The Evolution of Enterprise Computing

The Five Waves of Enterprise Computing

A call to action for...
Enterprises,
Universities
and
Enterprise Computing Suppliers

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Historical Perspective The enterprise computing marketplace is undergoing a complete metamorphosis for yet a fifth time in the past thirty-five years. These changes have been so incremental and gradual that one can only really recognize them with the benefit of hindsight. In this paper we will refer to the change periods as waves because with our historical view they might represent giant waves crashing on the beaches of information technology history.

•The First Wave, the "glass house" era.
The mid 1960's and early 1970's were the period of the "glass house", the mainframe and centralized systems. Those graybeards of enterprise computing who sometimes refer to the "good old days" often refer to this period with misty eyes and fond memories. This was before the evolution of "Chief Information Officers", when most large enterprises had a "Director of Data Processing" who typically reported through the financial organization. During this wave, which arguably began with IBM's announcement of the System/360 on April 7, 1964, companies were automating standalone systems such as payroll, order entry, accounts receivable and inventory control. Data Processing departments, even in the Fortune 100 companies, typically consisted of at most a few dozen "computer specialists" who were usually mathematics, engineering or business majors trained by the computer companies. Most data was introduced into the computer in these days in the form of punched cards and the "5081 card" became the favorite notepad of corporate America.

A new approach to managing the DP asset had been orchestrated into systems such as the IBM S/360 and the RCA Spectra systems...the operating system...which allowed job to job transition, channel processing, spooling (the term "spool" referred to the "simultaneous peripheral output on line"), and in the later stages of this wave even the revolutionary concept of multiprocessing.

Basic assembly languages were the normal means of constructing programs in those days and an output of 10-15 lines of code per day was considered high productivity. People were cheap (starting programmer salaries in the mid 1960's were $350-550 per month) and machines were expensive (early models of the S/360 were priced at several million dollars/MIP), so programmers spent weeks trying to save a few hundred bytes of memory.

Mainframe computers were considered something of a novelty and were often the subject of corporate bragging rights...as in "we have a S/360 model 65 but I heard that your company only has a S/360 model 50". Companies built DP Centers that were showcases of their technology....most corporate tours visited the "glass house" and guests were always impressed by the technology they saw...especially the card sorters, spinning tape drives and all those blinking lights.

It was during this and the following wave or two that the seeds of the Y2K problem were being sowed....after all, the year 2000 seemed a long way off at that time. Who ever would have thought that some of those programs then being developed would see their way into the new millennium?

During the middle 1960's as the First Wave was in full swing, a small company in Maynard, Massachusetts named Digital Equipment Corporation was busily developing the family of computers that started the Second Wave, the minicomputer era, the PDP (Programmed Data Processor) family.

•The Second Wave, the minicomputer era.
The most significant of this family was the venerable PDP-11 announced by DEC in 1970. The PDP family, soon followed by the Data General NOVA (developed by a former DEC lead hardware engineer named Edson DeCastro), created the minicomputer era.

These systems broke new ground in that they were priced within the budget constraints of the user department. For the first time user executives could acquire computing power outside the control of the DP Department. Users could train their own people and solve their own problems without ever having to conform to the bureaucratic demands of the corporate DP staff.. As a result, DEC revolutionized the enterprise computing model. The PDP family became the hottest thing in the IT industry as smaller corporations, departments within large companies and universities all embraced the technology. DEC actively worked to win over the re-seller marketplace and hundreds of software companies developed software for the PDP family.

Although the minicomputer did certainly impact the growth of the mainframe industry, the marketplace was insatiable and both mainframes and minicomputer revenues continued to grow in double digit figures.

But technology developments are never-ending and in the late 1970s and early 1980's the third wave was starting to form...fittingly enough in a place that would soon become known as Silicon Valley. Not because of the beautiful sand beaches (upon which the Third Wave crashed) but because of the silicon wafers that would soon revolutionize computing.

•The Third Wave, the desktop era.
In the 1980's the personal computer was developed and opened the door for the move from centralized systems and minicomputers to the desktop. Steven Jobs and Steve Wozniak, working in their California garage were sowing the seeds of the microprocessor evolution and in so doing changing the technology landscape forever. Their Apple (and later the "Mac") led the transition from the glass house to the desktop and it became the darling of every computer hobbyist and some corporate technologists as well.

Then in 1981, IBM, using the Intel microprocessor and the DOS operating system from a startup company named Microsoft, opened the door of the corporate world to microprocessor technology with the announcement of the IBM PC. Even with the comedic help of Charlie Chaplin, top IBM executives thought that the most PCs they would ever sell would be a few hundred thousand. Nobody, including Bill Gates, anticipated the fervor of creativity that would be unleashed by this amazing technology.

The PC took the world of computing from the DP Professional to the common man and allowed anyone to improve their personal productivity beyond imagination. Who can ever forget their personal amazement when they first began to realize what they could do with a spreadsheet?

"Wow...it automatically added up the rows and columns! And I can change one of my assumptions and it will automatically update the entire spreadsheet. I can't believe this functionality."

Even such prehistorically crude spreadsheets, by today's standards anyway, allowed anyone...a sales manager, an engineer, a corporate financial analyst to do things they never thought possible. Capabilities provided by spreadsheets, word processors and an evolving array of specialized software such as CAD/CAM and project management software allowed anyone to benefit from the tools of this amazing new technology. Entire new industries developed, from small software companies developing games, to specialized peripheral companies, to distributors, to retailers. Seldom in the history of mankind has a single technology development spurred such activity.

And we haven't even mentioned one of the key drivers of this technological revolution...the graphical user interface or GUI. What an innovation! For the first time users could get information in a format that was interesting and eye-appealing, rather than the "green screen" non-graphical format used by mainframes. Because of the GUI appeal, many large enterprises started a program to refresh their legacy applications by using PCs to intercept the character streams coming from their mainframe computers and present the data in a more graphical format.

There was great turmoil in the IT industry as the old giants such as IBM, NCR , DEC, Amdahl and Burroughs tried to keep pace with the startups...Apple, Microsoft, Lotus, Novell and thousands of others.

Everywhere the industry analysts and pundits predicted the demise of the mainframe. With this incredible new PC technology, which was changing more rapidly than any technology in history, who needed the old "glass house" and computer specialists? Much of the focus of the IT industry during this time frame was focused on the development of PC based solutions. Many large enterprises had programs to place PC technology in all their executive's homes...providing the capability of both PC emulation of legacy terminals and all the standalone function of the PC.

Universities embraced the move to the desktop because it fit their educational model so well. PC labs could be fully equipped for less than one hundred thousand dollars whereas mainframe or even minicomputer labs typically cost in the millions of dollars. And PC technology focuses on the individual; which is very consistent with the focus of the education system. Self paced learning fits the desktop model very well.

The explosion of technology increased because companies could become players in this new microprocessor based industry with minimal capital layout compared to the previous technologies. Invariably, new communications protocols began to surface allowing peer to peer relationships as opposed to the hierarchical communications that had dominated the mainframe and minicomputer eras. These new technologies created the opportunity for the fourth wave in enterprising computing.

The Fourth Wave, the client server era.

In the latter 1980's, as communications standards and better communications technology began to emerge, people began connecting their desktop machines and the era of client server was born. The client server technology might be viewed as trying to have the best of both worlds,centralized and decentralized (or in the vernacular of this paper, mainframe/minicomputer and desktop). In some ways it was an outgrowth of some of the problems of the desktop era. As large enterprises distributed more and more desktop capability, the maintenance and support problems grew astronomically. Imagine the challenge of maintaining tens of thousands of systems, scattered throughout the world, on the same level of the operating system and same versions of solution based software. Or worse yet, the challenge of maintaining hundreds or thousands of copies of the same distributed databases. As the number of desktops grew the challenge was amplified geometrically.

In the meantime, excellent communications protocols such as ethernet and token ring were developed and allowed enterprises to embrace the new client server technology. Now one large PC or UNIX based minicomputer in each of a company's major locations could become the cornerstone of that location....the server. And all the other desktop devices (clients) could be supported by that one common repository of software and data. This made the maintenance and support problems of the desktop era much more manageable.

The end user could now be "freed" from the endless backlogs of the DP Department. He could go about solving his own business problems by using the "free" (relatively free resources because they didn't include the huge apportioned costs of the glass house resources) programming talent within their own departments.

Hence the birth of the client server era. There were many other advantages of the client server technology base..…

Training requirements were lessened.
Cost effectiveness was improved.
Control was better than with the desktop model.
Fewer IT Professionals were required.
Universities were training people with the right skills...Unix and Windows skills.
Less proprietary more open architecture meant more choices.

For these reasons the client server architecture became the dominant architecture of the late 1980s and many would argue that it is still the architecture of choice as the century draws to a close. As is the case with all architectures, the client server model does also have a few key limitations:

Scalability As many large companies have discovered, the client server model has some of the same problems of the desktop model. As solutions are propagated across large multinational companies, the number of servers grows to the point where they experience the same maintenance problems as in the desktop era concerning databases and software.
Reliability Although UNIX and Windows/NT are excellent operating systems, their legacy is desktop workbench and single, or small group focused environments. Although much has been done to make them truly "industrial strength" neither is there yet. In fact, many argue

that they will never have the reliability of a system such as IBM's OS/390 which was built from the ground up to handle the rigors of "24 X 7 X 365" reliability and availability.

Support Costs Just as the desktop model had support costs that escalated geometrically as the number of users increased, the client server model has similar characteristics as the network size increases. Remember the "free" resources, programming skills that were within the end user department? All of a sudden those people discovered that they became involved in all kinds of operational issues just to keep the systems running. So now we had highly paid end user resources focused on computer operations issues...not quite what user department management envisioned when they started down this path.

In the early 1990's, just as the client server era became the dominant prevailing architecture, the phenomenon of the Internet began to appear. Never in the history of the information age had a movement taken hold like the Internet, even eclipsing the impact of the personal computer in the early 1980's.

•The Fifth Wave, the e-business era.

Do you remember where you were when you first heard the term "Internet" or "cyberspace"? Probably not, it doesn't rank up there with the John F. Kennedy assassination or Neil Armstrong's walking on the moon, in terms of historical significance. Yet it may truly turn out to be one of the most significant happenings in the history of mankind, ranking with the invention of the wheel or the industrial revolution. Never has anything invented by man influenced so many people so quickly. Even one of the business world's icons of vision, General Electric's Jack Welch, has stated that never in his career has he seen anything impact business with the force of the Internet.

And in terms of the maturation of use of this technology, the Internet has gone from an item of curiosity, to every man's research instrument, to business enabler in just four or five years. We have all seen the statistics…

There will be 35.2 million new users in 1999.
At year end 1999, there will be 130.6 million users.
There will be 350 million active users by the year 2003, a 267% increase over the 95.4 million who were actively using the Internet at the end of 1998.
European utilization will jump from 34 million in 1998 to 100.3 million in 2003[1]

[1] All statistics courtesy of eMarketer, "The Atlas of the Internet"

Global Internet Users

YEAR	USERS in millions
1998	95.4
1999	130.6
2000	172
2001	223
2002	282
2003	350

And all these numbers refer to active users as opposed to casual users who might access the web once a month or less. The significance of this growth is best demonstrated by the incredible e-business growth that has been experienced by many companies.

e-Commerce Revenue ($ Billions)

Year	e-commerce Revenue
1997	10.8
1998	37.6
1999	98.4
2000	197.2
2001	381
2002	702
2003	1,244

Why is this happening?
IT is happening because it makes good business sense. Consider this example (provided by Booz-Allen & Hamilton) from the banking and securities industry. The example itemizes the cost of one banking transaction:

Branch Office Transaction	$1.08
Telephone Transaction	54 cents
PC dial up Transaction	26 cents
Internet Transaction	13 cents

Another, equally compelling example in the automotive industry comes from the Automotive Industry Action Group/Forrester Research/Bloomberg. They estimate that the North American automobile industry can save $1 Billion a year or about $71 per vehicle through e-Commerce.

Cisco sells over 75% of its products on the Internet, averaging $28 million per day. In December of 1998, IBM averaged $38 million in sales every day. Dell achieves 30% of its revenue on the web, $18 million a day. Companies which are using the Internet to handle administrative tasks are averaging 65% reduction in costs.

This is the real significance of the Internet...its ability to change the way businesses do business. In addition to producing revenue, companies all over the world are using e-Business to:

Improve customer service
Reduce administrative expense.
Improve employee morale.
Do targeted advertising.
Enable entirely new types of solutions.

The significance of all this growth on enterprise computing is huge. Booze Allen and Hamilton, in a recent survey found the 90% of top managers believe that the Internet will transform or have a big impact on the global marketplace by 2001.

Significance of the Fifth Wave

So what is the significance to enterprise computing of the Fifth Wave? It may not be entirely intuitive. Let's examine this in some detail. As major corporations attempt to benefit from the Internet explosion, their first area of activity is typically e-Commerce, selling goods over the Internet, either business-to-business or business-to consumer. As they gain experience with e-Commerce, they begin to see that they can exploit the Internet more broadly and they embark on a mission to truly make their company an e-business.

In the words of John Chambers, CEO of Cisco, considered to be one of the more enlightened users of the Internet:

"To compete successfully in today's global Internet Economy, providing critical information to employees, customers, partners and suppliers 24-hours-a-day, seven days a week, becomes a competitive advantage. New economy companies are using their networks to improve

> *productivity, reduce time to market, increase revenue and build relationships."*

As companies pursue what Chambers would call the *Internet Economy*, they enable their IT infrastructure to the world. As they dive into e-Business, they touch every piece of their IT infrastructure. They can't afford to re-create everything for the Internet, they must enable the legacy systems that they have. And one overwhelming fact overrides those legacy systems and all their legacy data:

> **Roughly two thirds of all corporate data has been implemented on the architecture of IBM's enterprise servers, and it remains there today.**
>
> **As Carl Greiner, VP of the Meta Group says, "because over 70% of the world's business data still remains on the mainframe, solutions that provide easy access via Web technology to legacy applications will be in demand."**

So it is incumbent upon major corporations that they find ways to enable that enterprise data in their legacy systems to be accessible to their suppliers, employees and customers via the Internet. This puts a real premium on both their legacy skills (CICS, IMS, DB2, COBOL, Assembler, etc.) and their enabler skills (JAVA, San Francisco, EJB, XML, etc.) in their corporations because these are the people who understand the data and how to make it accessible. Finding people with the enabler skills will not be a significant problem. These skills are the hot new technologies of the fifth wave and the new young people coming into the IT field will be attracted to them. Universities offer courses on these technologies and they are some of the more popular electives in their portfolios.

The skills problem that major enterprises will surely face is finding the legacy based personnel who understand where the enterprise data is and how to access it. This problem, as stated in the companion paper authored by DCTA, Inc., The Future of System/390-Success, Threats and Remedies, is that those skills are limited, aging, and decreasing. In his paper, David Thewlis indicates that S/390 skills are so constrained that experienced, qualified people are commanding salary premiums of from 15% to 30%. Since virtually no new skilled people are entering the marketplace, the premium is what companies pay to hire experienced S/390 skills from one another.

Lou Gerstner, CEO of IBM, in a recent speech to financial analysts stated:

> ***"You all know there's no server in the world that competes effectively against the System/390 on these attributes of scalability, reliability and availability. We are seeing escalating demand for high-end MIPs: three straight quarters of more than 60 percent growth on the 390. In the first quarter, more than 25 percent of the growth came from new workloads. And the e-business portion of those new workloads doubled."***

In fact, the S/390 has experienced high rates of MIP growth even during the period of time when the industry prognosticators were on "the mainframe is dead" bandwagon, during the second and third waves. The S/390 has had MIP growth over the past thirty years in the range of 30-60% annually...even during waves two and three when the IT workload was supposedly moving to the desktop.

This MIP growth was driven, in part by the incredible price/performance improvements made by all the mainframe suppliers through technological improvements. Breakthroughs such as CMOS technology allowed the mainframe pricing to improve to the point that Enterprise Servers (as they are now called) are price competitive with PCs and UNIX processors. The price performance improvements are highlighted in the following chart.

Era	Time Period	Dollars per MIP
"Glass house" Era	Mid 60's/Late 70's	$10 Million/$2 Million
Desktop Era	Early 80's/Late 80's	$2 Million/$ 100 Thousand
Client Server Era	Late 80's/Early 90's	$100 Thousand/25 Thousand
e-Business Era	Mid 90's/2000	$25 Thousand/$ 5 Thousand

The Effects of the Fifth Wave on the Enterprise

The effect of the Fifth Wave on large enterprises is very significant. It puts tremendous pressure on the enterprise's mainframe IT professionals as they try to e-enable legacy solutions on the Internet for their three constituencies....suppliers, customers and employees.

Those IT professionals are very limited today and are diminishing because of the graying of the mainframe literate work force (please refer to DCTA paper). If enterprises can't find a way to augment their S/390 resources, they will be subjected to having to replace their legacy systems one by one because they won't have sufficient resources to maintain them let alone e-enable them for the Internet.

Seventy percent of the data that corporations want to make available to their constituencies is being maintained by an ever decreasing pool of resources. That is frightening all by itself, however, with the fifth wave motivation of exploiting that data on the web, the problem will be greatly exacerbated.

IBM and other software companies have tried to help with this problem by creating middle ware such as MQSeries, DB2 and XML which will help enable legacy systems on the web, but they still require mainframe skills and the experienced people who understand those legacy applications.

Paying skills premiums is one thing, but actually having to change architectural directions to less desirable platforms because of skills shortages is something that large enterprises cannot let happen.

The Effect of the Fifth Wave on Universities

Computer Science departments in Universities are used to changing their curriculum faster than their counterparts in other departments such as Physics or Chemistry. The basic laws of Physics don't change, but the technology of the IT industry changes often and dramatically.

Most Universities have modified their curricula consistent with the Five Waves. In the 1960s and 1970s much of their curricula was focused on the mainframe. In the 1980s most universities moved their computer science curriculum from the glass house to the minicomputer and then to the desktop. And in the later 1980s many of them again modified their curriculum to have a client server dimension.

Now...as we enter the Fifth Wave....universities are starting to recognize the changes and are modifying their curriculum by adding courses such as these:

Enterprise computing architectures
e-Business architecture
e-Business Strategies
MQSeries...messaging in general
JAVA
Data Enablement

Business schools have been quite focused upon the e-Commerce phenomenon for some time and several of them have responded with curriculum changes. Consider the following:

> "There was tremendous student demand and recruiter demand." said Professor Erik Brynjolfsson, co-director of the Massachusetts Institute of Technology's e-Commerce program. M.I.T.'s basic e-commerce course, designed for 80 students, drew 200 applicants last year, Brynjolfsson said. "Now we have a whole track with a cluster of classes," he added, "it instantly became the most popular track".[2]

Vanderbilt's Owen Graduate School of Management now offers 17 e-commerce courses, with about twenty five percent of the Owen school's MBA students participating.

The computer science departments of universities have made corresponding changes to their curricula by including many of the enabling technologies in their portfolio. What they generally haven't done is focus on the legacy systems that enterprises want to enable. They have focused on one-half of the problem, our contention is they must now focus on the other half.

We are not advocating that Universities should make dramatic change to their entire curriculum to accommodate the Fifth Wave. Rather, what we are advocating is that they consider adding a few courses which would raise the awareness of their students about the key role of the legacy environment and prepare their students to recognize the significance of e-enabling legacy software and data for the enterprise.

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[2] Dow Jones News Service, US Universities Hurry to Offer E-Commerce Programs, Dinah Wisenberg Brin

Why should they do it? Why should they go to the trouble and complexity of developing new curriculum?

We believe that there are four significant motivating factors:

It is vital to the national economy First, as is well documented, the US has a significant shortage of skilled IT professionals. As this paper maintains, that skills shortage is greatest in the legacy systems area. As the e-Business era, the fifth wave continues, these skills will become even more in demand and more scarce. Universities can play a tremendously important role in helping build educated CS graduates who have an understanding of the historical significance, architecture, data organization and relevance today of the large enterprise server.

A competitive advantage for their graduates Second, there is a well documented shortfall in the number of people who understand the enterprise computing model and have the skills required by large enterprises. We think that if universities were to provide their students with appropriate courses, those students would have a competitive advantage when looking for employment.

Dr. Rod Angotti, Chair of the Computer Science department at Northern Illinois University, whose curriculum has a strong S/390 component has stated that…

"We feel that there is great educational value in providing our students with some instruction about mainframes and the enterprise server environment. Because our students understand the enterprise computing model and have practical experience with s/390, they are sought after by large enterprises. They can capitalize on the salary premiums which are offered for people who know the enterprise environment."

Local Enterprises Need Their Help Third, universities tend to develop strong ties with local enterprises. In a recent survey of enterprise IT executives, 55% indicated that they would support an internship with local universities if the schools better prepared their students for enterprise computing. Universities who work closely with large local enterprises tend to do a better job of preparing their students to work for those companies because of the advisory role those companies play. Although no data exists to substantiate it, one could assume that enterprises which are involved with local universities are more committed to supporting those schools financially.

By Supporting Local Enterprises, Universities Can Influence Their Legislators Fourth, state supported schools are very dependent on legislators' perception of the job they are doing of serving their constituencies. A major part of the local constituency is the large enterprise. If a university can demonstrate that it is doing an excellent job of providing graduates with an education that meets its large enterprise constituent's needs, it follows that those budget granting legislators should look favorably on the

university. The significance of this positive perception could be invaluable to the always financially strapped Computer Science department of a state school.

The Effects of the Fifth Wave on the Mainframe Industry Suppliers

The Fifth Wave presents an opportunity not only for IBM but for the hundreds of other companies who derive significant portions of their revenue from the mainframe. IBM just happens to be the biggest. Who are these "others"? All the companies who are suppliers to the enterprise computing marketplace, for example:

Software Providers:

BMC Software, Candle, Tivoli, CA, Boole and Babbage**,** Lotus, many others

Mainframe Providers:

Amdahl, Hatachi, Fujitsu, Unisys

Peripheral Companies:

EMC, STK, IBM Storage Systems Division, many others

Services Providers (those heavily invested in mainframe skills)

EDS, CSC, IBM Global Services, Sabre, Gartner, Forrester, many others

For the first time in two decades, these companies have a real opportunity to move the "mainframe" to the "mainstream**"** of computing in the new millennium. In the past these companies have all viewed themselves as competitors and deadly enemies. With the very survival of the mainframe industry at stake, it is really in all their best interests to work together to solve the skills issues they share in common.

But, IBM and the others can't just let it happen. They all need to seize the opportunity by collaborating with one another and universities and community colleges on a much broader scale than they traditionally have:

Make hardware and software available free or with a greater educational discount.

Provide "elements" of the curriculum. A great start would be to provide the e-Business middle-ware products along with course materials.

Sponsor a "Special Interest Group" of universities at Share and promote their interchange of materials and "elements" of curriculum

Offer grants to professors to develop "elements" of curriculum.

A Call to Action

Rarely are three constituencies such as these...large enterprises, universities and the mainframe supplier industry...as aligned as these three are in the fifth wave.

If enterprises don't find a way to fill their growing need for large systems resources, they will pay a price:

Higher salaries/signing bonuses will skyrocket as competing enterprises compete to attract the shrinking inventory of large systems skills

Slower Web-enablement of services for their suppliers, customers and employees will lessen their competitiveness.

They will lose their investment in enterprise based applications solutions if they are forced to replace those assets because of lack of mainframe skills.

If Universities don't start training Computer Science people who have a basic understanding of the mainframe architecture and data enablement they will begin to pay a price.

Major enterprises will try to hire people from other sources with these skills.

Their graduates will not command premium salaries offered for those with e-Enablement skills.

They could risk the support of their legislators and enterprise constituents because they are not providing graduates with the right educational base.

And for the Enterprise Computing vendors, the outlook might be most devastating of all. As the population of people with large systems skills approaches retirement, if these companies cannot find a way to replenish those skills, the mainframe will fulfill the predictions of those who have been saying "the mainframe is dead" since the 1970s.

They will see their enterprise market diminish over time as the skills pool slowly evaporates through retirement.

They will lose the value of their investment in mainframe architecture.

They will have to invest to retrain their remaining mainframe personnel.

They will have to pursue new markets in which to invest as this one goes the way of a dead language.

Or they can collaborate to change the situation by working with universities and community colleges to include elements of enterprise computing in their curricula. They can solicit the collaboration of their large customers, the enterprise computing constituency. Are they up to the challenge? Or in a few years, when we are well into a sixth wave, will we again look back at this era with the wisdom of hindsight and conclude that the mainframe died due to skills shortages during the latter part of the fifth wave?