Space invaders

SANTA CLARA, CALIFORNIA, AND CAMBRIDGE

America’s Intel and Britain’s ARM have long dominated different bits of the global chip market. Now each is attacking the other’s stronghold

LAS VEGAS is a city of fast bucks, fast food and fast marriages. It could also be the place where a long war was declared. On January 10th Paul Otellini, the boss of Intel, will address the International Consumer Electronics Show (CES), a vast gathering of gadget-makers, sellers and aficionados in Sin City. He will introduce a phalanx of products showcasing the chips the world’s largest semiconductor company most wants to hype.

Up on the stage with Mr Otellini will be not just PCs of the sort that the company has powered for decades, but also new slimmer PCs known as “ultrabooks”, which are being made by the likes of Toshiba and Hewlett-Packard ( HP ), and even a couple of smartphones. They represent the front-line of an army of Intel-powered kit going into battle against smartphones and tablets which use processors based on designs from ARM, a British firm.

Intel and ARM, pretty much as different in size and approach as competitors can be, have carved up most of the world of microprocessors—the most lucrative bit of the $335 billion global semiconductor market—between them. Each has a well-defined patch in which it is pre-eminent. Intel bestrides the market for the microprocessors at the heart of PCs and servers like a colossus; ARM’s legions hold sway in the wide open spaces of the mobile market, having expanded without hindrance from their home turf in mobile phones to the booming world of tablets. Neither side has shown the stomach for more than the occasional raid into the other’s domain.

The wares on show at CES provide the clearest indication yet that Intel is escalating hostilities. It is trying to break into the rapidly growing smartphone market (it already makes chips for some tablets). ARM, meanwhile, has set its sights on the server business, where its low-energy chips should appeal to customers worried about high electricity bills. And more of its processors are likely to find their way into PCs in the coming years too.

The battle is not just about dividing up territories already occupied; it is also about finding new lands to conquer. Both firms are keen to stake claims on the largely uncolonised and still somewhat notionally terrain known as the “internet of things”: the myriad processors in industrial machinery, consumer goods and infrastructure, ever more of which will communicate with each other and with distant computers. Cisco, a giant American maker of networking gear, estimates that by 2015 there may be almost 15 billion internet-connected devices, up from 7.5 billion in 2010. Whereas the market for more phones and other personal computing devices is limited by the number of persons the planet has to offer, things being more numerous than people, provide a lot more long-term room for growth.

Intel, founded in Silicon Valley in 1968, is responsible for many of the advances that have made today’s semiconductors possible. It employs almost 100,000 people and mints money. In the first nine months of last year, the company generated $40.2 billion in revenue and $23.2 billion in pre-tax profit. Admittedly, in December it cut its revenue forecast for the fourth quarter of 2011 by 7%, to $34.4 billion-$34 billion, because floods in Thailand had disrupted the production of hard-disk drives and hence demand for its chips. But that was a hiccup; Intel has no real rival in the market for chips that power PCs and servers. Advanced Micro Devices ( AMD ), the distant second in both, has been struggling. It replaced its chief executive in August after a seven-month search and laid off 1,400 workers in November.

Empire and foundry-nation

Intel’s business has been intricately entwined with the steady fall in the cost of processing power known as Moore’s Law, which is named after one of the company’s founders. Ever better chips mean ever increasing sales, which mean ever more money with which to build ever better factories for ever better chips.

The firm’s top brass attributes much of the company’s success in harnessing this virtuous circle to the fact that it both designs and makes its chips, with ten chip factories (“fabs” in industry argot) operating and two more under construction. Brian Krzanich, Intel’s manufacturing head, says this means it can bring chips to market faster and with fewer faults than rivals who
use external firms, known as "foundries," to make their chips. This helps explain why it dominates the market for high-performance processors in PCs and servers.

ARM’s chips are, by contrast, designed to economise on energy rather than to maximise processing power. And it makes none itself, instead selling licences for its semiconductor designs or its "architecture" (a recipe from which licensees make their own designs). Licensees pay a fee and a royalty of 2% per chip.

In essence, ARM provides a development base on which others build. The costs are shared, as are the resulting revenues and profits. ARM expects to recoup a chip’s development costs from the sale of the first ten licences. Royalties, which flow later, make up just over half its revenues.

Next to Intel’s leviathan, ARM is a shrimp. It employs just 2,000 people. It reported revenues in the first nine months of last year of £354m, or $568m, on which it made a pre-tax profit of £87.3m (see table). But it lies at the heart of a huge “ecosystem” of companies: a federation, perhaps, as opposed to Intel’s integrated empire. It has 270 odd licences with 850 licences. Between them they shifted perhaps 8 billion ARM-based semiconductors in 2011, half of them in mobile phones and mobile computers, the other half embedded in consumer items and elsewhere. According to IDC, a research firm, the market for PC-powering chips that use Intel’s x86 processor architecture, which Intel dominates, was about $400m last year.

The ARM federation comprises not only chipmakers but also designers of chipmaking tools, devicemakers and software companies. ARM uses collective insights to design chips it thinks its partners will need; and they in turn shape their products with ARM’s processors in mind.

The dead past
There are intense rivalries within the federation, for example between NVIDIA and Qualcomm, leading makers of graphics chips. And the dividing line between federation and empire is not always clear. Design tools such as Cadence Design Systems and Synopsys work with both ARM and Intel. So do Microsoft, IBM, Apple and others. Intel itself is an ARM licensee. But that is for the most part because those businesses straddle the divide, not because the divide is not there.

ARM’s impressive position in the mobile-device market was born out of what seemed at the time like a string of failures. In the 1980s, when the trend in chip design was to make the hardware on processors capable of ever more varied and subtle types of calculation, Acorn, a then-marginal and now-defunct British computer maker, had a niche in designing chips good at carrying out only a few types of calculation, but which did so very quickly. This reduced-instruction-set computing (RISC) approach requires software that can make up for the limitations of the chips, but uses less power than other approaches.

In 1990 Apple, struggling itself, needed a chip for its Newton, a personal digital assistant that was to restore the company’s fortunes. It liked Acorn’s chip designs: the two formed Advanced RISC Machines as a joint venture with a chipmaker. The Newton was a flop, and Acorn was wound up in 1999—the year that ARM floated. Apple, which today has a cash pile of $81 billion, sold its 43% stake because it needed the money.

When the mobile-phone market took off, ARM’s parsimonious processors were ideal for products in which battery life is at a premium and high-power chips and the fans that cool them are therefore not an option. Today more than 95% of the world’s mobile phones contain an ARM-based chip. Tudor Brown, ARM’s president and one of its founders, adds that the shift to “systems on a chip”—single bits of silicon that package together not just one or more central-processing cores but also graphics processors and other accoutrements—also helped ARM. Its stripped-down processing cores play well with others.

As mobile phones have become cleverer as well as commoner, ARM has gained again. Cleverer phones use more and pricier processors. The average number of ARM-based chips in a phone went up from 15 in 2006 to 2.5 in 2010. NVIDIA’s new Tegra 3 system on a chip for smartphones and tablets contains five ARM cores as well as NVIDIA’s own graphics-processing unit. And more, dearer cores mean more royalties. A smartphone can in the best case bring the company eight times as much in royalties as a basic phone, a laptop computer 11 times as much. This shift is far from over (see chart).

There is no such growth in the market for new PCs, which increasingly depends on the replacement of old computers by new ones with better, but not more numerous, processors, and makes up ever less of the total market for microprocessors. No wonder Intel is desperate for new territory, and willing to fight for it.

It is bringing two powerful siege engines to the field. One is its low-power Atom line of chips. The latest of these, code-named Medfield, is already in production and will almost certainly feature in the phones Mr Otellini shows off at CES. A study by Jefferies, an investment bank, says that Medfield is on a par with several popular ARM chips when it comes to processing bang for the energy buck. And Intel is working with Google to ensure that the search firm’s Android mobile operating system runs smoothly on Atom chips.

The company does not intend to stop there. The width of the circuitry on a Medfield chip is a mere 32 nanometres (nm), or millionths of a millimeter. Using a three-dimensional chip design, Intel plans to shrink that even further over the next couple of years, to 22nm and then 14nm, and sell chips that beat the competition on both energy-efficiency and performance.

The wedge
The other thing Intel is counting on to help it succeed is new leadership. In December it put Mike Bell and Hermann Eul in charge of a streamlined internal unit focused on cracking the mobile-device market. Mr Bell, who joined Intel in July 2010 after working at Palm and Apple, says the firm has hired more people with a telecoms background and assembled a team to develop software to help phonemakers get the most out of its chips. Intel has also acquired businesses such as the wireless operation of Germany’s Infineon Technologies to help with systems-on-chips. Mr Bell is confident that combining all this with the company’s manufacturing might will make it a force to be reckoned with. “We can move this army en masse over to our mobile efort,” he says.

But even if the chips prove effective, Intel will be hard put to build a phone business out from its beachhead. Getting processors on a technical par with ARM’s, says Michael Rayfield of NVIDIA, is “the easier of the two hurdles. The software hurdle is staggering.” Firms that have invested in ARM’s silicon-and-software combination
will be reluctant to give Intel's chips a chance until they are sure they can handle all kinds of software applications as smoothly as ARM's. Intel will also struggle to match the extensive and deep relationships its rival has in the phone arena. The complex relationships that make up ARM's ecosystem, says Mr Brown, the company's president, are "probably our biggest barrier to entry."

The fragmented mobile-device market also requires lots of different system-on-chip configurations, which Intel will find a challenge to match. And makers of tablets and smartphones may be reluctant to commit themselves to an architecture dominated by a single company that makes its own processors. "With ARM, when you are tired of Qualcomm you can go to Nvidia or another company," says Linley Gwennap, the boss of the Linley Group, a research firm. "But in Intel's case, there's nobody else on its team." 

Birth of a notion
While Intel is mustering its forces to attack the mobile-device business, it also faces an assault on its own redoubt. For years the firm has had an iron grip on the PC arena thanks to Microsoft's decision to design Windows, the operating system specifically to run on the x86 architecture. But last year Microsoft said that the next version of Windows, which it wants to look and feel on mobile devices as on desktops, will work with ARM chips too—one of a number of cracks in the "Wintel alliance". This could encourage more firms in the ARM federation to try their luck in the PC market, though Intel's extensive product lines and deep relationships with PC makers make it very difficult to beat.

ARM itself sees a bigger opportunity in another of Intel's dominions: servers. The server market is hatching a ride on the spread of smartphones, tablets and other devices. The more data is sent to and from the cloud by them, the more social sites they need endlessly to update, the more servers are required. And the data farms in which these servers sit have a prodigious thirst for electricity, a problem that ARM's chips were created to solve.

In November HP announced a project ambitiously named Moonshot to develop servers using ARM-architecture chips made by Calxeda, a Texas company which ARM owns 32%. The chips are less powerful than their Intel equivalents. But they are less thirsty and need less cooling, so whereas a standard rack (a man-high cabinet with about a cubic metre of volume) in a data centre can house a few hundred Intel server chips, Calxeda thinks it can cram in almost 3,000. With 100 racks in a hall, "you're talking megawatts", says David Chalmers of HP. Moonshot is designed to use a tenth of the power of current server systems and cost 60% less.

Moonshot and other low-energy servers could appeal to, say, social media companies and other web-based firms which do not need to carry out very complicated processing—which benefits from the architectures of more complex chips—or to do it very fast. But Reuben Miller of IHS thinks this segment is unlikely to be no more than 10-12% of the overall server market by 2015. And ARM's share of even that smallish slice may be modest to begin with. Just as phonemakers are used to things working in an ARM-ish way, most server software is written for Intel's chips, and reaps the benefits of its 64-bit architecture, which makes accessing lots of memory, among other things, much easier. ARM's architecture uses a 32-bit standard, and though the company recently unveiled a 64-bit version, no chips making use of it are yet available. Until they are, says Warren East, the firm's chief executive, "we can't even address probably 75% of the server market."

Meanwhile Intel isn't standing still: its investment in more energy-efficient processors, such as those of the Atom line, can reap benefits in servers as it does elsewhere. HP's Mr Chalmers, happy to work with both sides if it gets his clients the servers they need, expects to announce servers based on Atom chips and something similar from AMD this year.

Each side, then, seems to have defences against the incursions of the other. But that does not mean the war will end in stalemate. ARM is a stronger company than Intel, and the moves to develop ARM chips for servers are a sign that ARM's ambitions are no fluke.

What is more, the well-fortified world of Wintel provided the PC market with relatively juicy margins. In smartphones and tablets Intel will find itself in a much more brutal competitive environment in which the advantages of its integrated approach to design and manufacturing may well be outweighed by those of agile competitors who are better able to respond quickly to market changes.

The chips, like dust
Another big test for Intel will be the small but fast-growing market for embedded chips—the sensors and microcontrollers which will, as they become able to talk to each other, make up the "internet of things". Renesas Electronics, a Japanese company, holds the largest slice of the market. ARM also has a worthwhile chunk of it. But it is a lawless and fragmented market, largely served by inhouse designs and software that both Intel and ARM see as ripe for replacement.

In 2009 Intel splashed out $8.8bn on Wind River, a firm that specialises in software for things that you might not expect to need, in order to give its efforts in the embedded-chip market a fillip. It has since been able to ink deals with car companies, makers of digital signage and other firms that put chips into various wares. The company says that annual revenues from embedded-chip sales are now running at $1.5 billion, and it expects this to grow by 25% in the next three years.

Yet ARM's flexible business model, allowing for lots of different chips for different applications, and its success in low-volume, high-margin businesses, may well give its federation an edge in this business too. Its long experience of producing low-energy chips should be another advantage. Tiny embedded processors "will use huge amounts of processing power, but power consumption will become more and more critical," says Ganesh Ramamoorthy of Gartner, a research and consulting firm. ARM already makes a quarter of its revenue from embedded chips. And for the maker of the chips, which the company calls the Cortex-M family, nine-tenths of the licences so far sold have yet to lead to products, and thus royalties. Having your own fabs can be handy. But when it comes to invading virgin territory quickly, having lots of allies to help you is absolutely fabulous.