The Mainframe Is Dead. Long Live the Mainframe!

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Many have predicted the death of the mainframe over the last 10 to 20 years, yet it is still is a large part of enterprise computing today. Companies not only use the mainframe for "legacy" applications, but are also developing new applications for mainframes, resulting in a rise in mainframe sales. These increases, along with an aging mainframe workforce and academia's move away from mainframe-related curricula and courses, has resulted in a shortage of workers trained in mainframe applications. In this paper we report on a U.S.-based survey of industry and academia that confirms the existence of this problem. We conclude with some possible future research directions to explore as possible solutions to this potential dilemma.

1. Introduction

Over the last two decades, articles have declared the death of the mainframe computer [3], [22], [27], its extinction in large enterprise computing, and academia's purge of mainframe related courses. But, is mainframe computing really dead? Should companies do away with these "Legacy" systems that can act as a repository of business processes? [9] Furthermore, should educational institutions really be ridding themselves of mainframe-related curricula in favor of other enterprise technologies? In this paper we report the results of a U.S.-based study designed to ascertain the state of the mainframe in enterprise computing in industry and academia's ability to supply graduates with the knowledge and skill to run these systems. Based on the results of this study, several proposals for action are given for consideration.

Large enterprise computing includes two primary computing architectures. The first uses one or a few very large servers that provide batch and online transaction processing to hundreds or thousands of clients. These servers have historically been called mainframes and were mainly built by IBM, though other companies such as Hitachi and Tandem built similar machines. Companies such as Sun Microsystems and Hewlett Packard built smaller servers generally not classed as mainframes, but which provide analogous services for smaller enterprise subsystems. The second and more recent architecture is the clustering of many commodity servers in parallel and tasking them to process the transactions of these hundreds or thousands of clients in a distributed fashion. Although the debate about which architecture is better rages on [11], [8], both architectures typically provide the high-performance, high-availability computing needed for large enterprises, and both can be considered large enterprise computing. The rise of Cloud computing and virtualization has further muddled the debate of whether hardware needs to be housed within an organization [6].

While clusters have been touted as the logical successor to mainframes for the past several years, for reasons of economy, scalability, and fail-over capability, IBM has seen increasing sales of their mainframe hardware and software [24], [25]. The often-predicted end of mainframes has still not materialized, and indeed, the trend in some industries is to continue or even increase investment into mainframe architectures. The scope of the current research is not to analyze whether clusters or mainframes are better for a given application or industry, rather this paper focuses solely on the role of mainframes in industry enterprise systems.

To utilize mainframes as a viable part of an organizations enterprise platform, and integrate it with other systems re-

quires specialized training. The knowledge and skills required for this work includes skills in setting up, initializing, managing, and running a mainframe; as well as a knowledge of control or programming languages used in mainframes. Also included in this repository of knowledge are skills in integrating the mainframe with the rest of an organization's computing equipment, such as initializing data communications and integrating the middleware necessary to operate in a multi-platform environment.

Surveys [23], [7] suggest that the vast majority of mainframe knowledge in industry will disappear as the older information systems (IS) managers retire over the next three to ten years. The graduates to replace these people are being trained with little or no knowledge of mainframes. The resulting problem will be a lack of mainframe-educated workers to replace the retirees. According to Light [19], a risk of losing vital business information that has been stored within these systems as they have evolved is a real consideration for organizations to consider. Other factors, such as the speed or embeddedness of the system, should be considered when making discontinuance decisions [13]

This problem needs to be addressed because it seems that although those directly involved with large enterprise computing believe there is an imminent crisis in available skills, the educational system apparently either does not believe a problem exists or believes everything mainframe is dying and that the legacy should be buried. Legacy programs and mainframe systems are still widely used and even dominate certain industries (e. g. financial), and an even greater need is emerging in integrating mainframe systems with newer information technologies like web and client/server applications in mixed-platform environments. Indications from industry suggest that there is a need for academia to continue or reinstate education in large enterprise systems.

Previous research on the state of mainframes in industry and academia is largely limited to trade journals, as academics apparently have abandoned it as an unfruitful area of study. Most studies indicate that the number of students being prepared for large enterprise computing is declining [23] and that IS managers still see a need for this knowledge base [20], [7]. Financial institutions depend on mainframe processing to the point that COBOL handles nine out of ten ATM transactions within a mainframe environment [10]. Popular press reports the knowledge base for large enterprise computing is leaving the workforce [21], and indicates an exacerbation of the problem, since "few colleges [are] offering mainframe courses, most young people aren't prepared for the complexity of mainframes" [5], thus new graduates are unable to just walk in and function in their job roles without further training.

If academia does not successfully educate enough people to replace retirees, industry could be placed in a similar position as they were with Y2K. In the Y2K situation, expertise to work with mainframes and COBOL code was outsourced at exorbitant costs. If the current mainframe systems are not adequately maintained to meet the challenges of changing marketing conditions, companies may be forced to patch their operations together resulting in lost time and effort. Also, their systems might not be integrated properly so that redundant systems may exist across platforms, causing reliability, data interchange and maintenance problems.

Applications on the mainframe are not disappearing, so they need to be maintained and integrated into the organization's information system structure. The potential impact of upcoming retirements is indicated in an IBM study, which shows that a majority of the workforce with experience in IBM mainframe systems is nearing retirement age as illustrated in Figure 1 [15], [16]. This leaves companies faced with hiring under-qualified replacements and training them on the job, or removing mainframes from their enterprise computing capacity.

1.1. Rewrite or Integrate?

General Mills, a company with reported revenues of $11 billion in 2006, and ranked 206th on Fortune Magazine's list, made the decision in the early part of this century to do away with mainframes [14]. This decision was prompted in large part by the inability to find replacements for their retiring mainframe experts. Mission Linen Supply, Inc. is another company that converted away from mainframes as a result of losing 50 percent of their mainframe experts and being unable to find replacements [14]. Garvey [14] also cites a Meta Group study indicating that 60 percent of workers in data centers housing mainframes are 50 years old or older. This aging workforce is taking their knowledge with them upon retirement.

Carr and Kizior [7] showed some interesting trends relating to COBOL, the historically dominant language used on mainframes. In a study of 208 information systems (IS) managers, 56 percent reported current COBOL code development and

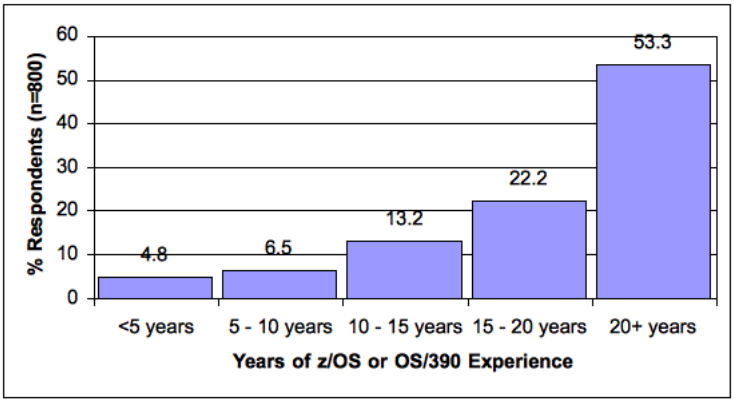

Figure 1 Years of z/OS or OS/390 Experience [15], [16]

maintenance. Of the organizations using COBOL, nearly 60 percent reported in excess of five million lines of code in use while nearly 30 percent reported 20+ million lines of code in use. Thirty percent of all the respondents' programming was an effort to maintain COBOL code and 10 percent of the programming effort was geared toward new applications using COBOL. These numbers are down compared to their 1999 study; nevertheless, the study shows that a large amount of code remains.

If organizations are moving away mainframes, then they are also very likely replacing legacy languages such as COBOL. Thus, a logical question is whether it is more efficient to rewrite the legacy code in another language on another platform, or maintain and extend the current code base. In order to rewrite the legacy code, organizations must not only convert these legacy programs to another language, but must find other utilities that provide support to those languages such as sort utilities and common file management operations. This requires a major restructuring of their information systems infrastructures without a disruption in their primary business functions. Legacy code cannot simply be rewritten line by line, converting from one language to another. Applications must go through all the analysis and design phases of the software development life cycle (SDLC) requiring large investments in both time and money. The cost/benefit analysis must demonstrate a significant gain from the replacement in order to justify the expense of rewriting. It is not sufficient to say that the newer technologies are better for the organization simply because they are new. Kelley et al. [18] outline many factors that impede the conversion of legacy systems that continue in use, such as stability of some systems having been built and maintained over long periods of time as well as the interwoven connections between the technology and business processes. They also highlight factors that are contributing to the need to revise such systems due to increasing inefficiencies and deviation of the core business processes from those embedded in a system.

A more prudent course for some organizations might be integration. Kanter and Muscarello [17] investigated the time it took to web-enable legacy systems. They compared the time required to adapt a COBOL/CICS system for web access with the time it took to rewrite the entire application in Java. The SDLC steps they used for this conversion were requirements analysis, specification, design, development, testing, and performance/value issues. The specification and performance/value issue phases were not needed for the COBOL revision. The total time to adapt the COBOL/CICS application was 29.5 minutes whereas the total time to rewrite in Java was 1275 minutes (21.25 hours) [17]. Kanter and Muscarello [17] put this in terms of money based on an average salary of $54,000. The cost of the revision was $26.30 and the cost of the rewrite was $1,134.80. In percentage terms, the revision took only 2.3 % of the time and cost of the rewrite. This was obviously a very small project but if these costs extend linearly to a large enterprise systems project requiring six months and 200 workers, the cost of a rewrite would be $11,232,000 compared to the cost of integration of $258,336. The cost and time benefits are obvious but integration is only a viable solution if there are curricula that teach large enterprise systems, including the components with which they interact and integrate.

1.2. Curriculum

The information systems (IS) curriculum as set forth by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET) emphasizes the need students to be prepared to effectively function in an IS environment as an IS professional [1]. The criteria indicates that an IS curriculum must also include principal coverage in many areas including hardware and software, a modern programming language, networking and telecommunications, analysis and design, data management, and the role of IS in an organization. One interpretations of modern language could mean that it is widely used in industry. COBOL, within a mainframe environment, is widely used in industry and would fall nicely into that category. COBOL is used in 75 percent of all production transactions on mainframes and 95 percent of finance/insurance data processing, and 60 percent of all web-access data lives on a mainframe [4].

IS managers have indicated the desire to incorporate the integration of large enterprise technologies with object-oriented and web-based technologies into the academic curriculum [23], [7]. Corporations depend on the speed, accuracy, and stability of their large enterprise legacy systems. It is an asset they have invested in heavily. In addition to the mainframe IS staff decline in industry, faculty interest in teaching large enterprise languages such as COBOL has decreased [23], likely due to the fact that many of the educators capable of teaching large enterprise systems and associated programming languages are nearing retirement age.

The current large enterprise systems workforce will be of retirement age very soon. Companies such as General Mills and Mission Linen Supply [14] have already felt this human resource shortage. As a result of the lack of qualified talent, some companies have chosen to replace their mainframes with newer technologies, leading to a large investment in terms of time and money in rewriting legacy programs based on a mainframe into a language that will interact with the chosen technology. If large companies as large as General Mills cannot find adequate staff to replace their mainframe experts, but IBM's mainframe sales keep increasing, this may indicate a continuing market for trained individuals. If there is a shortage of talent, perhaps there is a need for academic curricula in large enterprise systems.

2. Methodology

Two surveys were conducted, one in industry and one in academia. Both were sent out as interactive PDF documents that users returned via email. The industry survey contained questions pertaining to the number of new hires for large enterprise systems positions they expect over the next five years, the number of large enterprise employees retiring during that same time frame, and the number of positions in large enterprise systems currently open, as well as basic demographic questions. Questions were also asked about the languages, environments, and databases used in the large enterprise systems. The survey to academia had two parts. The first part consisted of questions relating to the number of large enterprise courses offered, the enrollment in such courses in the Spring and Fall semesters of 2006, the large enterprise languages offered and required, and an enumeration of courses constituting their large enterprise curriculum, if they had one. The second part asked questions about the non-large enterprise languages offered, which three languages had the highest enrollment in the Spring and Fall of 2006, and asked about the likelihood of large enterprise related courses being required or offered as electives.

The population for the industry survey consisted of Fortune 1000 companies for 2006 [12]. Sampling this population was difficult. The researchers had a list of contacts at various companies, furnishing a starting point, and others were distributed at various industry meetings the researchers attended. The sample of the population ended up being a networked list, making the sample less than the random ideal. A total of 222 surveys were distributed to these firms.

The population for the academic survey was all universities and colleges that have computer science or information systems programs that were accredited by the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET) as listed on their website as of January 18, 2007. The survey and cover letter were sent to all 259 institutions accredited by CAC/ABET [2].

3. Results

The results of this preliminary study indicate that there is an industry need for new hires in large enterprise computing but there is a shortage of academic institutions offering a skill set to fill this void. The discussion of the results is split into two parts: industry and academia, after which a synthesis of these findings is presented.

3.1. Industry

The level of analysis is at the organizational level with fourteen companies responding to the survey. The industries represented in this preliminary study include financial, computing, insurance, utilities, communications, construction and manufacturing, among others, with a mean number of employees per organization of about 88,000. Almost all of the organizations had IT departments greater than 200 employees in size (13 out of 14) with 100 or more employees working in the area of large enterprise computing (13 out of 14). Most companies (12 out of 14) indicated that languages such as COBOL, JCL (Job Control Language on the mainframe) and REXX (another mainframe language) were a large part of IT employees' jobs, as well as large enterprise databases on the mainframe like DB2 and IMS.

The industry survey indicates a growing need for individuals with mainframe expertise over the next five years as large enterprise computing employees begin to retire. Eleven out of fourteen organizations indicate a need to replace anywhere from six to 2000 large enterprise computing employees with a mean of 231 across organizations. Factors such as the cost of training, which averaged almost $32,000 (based on eight responses) and difficulty finding employees to hire (see Figure 2) were cited as impediments to finding qualified personnel, despite competitive starting salaries (an average of almost $43,000 for those organizations reporting salary figures) being offered. The issue in the next decade as large enterprise computing employees begin to retire will be finding individuals to fill their shoes. Will academic institutions provide sufficient well-trained students who are able to step into these positions?

3.2. Academic

Among the 40 academic institutions surveyed, only 6 offer large enterprise computing courses and only 1 of these 6 has a large enterprise computing curriculum. Of the remaining 34 institutions, only 3 expect to require such courses in the future, and only 12 foresee any likelihood of making such courses available as electives (see Table 1).

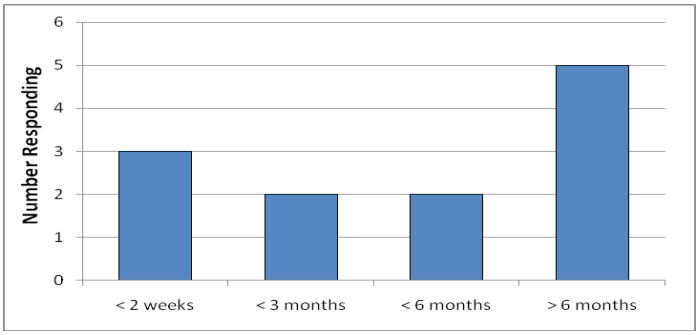

Figure 2: Length of time required to find large enterprise computing new hires

	Required	Elective
Definitely	1	2
Very Likely	0	2
Likely	2	8
Not Very Likely	24	19
Absolutely Not	7	3
Total	34	34

Table 1: Large Enterprise Computing Expected Future Course Offerings

So, a substantial industry need for large enterprise computing new hires exists, yet apparently few academic institutions are producing graduates who can begin to fill that void. In the Fall and Spring semesters of 2006, only at most six sections of COBOL were offered among our sample. If this trend holds nationwide, an extrapolated figure of 39 sections would be offered throughout the country. A much smaller number of courses were offered on topics which industry indicates are a significant part of their IT employees' jobs (see Table 2). A trend is noted (but not statistically proven) showing a decrease in courses from Spring of 2006 to the Fall of 2006.

3.3. Discussion

Companies are beginning to see a growing need for large enterprise computing graduates and are beginning to take steps to help academic institutions start programs (consider IBM's Academic Initiative) and the mainframe in large enterprise technology is alive and thriving. But will enough academic institutions take up the opportunity to expand (or restart) large enterprise computing curricula to meet industry's growing need? The results of this preliminary study indicate that universities are not producing enough students to fill the needs of those organizations participating in this study.

An opportunity exists for academia to entice students with the growing number of jobs available in this field, especially in light of the low enrollments at IT and IS university programs.

	COBOL S06	JCL 06	z/OS S06	COBOL F06	JCL 06	z/OS F06
0	0	3	5	2	4	4
1-25	6	3	1	4	2	2
26-50	0	1	0	0	0	0
>50	0	0	0	0	0	0
Total	6	6	6	6	6	6

Table 2: Large Enterprise Computing Courses by Section (size) and Semester

Enterprise systems are an area where outsourcing may not be an option for industry because of the critical nature of the systems involved. Continued partnerships allowing communication between industry and academia are necessary to ensure that universities are producing students that are able to fill available positions and universities are receiving the resources necessary to continue to attract students and develop large enterprise computing curricula.

3.4. Limitations

While the data in the study was collected in 2006 and analyzed in 2007, this issue is still very relevant in industry according to a recent study conducted by TheInfoPro, Inc., in September and October, 2008 [26]. According to this survey, 72% of responding organizations had mainframe staff already eligible for retirement. Further, those organizations using mainframes are expected to increase mainframe-related spending over the next two years, and ranked hiring and training new staff as their highest priority action to offset projected staff shortages.

This survey experienced difficulties in that the PDF survey, designed to be universal, proved to be unusable for some respondents due to enterprise security settings disabling the functionality of the emailed surveys. Therefore, the survey had a small number of respondents, curried from a convenience sample of industry. However, the firms that responded represent some of the giants of their respective industries, and their needs likely reflect the needs of many other large companies in this regard. An additional problem was that the survey to industry asked certain questions that were determined by the various legal departments to be unanswerable. The survey did not give an option for choosing not to answer a particular question. It was indicated in a few emails that when the particular firm was unable to answer, they would respond with either an "unknown" or a "0" (zero). It is beyond the knowledge of the authors which responses of zero represented an actual zero and which represent an unknown. It was assumed in the data analysis that all zeros were indeed zeros.

There were several organizations that chose to complete the survey as a committee effort. This gave a corporate-wide view, which is likely to be more accurate than one person's view. In the event that duplicate surveys were received from a single firm or a single academic department, the responses were averaged into one response for purposes to achieve the specified organizational level of analysis.

4. Future Research

This study indicates a need for a longitudinal study should be conducted to monitor trends in enterprise computing and mainframe technology, and the integration of mainframes with more traditional technologies. It could be argued that

mainframe technologies should be allowed to slowly die off to be replaced with "newer" technology, but questions remain as to which other technologies can scale to levels required for processing thousands of transactions. Another possibility is that the mainframe will be able to reinvent itself to support modern application delivery requirements.

As part of a longitudinal study the usage trends of the mainframes could be tracked to determine what trajectory it is following. Another possibility may exist in the need for legacy skills continuing to be taught well into the future, especially for those students who gain experience in both the "old" and the "new", even if only during a multi-year period of transition. Further study is needed to gather information with regard to industry solutions for finding qualified candidates. Will companies simply attempt to attract new hires and train them if traditional educational systems are not going to provide graduates with the necessary skills and knowledge for the large enterprise environment? Will these strategies include individual mentoring programs, internship programs, outsourcing programming skills, or even a "boot camp" training program similar to what was used during Y2K? In other words, is there an ongoing need for academic training in mainframes, or should private industry and training such as certification programs take this role.

Finally, it would also be beneficial to track organizations that have moved away from mainframe environments over the next five years in order to examine their successes or failures. This could provide some insight into lessons learned or strategies that were successful?

5. Conclusion

While this study is preliminary, it illustrates a continued need for mainframe-educated workers in industry. While this does not mean that every institution needs mainframe courses as part of their enterprise systems curriculum, neither should mainframes be abandoned. Enterprise systems consist of much more than mainframes, including cluster computing, ERP systems, data warehouses, and other enterprise systems, but mainframes are still a part of enterprise computing, and likely will be for decades to come. This study showed that academia is not currently capable of providing enough mainframe-educated individuals due to the discontinuation of large enterprise systems education over the last 10-20 years. Industry has an immediate and a foreseen need five years forward. A few industry respondents even indicated that looking beyond the next five years the need would be even greater. These findings, paired with academia responses indicating the unlikelihood of large enterprise courses, much less an entire curriculum, does not give an encouraging personnel recruiting outlook for industry.

Industry respondents specified a need for people with mainframe knowledge, large enterprise languages, databases, and systems knowledge, and integrated knowledge. The number of new hires needed by industry through retirement and attrition is greater than the number of people being prepared through academia. Furthermore, the retirement of older, skilled mainframe personnel over the next few years will exacerbate this situation as the shortage of graduates to fill mainframe entry level positions and the managers to supervise mainframe operations becomes critical to the survival of their information systems.

We propose two possible approaches to this problem. First, related research supports integration of mainframe and client/server technology over redesigning and rewriting legacy code in a new language on a completely different computer platform other than mainframe. Newer mainframe technologies (such as IBM's WebSphere) adapt mainframes to client/server and web environments so there is not a need to abandon the mainframe environment which has offered a stable and secure platform to allow organizations to meet their goals and objectives. Organizations can achieve the benefits of both environments by blending mainframe and client/server technologies into a multi-platform information system that will allow them flexibility to adapt to new needs, requirements, and trends. This approach will still require some mainframe educated workers, but fewer than to run the enterprise entirely on the mainframe.

The second approach is for industry to encourage academia to develop curriculum that focuses on large enterprise computing. Incentives for development could include, but need not be limited to, scholarships, internships for students, grant funding for curriculum development, faculty training programs, and guest lecture programs for prospective students. The fact that industry is integrating this technology and will seek graduates with these skills for an extended period of time should be an incentive for academia to provide graduates with these skills. A high placement rate for graduates can improve the declining enrollment often seen in information technology departments throughout the United States. While further study is needed to confirm these trends and the ongoing need for graduates, this pilot study should serve as a reminder for academia to consider the needs of industry when designing curricula.

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