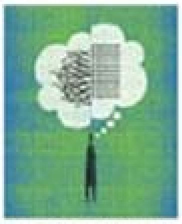

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Assembling the Future

A Newsletter About the Design and Production of Electronics

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Opportunities And Obstacles - A Look At EDA Business Models

Mike Gianfagna, VP Marketing, Atrenta Inc.

Much has been written about the fact that EDA software doesn't get monetized correctly. It's an industry that in some very real ways makes the semiconductor business possible. Yet the size of EDA is in the neighborhood of two orders of magnitude smaller than the semi business it supports. This seems odd. What causes such a disparity? I would like to explore some reasons for the disparity and maybe discover some solutions to the problem along the way.

Over the years, I have agreed and disagreed with things EDA industry analyst Gary Smith has said. A few years back he came up with a gem of a comment. Paraphrasing, he pointed out that the EDA industry is, at its root, an outsourcing business. That is, EDA started as a captive business inside some of the larger IDMs and vertically integrated companies. Bell Labs, Texas Instruments, RCA, General Electric, National Semi and IBM to name a few.

All had fairly large internal CAD development teams. In the early 1980's, some of the developers from these companies set up shop as independent software suppliers. Daisy, Mentor and Valid are the "famous" ones from that era. Only one remains today. Consider the sales cycle in those early days of EDA. The person that used to develop software for a particular IDM now comes through the front door to sell commercial software tools to their prior employer. The person sitting across the table from them used to be their internal customer. They are now their (potential) external customer. That person knows exactly what it will take to develop the software being sold. They watched it at close range for many years.

The prospect of getting these tools from an external supplier does have advantages. Lower cost of ownership, exchanging fixed cost for variable cost, amortization of development over a larger user base, etc. So, these early and very educated customers calculate the cost of internal development and offer just a slight premium over that cost to the new EDA vendor. And the EDA vendor takes that deal. At that moment, the EDA vendor had a choice. They could have positioned the value of the software relative to the business they were creating for their customer. You can't tape out a chip without EDA tools, and no tape outs means no business. Or, you could simply take the low hanging fruit represented by the cost-based deal, and not push for the value-based deal. The early vendors chose incorrectly, and we've been trying to fix it ever since.

And it got worse. What is the EDA budget for a given customer? If we know that, we can keep throwing product at them until we have all the budget, then move on to the next account. This strategy was carefully thought through, and the flexible access model, or FAM deal was born. All the software you want, for a fixed price (of your entire budget). This practice further eroded the value of EDA tools.

So, the value proposition for EDA tools has been obscured over the years thanks to predatory pricing. Let's put the pricing model aside for a moment and examine the basic sales model of EDA tools. With few exceptions, EDA has been sold as a cost of doing business, with no real connection to success. In fact, there is an inverse influence. The worse-off the design, the more EDA tools you'll need to fix it. So, bad design practices and tight schedules really help the model along.

If you look through the history of EDA, you will find times when a pay-per-use model was tried. On the surface, this seems to somehow tie what is paid to the benefit received. The problem with this model is that automation works best when it is aggressively used, and pay-per-use schemes incent the customer to use the software less, and not more. Back to the drawing board. A rather famous counter-example of EDA's somewhat dysfunctional business model was developed by a semiconductor IP provider Artisan Components.

Artisan gave away their IP for free to end users and the foundry paid the bill in the form of wafer sales royalties to Artisan. Brilliant move. More foundry tape outs are facilitated, and payment only occurs when there is actual silicon revenue which is the end goal for everyone. Some other IP vendors put a twist on this idea by charging wafer sales royalties to the end customer (and not the foundry) if their IP was used. In both of these models, everyone makes money *only* when wafer volume is achieved. This is a success-based model. Seems to make more sense.

Well, it does, right up to the point where the vendor asks for a cut of the end customer's profit - which is driven by margin on the chip sale, which is driven by the wafer price. If you ask for a royalty based on wafer volume, you are definitely affecting the profit for the end customer, and not in a good way. These discussions are usually short, and don't usually end in "yes".

So how do we fix the pricing model and overall business model for EDA? Let's start by admitting it's currently broken. If we can achieve widespread agreement on that point, progress becomes possible. The business model issue is actually easier to repair. If EDA vendors can propose reasonable share-the-success models, I believe there will be positive reception. Having a complete, reliable and compelling product offering will be necessary. The pricing model is more problematic however. As long as the major EDA suppliers focus on taking existing market share in order to grow, we'll have the problem. If the focus was on opening new markets, there would be a better chance for repair. So far, this hasn't happened, but one can be optimistic.

The EDA Industry Must Evolve

by Gabe Moretti

Professor Jan Rabaey of the University of California at Berkeley calls the coming smart world "societal information technology systems" or SIS. Information technology companies have identified smart systems as the next big thing. Sam Palmisano, IBM CEO, has made smart systems a priority for the company. Electronic hardware plays a significant but an ever decreasing part in the functionality of these systems. Is the EDA industry condemned to follow the hardware destiny, or can we grow with the coming systems?

The question should be addressed today, and in fact should have been addressed a few years ago, by our industry leaders. The fact that semiconductors transistors sizes will continue to shrink for the next four or six years is much less important to the potential for growth of EDA, than whether the industry can play a significant role in providing the tools and the environments to build the coming super systems.

From an economic and business model point of view, has our industry really mastered the globalization of research and development activities? Specifically will the United States find ways to maintain its leadership position in EDA? Some signs point otherwise. All US based leading EDA companies have off-shore activities, initially created in search of cheaper labor. But is this enough? Probably not. It is time to look at obstacles and opportunities for EDA.

Introduction

No one can argue that the EDA industry is in a period of transition. Any one with any remaining doubt has only to look at the publication in April last year of a document by Cadence's John

Bruggeman. A document he called EDA360. It is the first public attempt by an senior executive of our industry to provide a look at some of the opportunities for growth available to our industry outside of following Moore's Law, and one of the very few available documents that acknowledges the importance of the entire system, not just the electronic part to the future welfare of EDA. EDA360 encourages the companies in our industry to be a part of the development of smart systems in their entirety, not just their hardware components. The problem is not just how to integrate hardware and software on a piece of silicon, but how to implement an application on an IC.

The first EDA companies, Daisy, Valid Logic and Mentor, focused only on computer aided graphic design of electronic circuits. By focusing on the need to graphically enter the electrical design of a Printed Circuit Board (PCB) the initial EDA companies ignored all other parts of the system, like its physical characteristics and its environmental requirements, like enclosures. They also omitted any opportunity to connect the drawing to manufacturing, like parts inventory management. So while the early EDA vendors stimulated the birth and growth of workstation companies like Apollo and Sun Microsystems, they also limited the scope of the industry to exclusively electronic design and development applications. For them what functions where implemented on the PCB was not relevant.

Historians tell us that although it makes no sense crying over spilled milk, it is important to study the reasons for the spillage. The reason for the present state of EDA and the lack of growth commensurate to that of its major customer industry, semiconductors, is that the focus was too narrow. EDA vendors continued to be preoccupied with simply the design of hardware systems, avoiding even the support of most of the manufacturing issues involved. What are all of the components of a SIS? The correct answer to the question can provide a guide to opportunities for growth. Opportunities are available to those addressing the total needs of system architects, designers, and builders, when the system is seen in terms of the application it implements. What follows is a descriptions of some of the obstacles and opportunities facing the EDA industry.

The World is Getting Flatter

The EDA industry is extremely sensitive to world financial events because it is a service industry whose revenue depends on decisions made by companies producing electronic products. Globalization is both an obstacle and an opportunity to the growth of the EDA industry. Viewed in the abstract it is an opportunity to expand markets and to find qualified professionals to hire without the need for relocation. But from a national point of view, especially in the US, globalization is an obstacle. The fundamental reason is what noted TV commentator Fareed Zakaria calls the "hollowing out of the American middle class".

Globalization forces the entire world population toward the greatest common denominator in terms of quality of life. Thus richer countries, like those of the European Union and North America, are unfortunately moving toward a lower standard of living, while developing countries, like Brazil, India, and China in particular, are experiencing a modernization of their life style. As a country modernizes, its population gets richer, albeit in a very uneven manner. But the overall tendency is for an increase in salaries and benefits, as well as a growing entrepreneurial movement. Employees of EDA companies in India for example, who once were skilled cheap labor, are turning into local competitors first, and if sufficiently financed, into regional competitors. This trend is even accelerated if aided by a central government, like China, intent on growing national capabilities in view of achieving significant international leadership in the technology markets.

Social unrest, like what Greece and Ireland are experiencing, is bound to expand in western Europe, while polarized political sentiment is already growing in the United States. When companies cannot plan within a stable system, economic growth suffers. On the other hand, consumption of electronic goods and goods that have a high content of electronics components, such as automobiles, is increasing in developing countries. On the surface, it would seem that the impact on established EDA companies would be neutral. But this is not the case.

The EDA industry has used entrepreneurial innovation as its growth engine. And the innovation has occurred in very large part either in the United States or in foreign locations of American companies. As indigenous markets grow stronger in the developing countries, innovation will be global, supported by the availability of local capital as well as national governments stimulus.
The larger EDA companies will find it harder to grow by acquisition because they will have to develop a totally new set of business relationships. It is not just a matter of recognizing the technology, or even to calculate its monetary potential. It is a matter of negotiating the financial and legal terms. This is easier to do in Silicon Valley, where everyone involved knows each other. It is another matter dealing with financial individuals and legal teams in a foreign country, especially if that country is weary of "colonizers".

As system level design becomes the prominent growth area for EDA, vendors will find that the growth of off-shore accounts will be greater than that in the US. Thus international marketing and sales will become more important in order to reach promising small foreign companies with the potential for growth. Another problem for EDA vendors, whose major asset is their Intellectual Property, will need to be sure that they can arrange highly informed local support and still protect their legal rights in areas where Patent protection is "different".

Small is Not Beautiful

The EDA industry is so different from any other industry that it presents a real problem to the traditional financial markets. The EDA industry has around 18 companies that can be defined as true tools vendors. All other business entities, the vast majority of them set up as companies, are really, in the words of an executive of a very large US semiconductor company, "service providers". These companies have one product they have developed and sold to one or at most a handful of customers. They stay in business by maintaining and upgrading the product in response to the needs of the small customer base they have.

With the growth of international markets, small companies will find it very hard to expand their customers base because to do so would take more resources than they have. The problem is marketing and sales in various parts of the world and integrating their product within an existing flow. Convincing a prospect to invest very expensive time in testing and evaluating the expected productivity improvements, and beating the established competitor on price and support, is a task that requires significant time and a continuous local presence.

The only possible traditional exit strategy for investors backing small EDA companies is for the company to be acquired, something that is not about to happen as often as it was, or with last century's multiples. Acquisitions are very seldom made to obtain a superior technology. They are made for business reasons and very often for defensive reason when the small company successfully establishes a toehold in a key account of a larger company.

Venture capitalists are faced with a dilemma. The funding required to bring a product to market successfully increases annually, while the number of successful exits, either through an acquisition or a public offering, is diminishing. In fact today it is almost impossible, with the exception of at most a handful of privately owned EDA companies, to foresee a successful public offering by an EDA startup.

One possible solution is to bring back a business model that was all the rage in the 1970's: conglomerates. While at the time a conglomerate was built using companies from various industries to lower risk and improve revenue by averaging the fluctuations in the markets served, the EDA conglomerate would only be made up of "EDA" companies. I use the term EDA in quotation marks because most IP companies do not like to be known as EDA vendors, preferring fab-less semiconductor as their descriptive term.

A group of small EDA vendors could grow into a relevant financial entity if it is built around a design and development flow that addresses all of the needs of system development, from architecture to at least RTL, or even silicon. The financial and legal instruments that would assure the just payoff once the conglomerate goes public are available. What is needed is the vision and the fortitude to compete.

The Self Inflicted Brain Drain

Before globalization, nations, like the United States, were concerned with protecting the ability of finding a job by its citizens. The solution was to set up barriers to entry in the labor force by foreigners. Thus the US Congress passed a law that established a work visa quota for non-citizens that graduated from American universities. That barrier continues to exist today. It is called the H1-B visa. There are a total of 65,000 H1-B visas available each year, plus another 20,000 for foreign students achieving a higher degree (MBA, PH.D. or equivalent). Thus every year up to 85,000 non-citizens can qualify to obtain a work permit and start on the road toward eventual citizenship if they so desire.

It may seem that 85,000 is a fair number. But reality says differently. In 2009 there were over 670,000 foreign students that graduated with a degree from an American institution of higher learning. That means that well over half a million professionals have likely returned to their country of origin and entered the labor force there. With globalization, they are competing directly with US nationals, thus the H1-B visa has not only failed to limit competition for professional jobs, but has in fact become a deleterious factor in the US economy.

The reasons are evident. Once outside the country these professionals, even if employed by American companies, do not pay American income taxes, do not contribute to Social Security and Medicare, and do not pay state or local taxes of any kind. Thus, although they contribute to the productivity of American companies, they do not contribute to American society.

In the EDA industry a significant portion of the yearly 85,000 H1-B visa recipient stay in Silicon Valley giving the false impression to the superficial local observer that there is in fact an equitable policy toward foreign students. But the numbers say otherwise. The United States has put itself in the unique position of educating its own international competitors. People who, by the way, have no special allegiance to the US and must in fact compete with US companies in order to be successful.

It is time to take another look at the benefits of bringing back some of the jobs that have been moved oversea for economic factors. To begin with we need to revise the H1-B visa procedures to allow many more foreign professionals that have been trained in American university to stay and develop their careers in the US, thus contributing to our economy, not that of their country of origin. Taiwan, for example, claims to be a leading provider of automotive electronics, both in development and in manufacturing of those devices. Yet many Taiwanese engineers have been trained in the United States.

Companies must begin to think globally and act locally, by implementing strategies that increase local markets, not just foreign ones. This does not mean, by the way, condemning developing countries to stagnation. It just means that their development will take a different course, developing and manufacturing goods a healthier US economy will need and pay for.

One of the first things that all industries, not just EDA, must do is working to improve the quality of education that US students receive through high school. At present, US high school graduates are not competitive with their peers from practically all developed countries in the world. Our skilled labor force is not competitive. A worker needs a good all around education, not just the capacity to perform a specific skilled job in a quasi-robotic fashion.

The Shrinking Market For Custom Design Tools

EDA tools that help engineers transform the description of a circuit from Register Transfer Level (RTL) into a manufacturing input file have traditionally commanded a higher price and generated a higher profit margin, often by a factor of ten over design entry and analysis tools.

But the market for such tools is shrinking, not growing. As application specific integrated circuits (ASIC) designs become more complex and costly, the number of companies developing them is decreasing or, at best, not growing with the same rate as the market for electronic end products. The number of semiconductor manufacturers is also decreasing as foundries find ways of consolidating in the face of enormous investments (around $6 billion) required to build a new state of the art fab.

The ability to verify a design at the highest possible level of abstraction requires advances in formal verification and in fact in formal design techniques in general. Although higher level synthesis tools have made good progress lately, more is required in order to reliably support RTL signoff. This level of signoff will be required by the complexities inherent in device fabrication in the next foreseeable process nodes. System companies must, in order to retain development costs within practical limits, be able to assure themselves that semiconductor fabricators can take a design and implement it in silicon using proven methods that are capable of achieving a satisfactory level of optimization in both number of gates and execution speed.

Efficient computer based simulation is a requirement in the development and verification of large, heterogeneous systems. Designers have employed tools that support multi-threading, and now parallel processing to simulate the very large designs now possible. Hardware based acceleration and emulation, together with Virtual models of CPU's and MCU's are fundamental tools to satisfy the requirement. More development is needed, both to improve the power of the tools and to lower their cost. How such tools can fit in the cloud computing model is another challenge to the creativity of EDA companies. Can virtual prototyping laboratories exist in the cloud? What are the financial implications?

Faster execution times have madeit possible to use software where hardware implementation would have been the only solution just a few years ago. In fact execution speed is now sufficient to erase the deficit inherent in FPGA devices for many applications. EDA growth is at the system level, but these tools have been sold at a discount as a means of entry to the more lucrative "below RTL" market. Clearly a fundamental change in revenue generation strategy is required.

FPGA devices can be manufactured with the latest process. In fact FPGA geometries are used in the development of a new process node. The regularity of the structures and layout means that many of the design constraints are implicitly met. FPGA production has better yield than any other design with a new process, and thus as volume increases, prices can be lowered.

As the inventory of FPGA specific IP increases, more applications can benefit from choosing this type of implementation over ASIC. The economic tradeoff of developing an ASIC design for the 65 nm process versus implementing the same design on a 40 nm FPGA is no longer obviously in favor of the ASIC, even if the product is expected to sell millions of units. Significantly lower development cost and shorter time to market, combined with the flexibility of updating the design without having to change the physical characteristics of the device, generally counter the higher unit cost of the FPGA.

Design and development of FPGA based systems is a market that, with very few exceptions, has not been a priority for EDA vendors. There is an opportunity to consider the entire collection of issues faced by an FPGA implementation, and thus address new market opportunities. Certainly hardware/software co-design and co-development, but also optimization of partitioning among multiple devices, and issues of physically optimized packaging and integration of the device with the rest of the system, and the portability exploration, all would allow the use of competing FPGA vendors for the same implementation. A few years ago some companies tried to develop tools to migrate an FPGA implementation into a ASIC at a very low cost. None reached success, but I believe that the time is now different and this market segment has potential.

Redefining "System"

The entire EDA flow can be described in terms of enterprise software, as Mike Gianfagna of Atrenta has pointed out in the past. A new business approach that stems from this consideration might be the catalyst for a new business model that finally gets rid of the petty price competition that is the major cause of relatively low revenue when compared with the enabling capabilities provided by EDA.

What is a "system"? It is not just the hardware, it is not just the software, it is not, in fact, just the union of the two. When thinking about providing tools for system architecture, design, and implementation, EDA vendors must consider how a system comes together and support the tradeoffs that architects and marketing planners make in developing the engineering specification. Good tools that allow us to evaluate market requirements in light of what is possible and available to engineers. Tools to evaluate third party IP in a reliable and standard manner. Becoming, in fact, distributors of IP, like Cadence and Synopsys are doing, but without the parochial limitations that exist today. At present, the IP market is seen by both vendors as an enabler to sell EDA tools, while, instead, they should be developing their own components distribution market.

EDA vendors must start by targeting application markets, not just IC fabrication. What the Systems Division of Mentor has done is a good example of success that derives from this approach. What once was only a developer and seller of tools for PCB design, it now offers in addition cabling and harness design tools, and thermodynamic analysis tools all targeting the design and development of electronic automotive subsystems. Of course the inventory of tools is not yet complete, but it is a good start!

To simplify their life, EDA vendors have invented the term "System On Chip" or SoC. This limits how they think of a system to those tools that are used to produce the circuitry that is implemented in a ASIC device. Therefore they only consider hardware, in a few instances both digital and analog, and firmware. But packaging must be designed with the rest of the product, not as either a given constraint or an after thought. The overall product environment must be taken into consideration, not just the device itself. Temperature and power constraints, for example, derive from the entire product environment, not just from the limitations of a process or a packaging choice.

Human/computer interaction methods have improved tremendously since the introduction of a card reader and a printer as I/O devices. But more application specific inventions are needed, both in methods and in devices. Embedded and wearable electronic devices for humans are already available, but many more applications are possible. EDA companies should begin to look at these application markets and take a leadership role in developing the tools required to implement these products.

Conclusion

A system is only as smart as the human who who evaluates it. The EDA industry technology is very smart, while its business model leaves a lot to be desired. Therefore it is not surprising that the greatest opportunities for growth rest in the business methods of the EDA industry. Of course there are significant technological opportunities, but their benefit to the industry will be diminished without a new approach to profit generation.

Indigenous Innovation and Globalization the Challenge for China's Standardization Strategy

Dieter Ernst, East-West Center, Honolulu

China's 11th Five-Year Plan for Standardization defines standardization as an enabling platform for indigenous innovation. That commitment to use standards as a tool for economic development has virtually no parallel. It reflects a major transition in China's development model from export-oriented industrialization to an upgrading-through-innovation strategy. It is this development aspect that distinguishes China's standardization strategy from standardization strategies in the US, the EU and Japan.

A new report (Indigenous Innovation and Globalization--the Challenge for China's Standardization Strategy, *Draft scheduled for publication by the East-West Center and National Bureau of Asian Research (2011)*) documents the rapid pace of change in China's standards system and explores possible impacts for China as well as the global economy. At the center of the analysis is a fundamental challenge for China's standardization strategy: How to reconcile the primary objective of strengthening indigenous innovation with the countrys leading role in international trade and its deep integration into global corporate networks of production and innovation?

An in-depth analysis of recent policy initiatives (on indigenous innovation products; government procurement regulations; and the role of patents in standardization) shows that responses by Chinese authorities to complaints (by both Chinese and foreign organizations) have softened some of the initially harsh requirements. And recent developments in three ICT standards projects (TD-SCDMA, IGRS, AVS) indicate that both the Chinese government and industry are learning from mistakes and are moving to a more flexible and pragmatic approach.

While the implementation of China's TD-SCDMA project remains decisively top-down, the contents of policy is moving away from regulating the market to promotional policies. With the transition to next-generation mobile telecom standards, there is greater openness to foreign participation. In addition, R&D and patent data add to a picture of an overall positive impact of this project on China's innovation capacity. The report documents that China's IGRS and AVS standards projects are developing sophisticated standardization procedures and IP policies that are demonstrably fair and transparent. While both projects had to go through an arduous learning process, they have succeeded in developing institutional innovations that have allowed them to overcome their latecomer disadvantage. Policy makers and corporate executives in the US, as well as in the EU and Japan, would be well advised to study these Chinese institutional innovations and to learn from them.

However, the report also highlights two important drawbacks of China's standards and innovation policy. First, elaborate lists of products and technologies that are constructed to assess compliance with China's standardization and certification requirements may have significant negative impacts in the rapidly moving ICT industry. These lists risk being quickly outdated and bypassed. Even more important for China's objective to foster indigenous innovation is that such control lists focus on *existing technologies,* rather than on the future innovations that they are designed to promote.

Second, in its current form, China's policy on Information Security Standards and Certification (especially the National Information Assurance Policy Framework Multi-Level Protection scheme [MLPS]) could create unintended disruptive side effects for the upgrading of China's standardization system. There are widespread concerns in the international community that an extensive scope of regulation and a lack of coordination between Chinese security policies and trade policies could create potentially serious trade disputes.

China's standardization strategy needs to be viewed in the broader context of its development strategy to catch up with the productivity and income levels of the US, the EU and Japan. To achieve this goal, China's government seeks to move from being a mere *standard-taker* to become a *co-shaper*, and in some areas a *lead shaper* of international standards. In a ‘two-track' approach, China is working, on the one hand, withinthe international system with the long-term goal of creating patent worthy technology essential to global standards. By including Chinese technology into global standards, China seeks to strengthen its bargaining power and to reduce its exposure to high royalty fees. At the same time, however, China seeks to use its increasing geopolitical influence to promote new sets of rules for international standardization, and hence to transform the international standards system.

Globalization and rising complexity make it necessary for China to combine a government-centered standardization strategy with elements of market-led standardization. China needs to increase the flexibility of policy tools and institutions in order to cope with sometimes disruptive effects of unexpected changes in technology, markets and business strategies. China's policies for standardization that were successful during catching-up, need to be adjusted once the strategic focus shifts to an upgrading-through- innovation strategy. Any attempt to preserve the *status quo ante* in the context of globalization and increasing complexity is likely to constrict learning and innovation, the two fundamental prerequisites for sustained industrial upgrading.

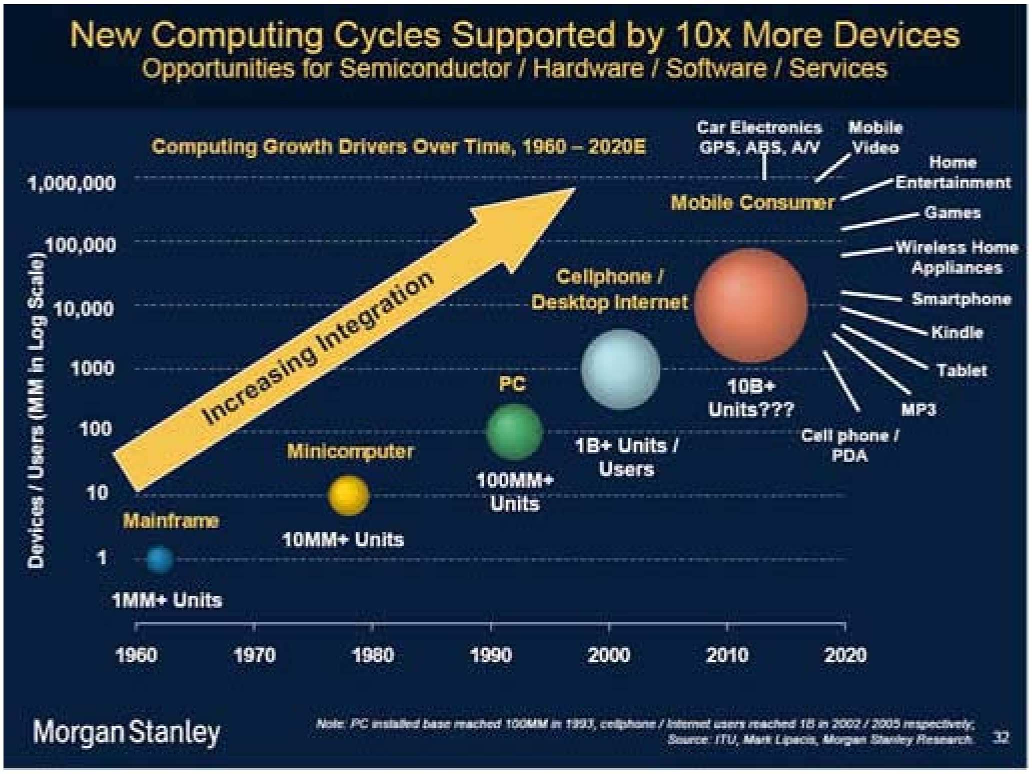
Change however should be constrained by the need to build on accumulated capabilities. "Big Bang" change, which discards the latter, often involves prohibitively high opportunity costs; it may also destroy social consensus, i.e. the most fundamental prerequisite for economic development.

To conclude, the international community should acknowledge that the challenges faced by latecomers like China are very significant and one should not always apply the same criteria in judging performance of latecomers as one would with the advanced industrial economies. China will need to find its own institutional and legal approaches to develop a standard system that can both foster indigenous innovation and cope with the challenge of globalization and rising complexity.

A Look at the EDA Industry

John Sanguinetti, Chief Technology Officer, Forte Design Automation

The EDA industry is symbiotic with the Semiconductor industry. The Semiconductor industry, the EDA industry's customers, has opportunities and obstacles. The opportunities of the Semiconductor industry are the economic drivers for EDA's customers. The obstacles of the Semiconductor industry are the economic drivers of the EDA industry. They are the opportunities for EDA. If the Semiconductor industry didn't have obstacles, there wouldn't be any need for EDA.



The Semiconductor industry continues to be driven by shrinking geometry, increasing bandwidth, and technology convergence. Ever smaller nodes give the opportunity for larger, more functional, more economical integrated circuits, and ultimately the end products which they power. There are obstacles to creating ICs with new process nodes, of course, and the EDA industry continues to be tasked with overcoming them. The trend is illustrated in Figure 1. For a more in-depth discussion of the effects of this trend, see the talk by Lucio Lanza at the 2010 ICCAD.

Increasing bandwidth, and the infrastructure which delivers it, is also offering an opportunity to the Semiconductor industry. All sorts of new product categories are possible because bits can be moved from one device to another in quantities that allow qualitative improvements in delivered features. An example is a wireless TV monitor that can be placed at a distance from the set-top box or satellite receiver. Another example is the ability to watch an HD movie streamed across the Internet. Not long ago that was a pretty bad experience. Now, it is routine.

Convergence of shrinking size and power with increasing bandwidth has led to the mobility revolution, which is only accelerating. The smartphone is rapidly becoming the universal computing device of choice, and it is quite clear that we have the technology to continue that trend. We can see the future that technology convergence offers with the iPhone and Android phones, streaming Netflix, hundreds of thousands of apps, iPads, GPS navigation, and lots more.

Of course there are obstacles, and the primary one is cost. We know how to design ICs and fabricate them - we've been doing it for years. However, they have gotten so big, in terms of transistors, and small in terms of geometry, that it is prohibitively expensive to just make them the way we always have.

Cost is the province of EDA. The opportunity for the EDA industry is to overcome the cost obstacle for the Semiconductor industry. We do this through methodology, standards, products, and service. We get paid indirectly for methodology and standards, and directly for products and service. That is, EDA figures out a new methodology that solves a problem and then sells products and services that implement it. Standards evolve with the methodology, facilitating more efficient implementation of products and services.

Historically, a new methodology has been envisioned by a few EDA pioneers and customer visionaries, some new products developed, and the methodology tried out. As it matures, standards evolve, service providers support it, and more products are developed. The Semiconductor industry then uses the methodology, with slight variations, for a substantial period of time until it no longer will satisfy the industry's needs, at which time the cycle repeats.

We have been on the cusp of a new methodology for several years now. It is obvious to everyone that we need a new methodology, and a viable candidate which we have been calling ESL has been emerging. First the lunatic fringe and then the early adopters of the Semiconductor industry began using and developing the new methodology a number of years ago, and it is now crossing over to the main stream. The early adopters have mostly been in the consumer electronics part of the industry, but as you can see in the above chart, consumer electronics has become the main driver in the industry.

The new methodology includes co-design of software and hardware, virtual prototyping, high-level verification, high-level hardware design, and reuse of large IP components. Fundamentally, we need to put software, that is, algorithms, into hardware. But algorithms have to interact with data streams, system components, and other algorithms, which necessitates doing design and verification at a level higher than the hardware layer. We now have a methodology that can accommodate these requirements.

Along with methodology comes products and services. The products to support high level design and verification have been coming along for some time now. While those products are still largely in the hands of early adopters, they have definitely progressed beyond the lunatic fringe, and there are now many instances of successful semiconductor products that have been designed using the new methodology and the supporting products.

Standards have been evolving as well, and here ESL has probably had its greatest impact to date. SystemC has become the accepted standard for this new methodology, and is now firmly established. As a result, the SystemC eco-system is getting richer as products which supported alternative languages and dialects are being moved to the new standard.

The product area where there is still the most progress to be made is in reusable IP. While the IP part of the EDA industry is quite robust, there is very little IP that can be characterized as high-level. This is a clear need, and one that will be met by new entrants, or established IP vendors who adopt the new methodology in a timely manner.

Finally, the industry needs more service providers. To date, most design and verification service supporting the new methodology has come from product vendors. That has been sufficient for the early adopters, but it will not be sufficient when the main stream of the industry uses the new methodology. This is a big opportunity for those design and verification consultants who can adapt to it.

In this article, I have spoken of the “new methodology” as if it is a done deal, and its characteristics relatively fixed. While the high-order bits are mostly fixed, there is still a lot of evolution to come. Supporting products, and their vendors, will come and go. Innovative combinations of products and IP, products and service, and IP and service will most likely appear, changing the look of the methodology. And eventually, a newer methodology will come along to solve the problems that this one does not.