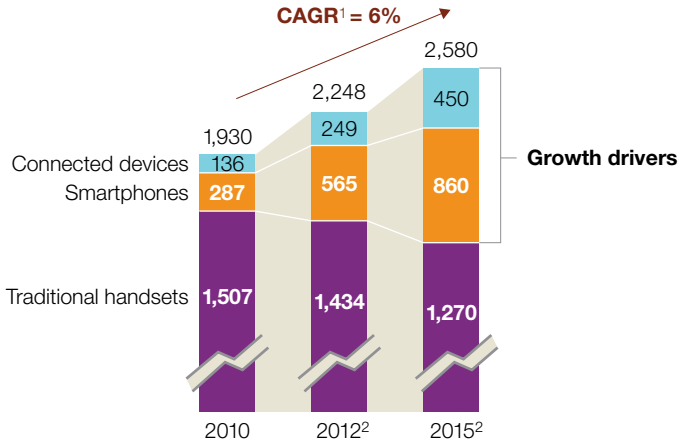
same time. Apple in particular profits from its leading position as an innovator in the mobile space. Nokia, on the other hand, steadily lost ground, and its attempts to catch up in smartphones have not yet yielded the desired results (Exhibit 2).

The shift in market share of handset makers also has led to discontinuities in the market for operating systems. Symbian, once the leading mobile operating system, with more than 50 percent market share, claimed only 17 percent in 2012. Google's Android (with 49 percent share in 2011) and Apple's iOS (with 19 percent share) have taken the lead. Both Apple and Google have created open platforms for third-party application developers, resulting in an unrivaled breadth of apps—more than 850,000 for iOS and 500,000 for Android. Indeed, mobile operating systems are increasingly becoming differentiators in their own right, apart from the device hardware for various handsets. It would be difficult for Blackberry OS and Windows Mobile to catch up; their combined market share has fallen to 13 percent. However, the new HTML5 standard, which is still under development, aims to provide an alternative to today's downloadable apps that are written for a single, specific platform. HTML5 will provide a platform that shows the content of Web sites

Exhibit 1

The wireless industry is growing rapidly, creating an opportunity for leading semiconductor suppliers.

Growth of baseband sales, million units



Baseband revenues, $ billion	12	~15	~17

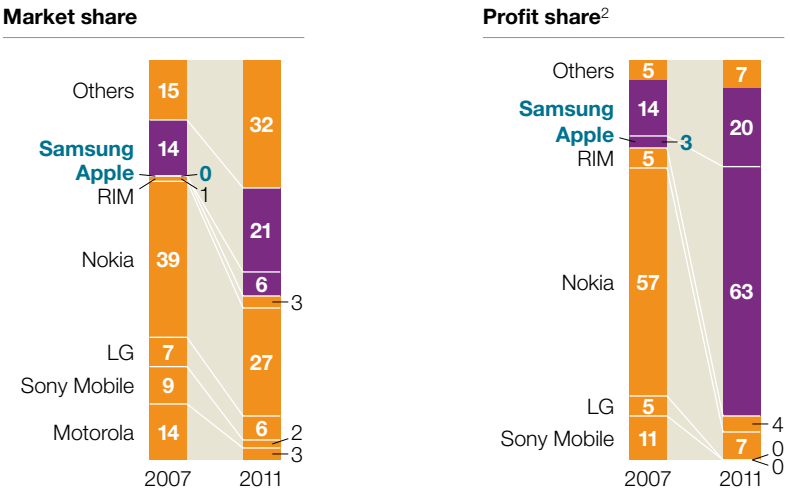
[1]Compound annual growth rate.
[2]Estimated.

Source: Strategy Analytics; McKinsey analysis

Exhibit 2

The mobile handset market has seen sizable shifts in market and profit share.

%[1]



[1]Figures may not sum to 100%, because of rounding.
[2]Losses considered as 0 in calculation of totals.

Source: Strategy Analytics; McKinsey analysis

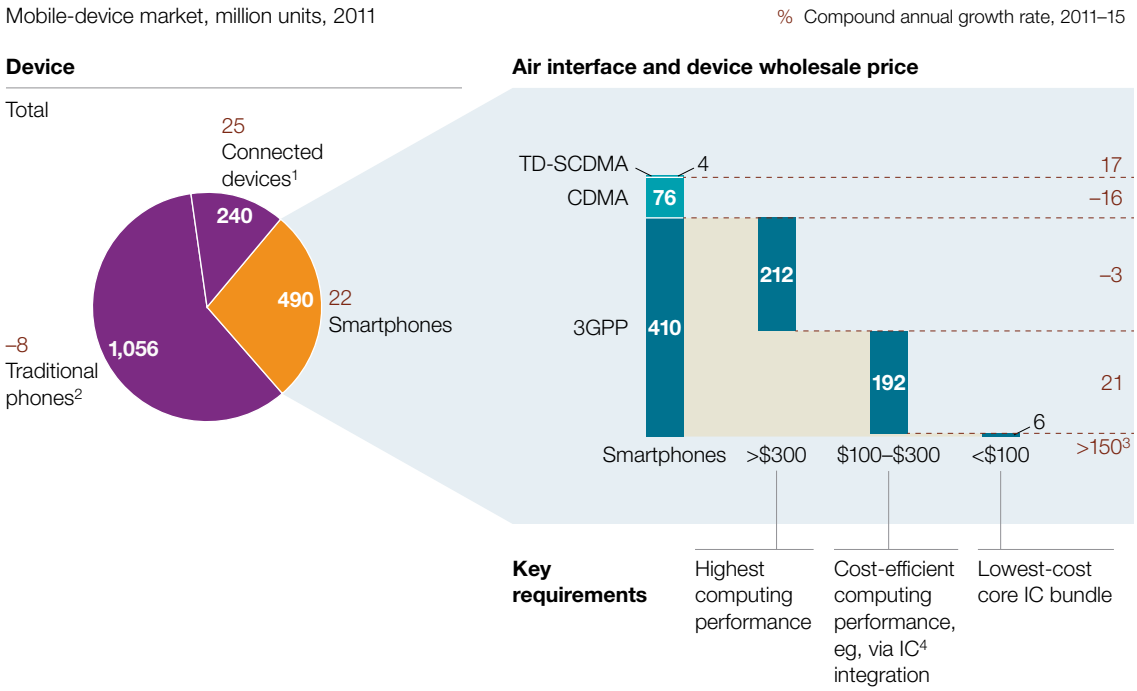
independent of hardware and operating system. This shift is likely to once again shake up market shares within the industry.

A new battle comes with the advent of low-end and midrange smartphones. While first-generation smartphones competed head-on with Apple's iPhone, lower-end smartphones, with retail prices under $300, are now being developed to cater to the needs (and pockets) of broader customer groups. These segments will grow annually by more than 20 percent, and they are expected to take the largest share of the smartphone market by 2014 (Exhibit 3). With silicon content typically running at 6 percent of handset price, this type of smartphone requires different chip architecture in order to meet a price point of $7 to $20 (compared with $25 to $40 for high-end smartphones). And top-tier smartphones typically have discrete chips for application processor (AP), radio frequency, and baseband (cellular modem) tasks. This functionality must be integrated in midrange and low-end smartphones in one-or two-chip designs. For chip makers, the emergence of lower-end smartphones has three major implications.

First, players need to develop an integration strategy that allows them to offer a powerful AP at a reasonable cost. Given the speed of the handset market, APs need to keep pace with short innovation cycles of 9 to 12 months. However, due

Exhibit 3

The low-end and midrange smartphone segments will grow rapidly.



[1]Including iPad, machine-to-machine communications, 3G/4G cards, dongles, and so on.
[2]Real-time operating system.
[3]~220 million units by 2015.
[4]Integrated circuit.

Source: Strategy Analytics; McKinsey analysis

to integration with the analog baseband on a single chip, some chip partitioning is needed to allow for frequent upgrades to the high-speed digital part of the AP, while permitting for reuse of the analog baseband. This approach should keep the development cost within limits.

Second, chip makers must broaden their customer base beyond the established smartphone players such as Apple, LG, and Samsung to capture the growth opportunity of low-end smartphones, especially in the Asia-Pacific region. In this part of the world, MediaTek is emerging as an aggressive "local hero"; its revenues climbed from $1.43 billion in 2005 to $2.95 billion in 2011. The company recently announced a bid for Taiwanese chip maker Mstar worth $3.8 billion. MediaTek's low-cost strategy and its focus on lagging-edge mobile standards, as well as its stringent standardization and low-cost local development, make it difficult for incumbent players to match its price points.

Handset and chip makers can now choose between two ecosystems that are expected to be of equal power in the near term; they must carefully decide which is right for their portfolio.

Third, players need to offer integration support to local handset makers in China that do not have the integration capabilities of incumbents. These manufacturers need ready-to-use reference designs and extensive engineering support. Both factors were essential for MediaTek in its early years. In this market segment, we believe that turnkey designs will be offered eventually; these will provide white-label phone makers with fully functional phones on a printed circuit board that only needs to be customized and surrounded by a case.

Challenge 2: ARM versus Atom

Today, the fabless vendor ARM Holdings is the de facto standard and the dominant provider of CPUs for mobile handsets. ARM's business model is tailored to the needs of mobile communications: it offers chips with the lowest power consumption and highest design flexibility in the industry. ARM develops CPU blocks of different sizes and speeds and then licenses its technology to chip vendors that can either incorporate the ARM CPU as is or customize it to their needs. This way, chip makers have design flexibility and can, for example, use a smaller, lower-power ARM A7 chip as the CPU for the digital baseband, while building the application processor on a more powerful ARM A15 core. Customers can also tailor ARM CPUs as necessary—Qualcomm, for instance, has customized an ARM core for use in its Snapdragon system-on-a-chip series.

Intel recently entered the market for mobile APs with its Atom series. Coming from the land of PCs, which have higher computing power as well as higher power consumption, Intel has released an aggressive road map to match the needs of mobile customers. The Atom series reduces power consumption with a broad range of power-saving techniques. The company is also working on low-power process technology, and it acquired a wireless business unit from Infineon Technologies to complete its wireless portfolio. As a result, all mobile operating systems (such as Android and Windows Phone) and application environments (such as Flash and HTML5) are expected to be ported to the x86 architecture by the end of 2012. This gives handset and chip makers the option to choose between two ecosystems that are expected

to be of equal power in the near term. Consequently, chip makers must carefully decide which ecosystem is right for their portfolio. Because of the high switching costs that result from the significant differences between the ARM and x86 architectures, most chip makers will need to choose a single architecture for their products.

Challenge 3: Rapid introduction of LTE

The next-generation mobile-communications standard, LTE—or 4G, as it is also called—is being rapidly introduced to the marketplace by telecommunications operators. This comes as a surprise to many players in the semiconductor industry, who still remember the slow introduction of the prior mobile-communications standard, 3G. When 3G debuted, there were no killer applications ready, power consumption was initially too high, and actual performance fell short of expectations. With LTE, things are quite different, as the use case for mobile Internet creates strong pull: from an operator's perspective, LTE technology offers much-needed transmission bandwidth for mobile data. Furthermore, the higher data rates cater to the consumer need for fast connectivity on tablets, high-end smartphones, and netbooks. As a result, both handset original equipment manufacturers and telecommunications operators are expected to migrate to LTE as early as possible to take advantage of its greater speed and data capacity. However, LTE brings three challenges for chip makers, and these will contribute to the industry's shake-up.

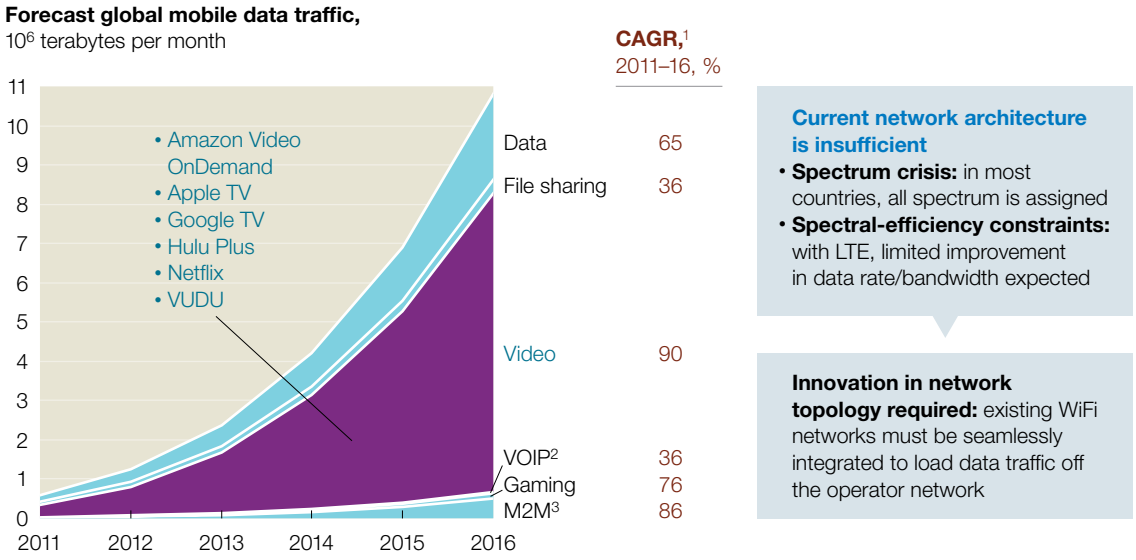
First, research and development costs with LTE will be roughly twice what they were for 3G technologies. This is because LTE, for the first time, unites the two separate mobile-communications standards, GSM (as well as its successors) and CDMA (and its derivatives). For each LTE standard release, updates to the majority of previous standards, such as W-CDMA, UMTS, HSPA, and HSPA+, are included. All these features must be developed and tested—not only in the laboratory but also in field tests with operators—and this drives up the effort required for verification. As a result, the engineering effort and R&D costs grow by an estimated factor of two, because both 3G and LTE are being updated significantly throughout release 11.

Second, the time-to-market gap between players is widening. The LTE standard is still in the development phase, and new features are being introduced rapidly. Qualcomm is one to two years ahead of its peers with regard to time to market, and the company introduces products on each version of the LTE standard roughly a year after the release date. This first-mover benefit gives Qualcomm multiple lead customers, lead operators, and equipment partners. It also creates opportunities for Qualcomm to shape the standard itself. In contrast, players that are one cycle late have to offer discounts of more than 20 percent to secure a lead customer. Players that are more than one cycle late find it hard to win lead customers and cannot offer a competitive, leading-edge feature set.

Third, with LTE, critical intellectual property is becoming more and more of a competitive weapon. Royalties have become a stronger value-redistribution lever, increasing from an average of only 3 percent of a phone's average selling price in the 2G era to 12 percent of an LTE smartphone's average selling price. Royalty

Exhibit 4

Mobile data traffic will grow tremendously.



[1]Compound annual growth rate.
[2]Voice over Internet protocol.
[3]Machine-to-machine communications.

Source: Cisco Systems, Feb 2012; McKinsey analysis

payments can be as much as twice as high for new entrants without any intellectual-property rights (IPR). For smartphones, those payments are divided roughly evenly between the wireless-communications stack and other areas.

IPR is unevenly distributed, putting new entrants at a real disadvantage against established players like Ericsson, Motorola, Nokia, and Qualcomm. Recent lawsuits, such as the fight between Apple and Samsung, demonstrate the threat of products being banned from specific markets, and of long and costly court battles in general. This has motivated players to invest in IPR purchases; for instance, the Nortel IPR auction yielded roughly $4 billion in revenue, Google acquired Motorola Mobility for $12.5 billion, and Intel acquired a group of InterDigital patents for $375 million. The need for a strong IPR portfolio will drive further consolidation throughout the industry, and it will also create entry barriers for players that are not active in the market today.

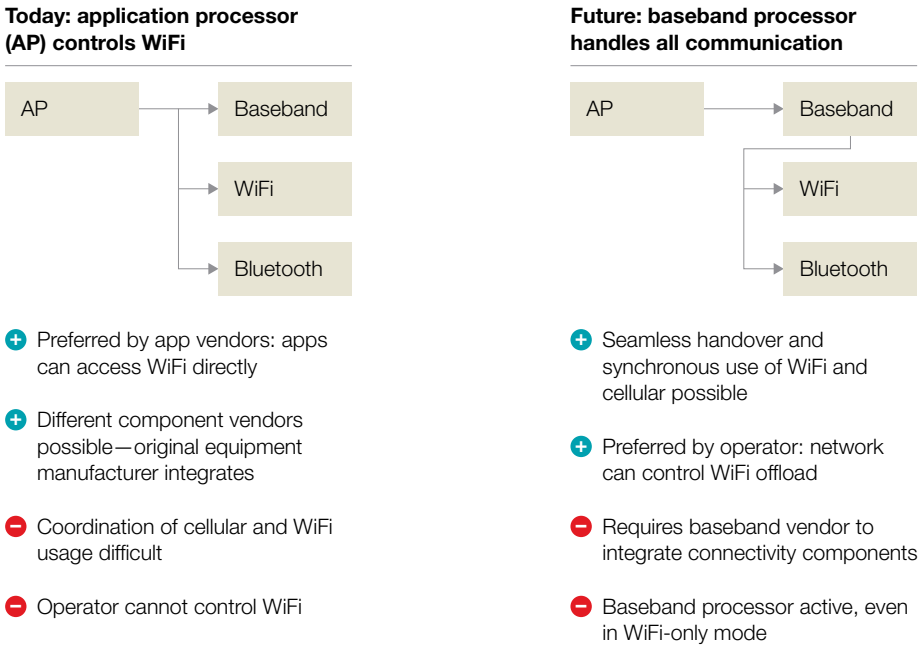
As a result of the challenges regarding the cost of R&D for LTE chips and the time-to-market and IPR battles that are likely to be fought, we expect that at most two players other than Qualcomm can make profits at the leading edge of the base-band chip market.

Challenge 4: Emergence of 'multicom' solutions

Mobile data traffic is projected to double each year between now and 2015, according to Cisco

Exhibit 5

Changes in partitioning of building blocks will likely allow for 'multicom' offerings.



Systems—a trend largely attributable to the rapid growth in mobile video (Exhibit 4). In consequence, mobile operators will find it increasingly difficult to provide the bandwidth requested by customers. In most countries, there is no additional spectrum that can be assigned. Furthermore, the spectral efficiency of mobile networks is reaching its physical limits. A solution lies in the seamless integration of existing WiFi networks into the mobile ecosystem. The chips designed to accomplish this integration are known as "multicom" chips.

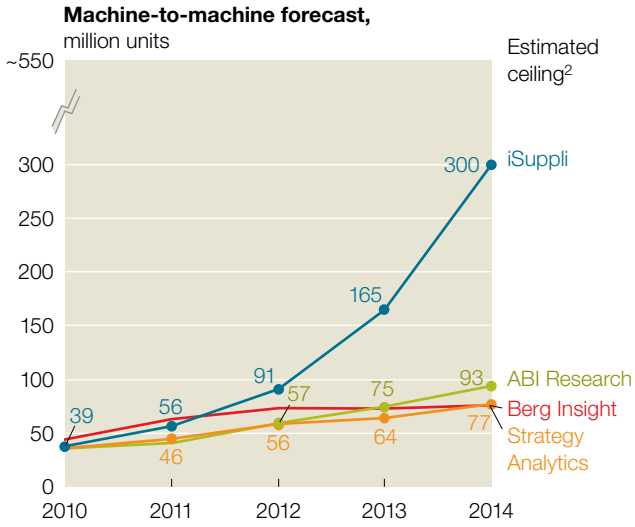
WiFi and baseband communications are expected to converge in three steps. Today, the applications running on the mobile device decide which data are handled via 3G network and which are routed over the WiFi network. In the next step, LTE release eight calls for seamless movement of all IP traffic between 3G and WiFi connections. In the final step, with LTE release ten, traffic is supposed to be routed simultaneously over 3G and WiFi networks.

To allow for such seamless handovers between network types, the architecture of mobile devices is likely to change. Today, the AP is connected to baseband, Bluetooth, and WiFi chips directly. In the future, the baseband chip is expected to take control of the routing (Exhibit 5). Thus, the connectivity components are connected to the baseband or integrated in a single silicon package. As a result of this architecture change, an increasing share of the integration work is likely done by

Exhibit 6

Strong growth in machine-to-machine communications is expected, though estimates vary considerably.

Drivers	CAGR,[1] 2010–14, %
Automotive • E-call • Tracking (theft) • Insurance by actual mileage	~55
Smart grid • Cellular smart meters • Cellular connectivity to network infrastructure	~90
Remote monitoring • Monitoring of power plants and machines	~70



[1]Compound annual growth rate.
[2]Based on rough calculations.

Source: ABI Research; Berg Insight; Strategy Analytics; McKinsey analysis

baseband manufacturers rather than by handset makers. Baseband makers need to quickly define their connectivity strategy; in particular, they must decide whether to make or buy the relevant intellectual property. As a reaction to the increasing need for on-chip connectivity, Samsung recently acquired Swedish fabless company Nanoradio, which is well-known for its ultra-low-power WiFi capabilities in the mobile arena.

Challenge 5: Mobile-to-mobile communications

Another longer-term opportunity for wireless-communications chip makers is the rise of machine-to-machine (M2M) computing, also known as the Internet of Things, which spans a broad range of applications. In the automotive industry, tracking features might allow for the reduction of insurance premiums via innovative business models, such as car insurance that only bills for miles actually driven. In the smart-grid arena, cellular communications will allow sensors to report power outages and let utilities read meters without sending meter readers into homes or buildings.

While there is consensus that M2M is a promising pocket of growth, analyst estimates on the size of the opportunity diverge by a factor of four (Exhibit 6). Conservative estimates assume roughly 80 million to 90 million M2M units will be sold in 2014, whereas more optimistic projections forecast sales of 300 million units. Based on historical analyses of adoption curves

for similar disruptive technologies, such as portable MP3 players and antilock braking systems for cars, we believe unit sales in M2M could rise by as much as a factor of ten over the next five years.

At the moment, the M2M value chain is fragmented, with a wide range of semiconductor players, as well as traditional machinery and electronics manufacturers, vying for a slice of the market. So far, no player has attempted to integrate the sector vertically by forming an alliance of, say, an automaker and chip-set makers, modularization specialists, system integrators, and application developers. Once a few such alliances have formed, we expect additional growth will be driven by standardization. Chip makers must determine how to best address this potentially very large market. They need to decide how much to invest up front in the development of M2M chips, given that current sales volumes are comparatively small. Finally, they have to define which steps in the M2M value chain they want to address to be in a good position once the market takes off.

• • •

The market for wireless communications is one of the fastest-growing segments in the integrated-circuit industry. Breathtakingly fast innovation, rapid changes in communications standards, the entry of new players, and the evolution of new market subsegments will lead to disruptions across the industry. LTE and multicom solutions increase the pressure for industry consolidation, while the choice between the ARM and x86 architectures forces players to make big bets that may or may not pay off. Companies in this industry need to carefully craft, and periodically review, their strategy in order to make the right choices in an unforgiving environment.

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