Analysis of job advertisements: What technical skills do software developers need?

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Abstract

An American web recruiting service was used to find the most common technical skills sought in job advertisements for various software developer positions. Data was collected between January and July 2004. The top five skills sought were Windows, Java, C++, SQL, and Unix. Distributed technology skills were analyzed thoroughly because as a consequence of World Wide Web technology, these skills might be required now more often than ten years ago. Results about distributed technologies showed (a) 40% of positions had some skill for the distributed systems mentioned. (b) Microsoft's and Sun's technologies were required approximately as often. (c) These skills were required more often in senior-level than in entry-level positions. This was the only noticeable difference between entry-level and senior-level positions.

1 Introduction

Unlike most previous job advertisement analyses, this research was targeted particularly to technical skills needed in software developer positions. The four main questions were: (1) What skills were needed most in positions for programmers, software developers, and software engineers? (2) What were the differences between these three job titles? (3) What were the differences between entry-level and senior-level positions? (4) How well do entry-level job requirements match the requirements of a typical bachelors program in computer science?

World Wide Web technology was released in 1993. After this, the number of web sites has increased rapidly. As a consequence, skills related to distributed systems might be required now more often than ten years ago. In this research, distributed technology skills were analyzed thoroughly. Based on the literature survey, these results are new.

As a data source, an American web recruiting service was used instead of, for example, a Finnish web service or a newspaper because in the USA job market is so much bigger than in Finland. A large number of advertisements was necessary for some parts of this research (e.g., analyzing rare skills such as Prolog). In the USA, web recruiting services are now dominant in the information technology job advertising market. The biggest service is Dice (http://www.dice.com) that was used for this research.

The results of this study might be useful for training departments of companies, training institutes, and curriculum designers in universities—in particular for those educators who are responsible for Software Systems specializations. Students might use the results when they are selecting elective computer science courses, especially in industry-oriented masters programs. A software developer working in industry might want to compare his or her skills to the results of this article. The results might even reveal something about what technologies were used in new projects if it is assumed that new employees are often hired for such projects. From this viewpoint, the competition between Microsoft's and Sun's technologies for distributed systems is particularly interesting.

The structure of the article is the following. First, the related work is considered in Section 2. In Section 3 the research method is described. The results are presented and analyzed in Section 4. Finally, implications to education are considered.

2 Related work

For any reader wishing to get an overview of research into IT needs assessments, two good starting points are (Nakayama and Sutcliffe, 2000) and (Nakayama and Sutcliffe, 2001). Most

previous relevant research has been carried out by educators and researchers who work for information systems/technology (IS/IT) degree programs, not for computer science (CS) or software engineering (SE) programs. 26 publications that are related to this research were found. 22 (85%) of them were from the area of IS/IT. The results have been typically published in publications like the MIS Quarterly and the proceedings of ACM's Special Interest Group for Computer Personnel Research (SIGCPR, currently merged with SIGMIS).

These 26 relevant publications were classified according to the research methods: 9 (35%) were content analyses of job advertisements, 8 (31%) were surveys, 3 (12%) were literature surveys or research in progress reports, 1 (4%) was interview, and 5 (19%) used more than one method.

Next, previous content analyses are described shortly. Main topic of (Adelman, 2000) was certification. In addition, he has written a WWW page (Adelman, no date) that contains results about technical skills such as C++. However, the sample apparently included all kind of IT positions, not just software developer positions. Arnett and Litecky (1994) targeted their research to technical skills for IS positions and found that most wanted skills were PC-LAN, relational databases, Unix, C, and Cobol. (Litecky and Arnett, 2001) and (Prabhakar et al., 1995) are extensions for the previous Arnett and Litecky's research. (Gallivan et al., 2002), (Maier et al., 1998), and (Todd et al., 1995) are trend analyses in IS field. Maier et al. (1998) analyzed individual technical skills such as C, Cobol, and Unix; the samples were from the years 1978–1994. Gallivan et al. (2002) counted proportions of different job titles and averages of skills per advertisement but they did not analyze individual technical skills. Todd et al. (1995) analyzed technical, business, and systems skills for programmers, systems analysts, and managers. Their samples were from the years 1970–1990.

Beside the previous scientific publications and articles in professional magazines, there are two non-scientific reports that are worth mentioning: ITAA report (Information Technology Association of America, 2002) and quarterly reports from a British research company (e.g., Salary Services Ltd. (2004)). The content analysis of job advertisements in the ITAA report (pp. 45–53) is based on Dice's data, and thus, the data source is the same as in this research. The research conducted by Salary Services Ltd. is a content analysis of British job advertisements from several newspapers and web recruiting services. It ranks 150 different skills and reveals which programming languages are required most often, for example. Although (Salary Services Ltd., 2004) is not a scientific publication, in my opinion, it is convincing or even impressive. In this research, the methodology presented in the Salary Services report was imitated on purpose to be able to compare the results.

From other type of research, the most relevant is the survey by Lethbridge (2000). He asked respondents from about 75 topics: How much they had learned about it in their formal education, how much they knew about it at the time of answering, and how important the topic has been for their career? Lethbridge's research is refereed later in Section 4.2.4.

The following characteristics are original or different to this research when compared to previous job advertisement analyses: (a) This research is limited to software developer positions and kind of digs deeper in the area of technical skills than previously. (b) Advertisements for more scientific or engineering-oriented positions have been sometimes excluded from the previous samples for an obvious reason: these positions are not very suitable for IS/IT graduates. I work at a university of technology and, therefore, included also more scientific or engineering-oriented positions in the sample. (c) Results about distributed technologies, comparing differences between entry-level and senior-level positions, comparing differences between job titles, and comparing requirements in job advertisements against the degree requirements are new (Section 4.2).

3 Method

Content analysis is a method that is widely used in communications research. Some good properties of content analysis are: (a) it is a non-disturbing method because data occurs regardless of whether the research is carried out or not, and (b) it is often possible to get a representative sample. In this research, a quantitative content analysis of job advertisements was carried out; that is, the frequencies of different phrases such as C++, Java, WebLogic, and 'operating systems' were simply calculated.

In February and July 2004, it was searched from Dice advertisements that had the job titles Programmer, Software developer, or Software engineer. The searches produced 9680 advertisements. From these 9680 advertisements it was searched for technical skills, using phrases such as Java, SQL, TCP/IP, and Windows. These phrases were typically names or abbreviations of different programming languages, operating systems, database vendors, and protocols. Also some more general phrases like 'embedded', 'object-oriented', or 'relational' were used but this was not common. Note that during this part of analysis the advertisements was not red but only Dice's search function was used. However, part of the results was calculated with two smaller samples (N=224 and N=25) from January and March 2004. The advertisements of the smaller samples were read and coded manually.

4 Results

The results are divided into three subsections. First, the most common platform, programming language, and database skills are presented in the subsection 'Updating earlier results', where the results of this research are also compared to prior findings. Second, in the subsection 'Results characteristic for this research' the results from topics that are more characteristics for the approach used in this research are presented. Based on the literature survey, the topics of the second subsection have been researched only a little or not at all previously. Third, in the subsection 'Verification of results' some results from other data sources are presented.

4.1 Updating earlier results

Not very much has changed during the past 5–10 years in the most common platforms, databases, and programming languages. The most important changes have been the increased need for Java and Microsoft SQL Server.

The five top skills and their proportions were Windows 42%, Java 35%, C++ 34%, SQL 34%, and Unix 29%. For example, the proportion of Java was 35% as Java was mentioned in 3359 advertisements and the number of advertisements was 9680. The sum of the proportions is greater than 100 because one position could be classified in more categories than one.

In Table 1, the top five platforms, programming languages, and databases are presented. The two-sided confidence intervals were calculated using Equation 3.74 from (Mitra, 1993, p. 122) and $\alpha = 0.01$. Below the table are presented intervals for the worst cases inside each category. The same method has been used later to calculate other confidence intervals, too.

The advertisements were classified into the following platform categories: Macintosh, Mainframe/midrange, Unix, Windows, and Cross-platform. For example, Windows refers to those positions where some Windows operating system or Windows based software such as Visual Basic or SQL Server was mentioned. Products that are available for both Windows and Macintosh (e.g., Word and Excel) were classified as Windows if Macintosh was not explicitly mentioned. The category 'Cross-platform' refers to positions where only cross-platform products such as Oracle were mentioned. Litecky and Arnett (2001) reported that in 1999 the proportions were Windows NT 23%, Windows 95 12%, Unix 17%, midrange (IBM) 7%, and mainframe 5%. The classification principles of their research were somewhat different than in this research but the order was the same: 1. Windows, 2. Unix, and 3. Mainframe/midrange when 'Cross-platform' is omitted from the comparison.

Table 1: Top five platforms, programming languages and databases.

Rank	Platform	Programming language	Database
1	Windows 42%	Java 35%	Oracle 22%
2	Unix 29%	C++ 34%	SQL Server 11%
3	Cross-platform 21%	C 26%	DB2 7%
4	Mainframe/midrange 19%	Visual Basic 10%	Sybase 5%
5	Macintosh 0%	C# 9%	Access 4%

Confidence interval is ±5% (N=224) for platforms, and ±1% (N=9680) for programming languages and databases (except ±5% and N=224 for Access).

The top ten programming languages were Java 35%, C++ 34%, C 26%, Visual Basic 10%, C# 9%, JavaScript 8%, Perl 8%, assembler 6%, Cobol 6%, and shell script 5% (N=9680, confidence interval ±1%). Clearly, skills in object-oriented and procedural programming paradigm were highly needed. The need for concurrent programming paradigm was unclear because at least Java can be used for concurrent programming, too. The need for functional and logical programming languages was very low: Lisp was mentioned only in 12 (0.1%) and Prolog in 3 (0.03%) advertisements. In the report (Information Technology Association of America, 2002, p. 46), the five most common programming languages were C++ 19%, Java 11%, Perl 5%, Visual Basic 4%, and assembler 4%. The proportions of the ITAA report were lower than results of this study because the ITAA data was from all IT positions, not just from developer positions. Interestingly, C was not mentioned in the ITAA report. This was probably a mistake or at least odd because it is hard to believe that assembler would be more common than C in the year 2002. In any case, when the results of this study are compared against prior researches (e.g., (Arnett and Litecky, 1994)), the most important change during the last ten years has been the strong increase of Java. But also older major languages C, C++, and Cobol are still alive and kicking.

The top five database vendors or products were Oracle 22%, Microsoft SQL Server 11%, IBM's DB2 7%, Sybase 5% (N=9680, confidence interval ±1%), and Microsoft Access 4% (N=224, confidence interval ±5%). The two most common database languages were SQL 34% and PL/SQL 6% (N=9680, confidence interval ±1%). As one might expect, relational databases dominated on the job market. In addition, phrases like ORDBMS, SQL3, object-relational, ODBMS, Jasmine, and Versant were used to search object-relational or object database skills. These skills were very rare. The phrase 'object-relational' was mentioned 9 times (0.09%), ODBMS 3 times (0.03%), and the other used phrases not at all. According to (Information Technology Association of America, 2002, p. 46), the top five vendors were Oracle 14%, Access 8%, SQL Server 4%, DB2 4%, and Approach 3%. The order is similar as in this research as the only exceptions were Access and Approach.[1] The high need for relational database skills was also noticed ten years ago, when Arnett and Litecky (1994) reported that relational databases were mentioned in 28% of advertisements. In addition, they reported that DB2 and Oracle were required approximately as often (DB2 9% and Oracle 7%) but Microsoft's database products were not mentioned in their report. This is reasonable because MS Access was released in 1992. Based on the results of this research and earlier researches, the need for IBM's DB2 has dropped and Microsoft's SQL Server is now a strong player but Oracle is still the most common database vendor skill.

[1]In this research, the result for Access was taken from the hand-coded sample (N=224) because with Dice's automatic search approximately half of the hits were false alarms (e.g., 'Knowledge of data access principles ...'), and Approach was excluded because all hits were false alarms (e.g., 'Our approach is based ...'). Approach might refer to, for example, Lotus Approach but it is more probably that there were three little mistakes in the ITAA report: C was missing, Approach should have been excluded, and Access' result should have been corrected.

4.2 Results characteristic for this research

Results about distributed technologies, differences between job titles, differences between entry-level and senior-level positions, and comparing requirements in job advertisements against the degree requirements are presented in the following subsections.

4.2.1 Distributed technologies

For distributed technologies three categories were used: Microsoft, Sun, and Other. A position was classified in a certain category if at least one skill of the category was mentioned. It is possible that one position was classified to several categories. The skills of each category are presented in the following lists:
- Microsoft: .NET, Active X, ASP, DCOM, IIS, and MTS
- Sun: EJB, J2EE, JSP, RMI, and Servlets
- Other: technologies that do not belong in the previous two categories (e.g., CORBA, Tuxedo, Tibco, WebLogic, WebSphere, client-server, or applications server).

In 40% of the positions at least one distributed technology skill was required or desired. The proportions of categories were Sun 20%, Microsoft 17%, and Other 8%. These results were calculated with the smaller sample (N=224) and the confidence interval is ±5%. Based on the Z test for proportions (e.g., (Mitra, 1993, p. 119)), the difference between Sun and Microsoft is statistically not significant and therefore, Sun's and Microsoft's technologies seem to have had an equally strong position. The most common individual distributed technology skills and their proportions are presented in Table 2.

Table 2: Most common distributed technology skills.

Skill	Abbreviation	Company	Proportion (%)
.NET	-	Microsoft	19
Active Server Pages	ASP	Microsoft	18
Java 2 Enterprise Edition	J2EE	Sun	13
Java Server Pages	JSP	Sun	8
WebLogic	-	BEA	5
WebSphere	-	IBM	5
Enterprise Java Beans	EJB	Sun	4
Java Servlets	-	Sun	4
Internet Information Server	IIS	Microsoft	3
Common Object Request Broker Architecture	CORBA	-	2
Distributed Component Object Model	DCOM	Microsoft	2
Microsoft Transaction Server	MTS	Microsoft	1

Confidence interval ±1%, N=9680.

In addition, 98 job advertisements that were published in Computerworld magazine in the year 1992 were analyzed. The year 1992 was chosen because WWW technology was released in 1993. One hundred and twenty-one software developer positions were offered in these 98 job advertisements. From these 121 positions eight were excluded because skills were not mentioned. Only in 4% of positions (N=113) at least one distributed skill was required or desirable. Based on the Z test for proportions, this difference between Computerworld 1992 (4%) and Dice 2004 (40%) is statistically very significant ($p<0.001$).

It was not possible to compare the results of this research against the earlier researches properly because earlier researches have been so IS/IT oriented or not targeted at distributed technologies. Litecky and Arnett (2001) reported that the proportion of WWW was 6%,

Internet 9%, and 'Network General' 9% in 1999. However, these results were for all IT positions, not just for developer positions.

4.2.2 Differences between job titles

During this part of the research, the purpose was to analyze if low-level programming skills would be more common in software engineer positions. For brevity, only results of C and the phrase 'embedded' are presented. The proportions were, respectively: programmers 16% and 1%, software developers 30% and 5%, and software engineers 40% and 15%. Based on the Z test for proportions, C's differences are statistically significant ($p<0.01$) between programmers and SW developers, between programmers and SW engineers, as well as between SW developers and SW engineers. Difference of phrase 'embedded' is statistically significant between software engineers and programmers but not for other job title pairs. Thus, there is some evidence that low-level programming skills are more common in software engineer positions.

4.2.3 Entry-level versus senior-level positions

Two groups were compared against each other: (1) Entry-level positions that had no word 'senior' in the job title and the number of required working years was 0–1 (n=41). Often these positions had the word 'junior' as part of the job title. This sample was collected mainly in March 2004 from Dice, using phrases like 'junior' and 'jr.' (2) Senior-level positions that had the word 'advanced', 'lead', 'principal', or 'senior' in the job title or at least five years work experience was required (n=73). During this analysis, the desired skills were excluded and only the required skills were compared. In addition, individual skills such as Java and SQL were not compared because the sample sizes were so small. Only the following criteria were used: (a) at least one common programming language (C, C++, Cobol, Java, or Visual Basic), (b) at least one common database skill (Access, DB2, 'database', Oracle, SQL, SQL Server, or Sybase), and (c) at least one distributed technology skill.

The average number of required skills was somewhat greater for the senior-level group. The average was 3.7 for the entry-level group and 5.2 for the senior-level group. The proportions of the different skill groups were: at least one common programming language 68% (entry-level) and 73% (senior), at least one common database skill 38% (entry-level) and 48% (senior), and at least one distributed technology skill 27% (entry-level) and 59% (senior). The Z test for proportions was used to analyze if the differences between the proportions were statistically significant. The difference between the distributed technology skills was statistically very significant ($p<0.001$). Other differences were statistically not significant.

In addition, the average numbers of software development life cycle phases when the number of required experience varied were calculated. The phases presented in the IEEE standard (Institute of Electrical and Electronics Engineers, 1990, p. 68) were used for analysis. There were no big differences. Even the least experienced developers were typically required to take part in more phases than just implementation. Tutoring younger developers and leading small groups of developers were mentioned often for senior-level positions but obviously not for entry-level positions. The proportions of these duties were not calculated because they are non-technical skills.

Maier et al. (1998) wrote that the proportion of advertisements where experience was required was 34–44% in 1978–1994. Arnett and Litecky (1994) reported "In review of the ads, very few required many years of experience. For the most part, the ads requested experience with words such as 'related', 'some', 'one-year', etc." Experience was required more often in Dice's advertisements than reported in these previous researches. In Dice, the distribution of required years was as follows: no experience 2%, one year 1%, two years 10%, three years 13%, four years 7%, five years or more 26%, and not mentioned 41% (N=224, confidence interval ±5%). Thus, some experience was required in 57% of the positions.

4.2.4 Bachelors programs versus required skills

Next, let us consider how well current curricula in the USA correspond to the job market. McCauley and Manaris (2002) reported that in ABET/CAC accredited bachelor programs the three most common programming languages that were taught first during the academic year 2001–2002 were Java (49%), C++ (40%), and C (11%). In this respect, the match between curricula and the job market is good because these three languages are exactly the same as the three most common programming languages in the job advertisements. With this comparison I do not imply that all degree programs should use these three languages. There can be other reasons than languages popularity in industry to choose the programming language used in education—especially the first one. For example, some institutes might use Scheme as the first language because its syntax is simple.

In addition, McCauley and Manaris reported how often various upper-level courses were required. Related skills are considered in Table 3 that is quite complex. The table combines results from two surveys and from this research. The 'Proportion' column is based on McCauley and Manaris' survey and refers to the number of times a course was required in accredited programs.

The column 'Importance' is based on survey (Lethbridge, 2000) that was targeted to software developers. The means indicate how important the respondents thought that related skills are. The scale was 0–5, and a greater mean indicates greater importance. The data is from Excel file that can be found from (Lethbridge, no date). If the survey had more than one related item per course title, the means were combined for this article.

In the column 'Required in advertisements' is presented my estimation how often the related skills were mentioned in Dice's advertisements. For this analysis, the exact proportions of phrases were calculated but they are not presented because the table would become too complex. For example, for course Database Management Systems phrases 'SQL', 'database', 'relational', and 'query' were searched for. The respective proportions were 7–32%. Similarly, related phrases from job advertisements for other courses were searched, too. The text 'Hardly ever' refers to proportions 0–1%, 'Sometimes' to 2–19%, and 'Often' to greater than 19%.

Table 3: Most common upper-level courses, their proportions in accredited programs, importance of related skills in Lethbridge's survey and my estimation how often related skills were required in job advertisements. See the body text of article for the explanation of the column 'Required in advertisements.'

Course name	Proportion (%)*	Importance (mean)†	Required in advertisements (my estimation)
Operating Systems	96	3.3	Sometimes
Programming Languages	87	2.7	Hardly ever
Software Engineering	76	3.0	Sometimes
Architecture	69	2.7	Sometimes
Analysis of Algorithms	67	2.6	Sometimes
Theory of Computation	49	2.2	Hardly ever
Database Management Systems	31	3.3	Often
Networks	18	3.1	Sometimes
Compiler Construction	16	2.3	Sometimes
Artificial Intelligence	9	1.3	Hardly ever
Human-computer Interaction	4	3.3	Sometimes

*Source (McCauley and Manaris, 2002). †Source (Lethbridge, no date).

This part of research was the most problematic. Here, maybe the main finding is not the results presented in the column 'Required in ads (my estimation)' per se but realizing

that this analysis has severe limitations because job advertisements do not contain enough suitable information. Simply put, one can find out from job advertisements that some skills are probably important but solving out if some particular skill or subject is *not important* can be much more difficult. Analysis seems to work quite well for language and product names such as Java and WebSphere. For other kind of search phrases—that are typically more general terms, selection of phrases can have dramatic impact into results. For example, if I had assumed that the course Programming Languages deepens the understanding of programming principles and is thus highly relevant for any advertisement that mentions programming or a programming language, my estimation would be 'Often' instead of 'Hardly ever.' However, I have not omitted Table 3 because the results show that topics for at least eight out of 11 courses are required sometimes or often.

4.3 Verification of results

A possible methodological problem with this research is that Dice's data was only from the first quarter of 2004. To verify the results also approximately 350 advertisements that were published in the Computerworld magazine in 2003 were analyzed. There were some differences between Dice's and the Computerworld's results but the results of this article would be similar if the data source were changed from Dice to Computerworld. Some differences were statistically significant but the order of skills was so similar that the differences had only a little practical relevance. For example, the biggest absolute difference was that the proportion of Java was 35% in Dice and 54% in the Computerworld. Based on the Z test for proportions, this difference is statistically very significant ($p<0.001$) but it has a little practical relevance because both results show that the need for Java was high.

In addition, the results of this research were compared against the results of the recent British analysis (Salary Services Ltd., 2004). In this research, the methodology of the British analysis was imitated on purpose to be able to compare the results. The most important difference was that, in the UK, the mainframe/midrange platform was mentioned more often than in the USA. In the UK, the proportion of the mainframe/midrange platform was 4% whereas in the USA it was 19%. As a consequence, the mainframe/midrange related skills Cobol and DB2 were also more common in the USA.

5 Implications for CS degree programs

Implications of the previous results are considered only for university-level education, not for training institutions or for an individual software developer working in industry. Further, implications are limited only to the typical requirements of accredited computer science programs in the USA because there are no statistics from other countries similar to survey by McCauley and Manaris (2002). The article by Parnas (1999) concerned the differences between CS and SE programs. He wrote 'In the SE program, the priority will be usefulness and applicability; for the CS program it is important to give priority to intellectual interest, to future developments in the field, and to teaching the scientific methods that are used in studying computers and software development.' Obviously, the results of this research are more relevant to SE programs. However, I write about CS programs and Software Systems specializations because the number of SE programs is so small. As Parnas put it, "Computer Science departments have tried to fill the gap by including so-called 'Systems' or 'Applied Computer Science' courses in their offerings."

Based on the results of this research, the course Database Management Systems should be made compulsory more often. This being said, it would be fair to suggest which one of the other upper-level courses could be changed from compulsory to elective in order to make room for a Database Management Systems course. However, I do not make such suggestion. As explained in Section 4.2.4, this type of analysis is too problematic to find out subjects or skills that are not important.

The results of this study imply that the need for distributed technology skills has increased during the last ten years. However, the results also imply that distributed technologies are not common enough in entry-level positions to make a distributed systems course compulsory in bachelors programs. These skills are common in mid-level and senior-level positions and therefore, the distributed systems course is very suitable as a compulsory course for a specialization Software Systems in, for example, a part-time or industry-oriented masters program.

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