

Memo to Paul Otellini, CEO of Intel

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In response to the previous request, we here provide an analysis of the processor industry and the Intel Corporation. This analysis is to serve as a primer to the industry, and outlines the major challenges facing Intel. We identify in detail many aspects of the market, as well as Intel's particular strengths and weaknesses. Following this analysis, we provide in depth discussion of particular challenges that may face Intel, and conclude with several proposed strategies for meeting the future.

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Industry Analysis:

Product:

- Numerous markets for processors
 - Laptops
 - Desktops
 - Both laptops and desktops have distinct markets, the high-end market for gaming and video editing, and the low-end market for casual users
 - Workstations – very high end desktops for graphics and special effects editing
 - Servers – also has a range of levels being demanded
 - Small computing devices: These may be in cell phones, “netbooks,” “smart” devices, or any of an expanding market of ubiquitous computing devices, that is evolving rapidly

Substitutes:

- Existing uses of processors replace pre-existing “dumb” substitutes:
 - Computers initially replaced typewriters
 - With the advent of the internet, computers also replaced visits to the library
 - Increasingly, computer applications replace older activities: computer games substitute for visiting the arcade, using printshop replaces hiring a graphics artist, viewing TV online substitutes having cable or renting from blockbuster
- The phenomenon of computers (specially, processors, the ability to make “smart” machines) replacing existing activities is not over. It will continue, and it may result in smart applications that will replace existing uses of the computer (and thus, existing markets for the processor).
 - Increasingly intelligent hand-held computing devices are replacing dumb cell phones that do nothing but make calls, increasing the market for more powerful processors.
 - The shift toward “smarter” machines has extended to cars, planes, helicopters, and various consumer devices, all expanding the market for processors.
- Existing markets for processors are at risk of radical changes, although these may be hard to predict
 - For years, predictions have been made that TVs and computers will eventually be merged into a single unit, which would change the range of customer needs a processor might have to satisfy. This is technically possible today, but not popular.
 - Many people are increasingly using only their laptops. They are sufficient for most uses (described in the next section) and can be supplemented by being “docked” to high quality screens and speakers when at home, eliminating the need for a desktop. Intel must be mindful of such shifts in technological needs.

- With powerful processors becoming ever smaller and running on less and less energy (coupled to the increased capacity of memory storage systems) the same could be done of a hypothetical “very powerful hand-held PC.” Connected to these things as well as a keyboard, both desktops and laptops can be substituted for something new.
- New and emerging markets may cannibalize old and existing markets.

Market needs:

- Laptops:
 - Generally for basic mobile computing – internet surfing (wirelessly), word processing, email, and other basic functions, on the go.
 - Needs cheap, low power, low heat processors
 - There does exist a “high-end” laptop market that serve as desktop replacements, having capabilities similar to high-end desktops
 - Needs low power, low heat, high performance processors
- Desktops:
 - Basic computing – internet surfing, word processing, email, photo editing
 - Needs cheap processors
 - High-end desktops – computer aided drafting, video editing
 - Needs powerful processors
 - Gaming desktops – powerful machines specialized for playing games.
 - Needs powerful processors. Heat and power consumption are not an issue.
- Workstations:
 - Essentially very high end desktops meant for quality graphics editing and special effects editing.
 - Needs multiple powerful processors
- Servers:
 - Servers are made for a variety of purposes and range in size and quality from a unit barely bigger than a desktop and no more powerful, to monstrous modular machines with thousands of times the computing capabilities of the average desktop
 - Needs the entire gambit of needs, but server processors are typically specialized from the others
- Ubiquitous computing devices:
 - The purpose of any particular device can vary radically, and a given device may require a specialized processor model that will only be made for a small number of devices.
 - The most ubiquitous requirements for processors in such devices are that they are very-low power, very-low heat. How powerful these processors can get may limit the

capabilities of the device. The capabilities of the device will influence its demand, and thus the price range needed for the processor.

Entry barriers:

- Intel and its only major competitor, AMD, have major brand name recognition.
- Intel and AMD produce on a massive economy of scale (marginal costs are negligible compared to prices). New entrants would need to achieve ~10% of the market to achieve a profitable market share – not an easy task.

Buyers:

- Essentially, everyone. Individuals cannot change the price due to the size of the market.
- Computer manufacturers can affect the cost somewhat by making bulk deals with Intel or AMD.

Suppliers:

- Silicon and other raw materials. Suppliers are many and insignificant - they have no bargaining power.

Complements:

- The complements of the processors themselves are the various components of a computer. Considering those complements that may be limited specifically by the type of processor, those include motherboards, ram and CPU fans.
- Some processors also deliver differential performance depending on what graphic card they are used with.
- Certain software works better with some processor types than others, beyond mere performance requirements.
- The performance of the processor affects the value of certain programs, especially games. The more powerful the processor, the more powerful the game.
- All distinctions in performance aside, a given processor is usually designed to have maximum compatibility with other components, making motherboards the most limited range of compatible products to complement a given processor. However, there are many motherboard manufacturers that make high and low end models for every processor type, so this is not an issue.
- It should be noted that Intel manufactures its own Intel-compatible motherboards in addition to manufacturing motherboard chipsets for other motherboard manufacturers. There are also entirely third-party motherboards that are compatible with Intel processors.
- On the same note, AMD currently manufactures graphics cards and graphics processors under the company ATI. These products are compatible with Intel processors and motherboards, however.

Competitors:

- AMD: Not worth trying to drive out AMD
 - Ruinous price war would be impossible to win quickly (AMD produces at roughly the same marginal cost).
 - Not worth going after AMD's small market share at the expense of Intel's large, existing market share
 - An expansion of the market in response to lowered prices would not mitigate the effects of a price war, as the market is near saturation even without price considerations (processor is only %10-%20 percent the cost of a prebuilt computer, the main source of consumer processor sales).
- New entrants:
 - Massive economy of scale inhibits entry into existing major markets.
 - Do economies of scale apply to specialized processors for ubiquitous computing devices? Intel must produce processors for the leading edge of small computing devices, lest it be supplanted by an unforeseen substitute to home-computing.

SWOT Analysis:

Strengths:

- Leading market share in computer processors
- Massive R&D budget
 - The computer processor market is highly R&D driven: Devices are constantly getting faster, smaller, cooler, and more energy efficient. R&D into any one type of processor can yield advances in other types (the same principle that lead to Intel's current flagship processor, the Core 2, efficiency in the circuit to improve performance, also allowed for a low-heat laptop version).

Weaknesses:

- Not currently in the ubiquitous computing market. R&D budget is tied to its existing market. A loss of revenue or conversion of its products into commodities would ruin the existing paradigm.
 - Intel formerly manufactured processors for ubiquitous computing devices (Xscale) but sold this line of processors in 2006.
- No market presence in GPUs (ceded the market for low-end, integrated GPUs to Nvidia).

Opportunities:

- The ubiquitous computing market.

Threats:

- Nvidia:
 - Currently manufacturing all-in-one processors (GPU, CPU, and memory controller) for ubiquitous computing devices (Tegra model, for example).

- Also manufactures popular motherboard chipsets and GPUs
- AMD:
 - In addition to manufacturing CPUs, manufactures GPUs and full graphics cards under ATI name.

Major Issues facing Intel

AMD:

AMD is the second largest manufacturer of computer processors next to Intel. AMD traditionally held onto the low-end market for desktop processors, but forced itself (eventually, successfully) into the market for high-end desktop and laptop processors in response to a challenge to its own market by Intel. Since then, AMD has acquired ATI, one of the two major manufacturers of GPUs. Intel has fortunately regained the lead in processor design with the release of the Core 2 duo and quad series of processors for both desktops and laptops.

Intel currently manufactures motherboards and motherboard chipsets that are only compatible with Intel processors, although they are compatible with AMD's ATI graphics cards. ATI manufactures these graphics cards as well as the graphics processors themselves for other companies' graphics cards. The incompatibility of Intel's motherboards with AMD processors does not affect the market, however, as numerous third-party manufacturers exist for both motherboards and chipsets. This same body of manufacturers (specifically, Via) prevented Intel's substantial market share in processors from translating into control over all other components of the computer.

Presently, despite competing with very substitutive products within the same market, both AMD and Intel price their products well above the marginal cost. There are several reasons for the absence of a price war between the two companies. Firstly, the market for processors is already rather saturated; processors only constitute 10%-20% the cost of a computer, so a change in price (which would be diluted by the computer manufacturers for most sales) would not dramatically increase the sale of processors even if the price was dropped to near zero. In addition, both Intel and AMD produce on a

similar scale relative to their market shares; AMD could not hope to supply as many processors as Intel does without experiencing a substantial increase in marginal costs and/or making a large capital expenditure. Contrastingly, to win a price war, Intel would have to sacrifice a substantial portion of its revenue for a long period of time to acquire AMD's relatively meager share of the market. Thus, even though the two companies are in competition for the same customers with substitutive products, the optimal price for each remains well above cost and a price war would be more detrimental than beneficial to either side.

The question arises, what would happen if Intel or AMD were to attempt to duel formats to diminish demand for the other's products? AMD, if it so wished, could make its graphics cards incompatible with Intel processors, forcing fans of ATI to use AMD processors. And Intel, if it so chooses, could do the same thing. However, if AMD adopted this strategy, Intel fans would still have Nvidia cards to use, and all AMD will have accomplished is ceding the bulk of the video processor market to Nvidia. On the other hand, if Intel made its processors incompatible with AMD, it runs the risk that Nvidia, an independent company could side with AMD. While Nvidia may be reluctant to side in a format war with its single major rival, it would also likely prefer not to be slaved to a single supplier of processors.

In conclusion on the matter of AMD, Intel faces no particular threat from AMD's current market model. Neither a price war nor a format war should be expected, nor is either a good choice for Intel. If AMD and Intel continue to compete by continually improving their products, the only chance of disaster to either company would come from

the possibility of one company achieving and maintaining a substantial superiority in product design in many or all markets for computer processors.

Nvidia:

Nvidia is one of the two major manufacturers of GPUs. Nvidia also manufactures popular motherboard chipsets. While Nvidia historically has not been in competition with Intel, it does compete in the market of ubiquitous computing processors with its Tegra line, for example. Amongst all the manufacturers for processing hardware for small devices, Nvidia is likely the single most well primed company to enter the computer processor market with its existing market share and expertise in building GPUs and motherboard chipsets. It also already has strong brand name recognition in the market for computers. Such an entry into the market should be a top concern of Intel, as it would be an extremely unenviable situation if Intel's two major competitors controlled the supply of one of the necessary complements to the CPU.

Ubiquitous computing:

Ubiquitous computing presents a unique challenge to the processor industry, one that can be ignored or embraced. The technologies being developed are at times in distinct markets from those populated by conventional computing technology (if such a phrase can be defined, given the rapid evolution of the field). For example, GPS navigators and ATMs created new markets for computer components without supplanting the existing market. Intel can, as it wishes, develop processors for these devices to diversify its market holdings. However, these are not typical markets for Intel, as its contribution to such devices is not a selling point, and so does not contribute to

competition between such devices (it is rendered a faceless second-order supplier by consumers).

But ignoring this market, or approaching it as being separate from home computing, may prove disastrous. Ever more frequently, hand-held computing devices and smartphones are acting as substitutes for many of the uses of home computers, such as web-surfing and email. While on some level these may act as mere alternatives to use when it is logistically impossible to use a computer (such as when one is on the bus), they may acquire a trend already seen in laptops. This trend is to own a small laptop for a portable computing experience, and then connecting it to a docking station at home that grants it a full sized keyboard, large screen monitor, mouse, printer, speakers and even external hard drives for desktop-like storage space. While this trend may be on such a small scale so as to be hardly significant, it may be an omen for things to come in the unpredictable world of computing. For a consumer who has done this has removed his need for a desktop. With the exponentially increase in processor performance, and regular advances in further miniaturizing information storage (hard drives, ram, solid state drives), it may soon be conceivable that a cell phone will possess the computing power of one of today's low-end computers. And if this phone could be connected to the docking station the same as a laptop, there would be no need for a computer. Of course, suppliers would be needed for these new technologies, and Intel may be among them, but it will change the face of computing. The average home computer may become a disposable commodity (keep the solid state drive with your data and programs, keep your monitor speakers and etc., but chuck the computer as easily as you'd chuck a finicky cheap cell phone).

However, this doomsday scenario for the home computer has been predicted on numerous occasions and has never come to pass. The major problems facing the scenario are: 1) With many interacting components, the possibility of failure can be higher than that for a single, prebuilt computer; 2) Few consumers may be willing to accept such a radical change in how they use their home computer; and 3) The rapid changes in technology (shifting standards and performance demands) may make the concept impractical for most consumers.

An additional note of caution on this subject would be that many an electronic device has lived far beyond its predicted death: people still go to movie theaters even though renting is cheaper; radios are still popular decades after the introduction of the TV; we still have separate DVRs and computers even though they can come in one box; we still use landline telephones even though web-based services are cheaper; and we still rent from blockbuster even though we can order films online or through our cable TV service.

Recommended Strategies:

The computing market is closing the gaps between what were previously separate technologies (desktops/laptops and cellphones/smartphones etc.). Hand held devices are getting ever more capable, while laptops are becoming even smaller and cheaper. And assuming it catches on without supporting Windows, the \$200 laptop has already arrived. Thus, the world of computing technology is becoming increasingly commoditized, even as markets for high end processors and devices that use them continue to thrive. The path that Intel takes in the coming years must maintain its foothold in the classical markets for computer processors, while also preventing the prospect of challenges from a growing body of processor manufacturers for ubiquitous computing devices, or even challenging them itself.

Maintain the existing market paradigm:

As many consumers substitute their desktops or laptops for cheaper computing devices, Intel must act to maintain the high demand for high priced processors. While the market for such processors is in no danger of vanishing anytime soon, this high revenue market can fuel R&D that can both perpetuate advances in high end computing while providing key insights into building cheaper processors as well.

Intel previously maintained its share in this market by aggressive brand-name advertising when it was the performance leader in processor design. But the existing market is one in which the average consumer can do well with competing technologies, and in which the average consumer is also better informed and price conscious.

Intel's goal in this arena should be to maintain a demand for high-performance processors by maintaining a demand for performance intensive software. Intel should

take advantage of its current lead in processor performance and heavily advertise (jointly with software developers) the experience of cutting edge video games, video/photo editing, and other high-end applications. Ideally, as many consumers as possible should be perpetually dissatisfied with the performance of their current computer hardware.

Blocking new entrants:

Manufacturers of processors for ubiquitous computing devices are currently gaining expertise that may be exploited to gain entrance into the general computer processing market. As mentioned previously, Nvidia is the primary threat in this arena. In addition, these manufacturers are making processors for devices that are increasingly potent substitutes for some if not all uses of laptop and desktop computers. So while the general computing market is not at risk of vanishing, it may not grow as quickly as it would otherwise.

Intel's advantage in maintaining the entry barriers to its market comes from its massive market share. This market share, with high marginal profits, permits Intel to have a massive R&D budget. This budget allows Intel to continually make better and better processors, and can actually translate to advances in other markets as well. For example, when Intel introduced the Core 2 to replace the Pentium 4, it abandoned its previous strategy of making yesterday's high end processor today's medium processor. Instead, it brought an entire new line of processors, from low end to high end, all based on the same Core 2 architecture. Thus, even the cheapest Core 2 performed comparable to the most expensive of the competition. Nvidia and ATI have been following a similar strategy in the release of new GPU lines for years.

It does not seem too big of a stretch to assume that Intel may be able to translate its advances in R&D into superior small processors for ubiquitous computing devices.

With its prior experience in graphics processing, it should also be able to introduce full systems on a chip to compete with Nvidia and other players in the ubiquitous computing market.

This brings back Intel's primary advantage. With its massive R&D budget, and its substantial marginal profit, Intel can supplement the development of new chips for ubiquitous devices with experience gained in development for its existing markets. In addition, Intel could aggressively price its processors for ubiquitous computing devices. If R&D succeeds in supplementing a sufficient amount of the development costs, Intel could even choose to manufacture the chips for near costs. This would have the effect of strangling the profits of other players in the market. With Intel's budget coming from a different market, its competitors would have little hope of competing on the same terms.

Intel should also be prepared to reenter the market for graphics processors in case Nvidia decides to begin producing computer processors, lest it be isolated from the GPU manufacturers.