Analysis of Current and Future Computer Science Needs via Advertised Faculty Searches for 2017

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Abstract

This work uses the same methodology as work from previous years to study where Computer Science departments are choosing to invest faculty positions by examining data obtained from advertised faculty searches for the current hiring season. While the number of and areas for faculty searches does not necessarily translate into the same for faculty hires, we believe that they provide insight into current and future needs within the discipline.

We analyzed ads from 347 institutions seeking to fill hundreds of tenure-track faculty positions in Computer Science. There is a 30% one-year (and 56% two-year) increase in the number of institutions searching for tenure-track faculty in Computer Science and a 35% one-year (and 71% two-year) increase in the number of positions being searched for. The number of institutions searching and positions seeking to be filled has increased even more for non-PhD-granting institutions.

In terms of specific areas, we found that the area clusters of Security, Data Science and Systems/Networking continue to be the areas of greatest investment. We again found that 30-60% of all hires are for areas that are, or may be, interdisciplinary in nature.

Differences are also seen when analyzing results based on the type of institution. Positions related to Security have the highest percentages for top-100 PhD, MS and BS institutions. Data Science is of most interest for other PhD institutions. Finally, the abundance of potentially interdisciplinary areas is most pronounced for PhD institutions with 35-70% of all positions devoted to these areas.

1 Introduction

The wealth of faculty searches in Computer Science during this hiring season for positions starting in 2017 again affords the opportunity to study areas of Computer Science where departments are choosing to invest in new faculty hires. This report details results in a similar manner as a study of faculty hiring ads in Computer Science done in previous years [1, 2]

The primary focus of this work is to study where departments specifically, and the discipline more generally, are choosing to invest precious tenure-track faculty positions. It is an opportunity to understand where Computer Science departments think they are in terms of current needs as well as where they think they are going.

With this focus, there are a number of caveats to our study:

1. Our study is not exhaustive in that it does not necessarily take into account all searches currently underway for this hiring season. We describe the methodology used to discover ads, but ads may have been missed or may not have been placed in the timeframe of our study.

2. While our study focuses on preferred areas for faculty applicants, not all ads identify such preferred areas. These searches are accounted for in the data, but are not considered when analyzing particular areas of interest.

3. Our study analyzes searches and not hires. The number and areas of actual faculty hires may not match what is being searched for.

2 Methodology

As in past years, we used two primary sources for obtaining ads for Computer Science faculty positions: the Computer Research Association (CRA) Job postings[1] and the Association for Computing Machinery (ACM) list of jobs[2]. We again augmented these two sources with positions posted on the SIGCSE mailing list, which often includes ads for more undergraduate-focused institutions. This year we also used the Chronicle of Higher Education Vitae site[3] and found ads for a small number of additional positions not appearing in other venues. We considered ads posted on these venues between August 2016 and mid-November 2016, which is the same timeframe used in our previous studies.

Only ads for tenured and tenure-track positions by departments containing Computer Science or closely-related programs were considered. We did not consider non-tenure-track positions such as lecturers, instructors or researchers and we only considered institutions awarding at least a BS degree. Searches for Deans or department chair positions were noted, but not considered because they do not reveal information regarding areas. Similarly, searches for other departments and programs with interest in faculty with Computer Science background were noted, but also not considered.

[1] `http://cra.org/ads/`
[2] `http://jobs.acm.org/c/search_results.cfm?site_id=1603`
[3] `https://chroniclevitae.com/job_search/new`

3 Results

3.1 Institutions and Positions

Using this methodology our resulting dataset contains information for faculty searches from 347 institutions (313 are U.S. based). 269 (78%) of these institutions indicate a specific number of positions being searched for with the remaining searches using non-specific phrases such as "multiple positions," "several positions" or just "positions" to indicate the number. As comparison, our previous-year study [2] found searches for 267 institutions (249 U.S. based) with 216 (81%) of these institutions indicating a specific number of positions being searched for.

The left-side of Figure 1 shows three-year results for the number of institutions searching. It shows a 30% increase over the past year and a 56% increase over the past two years.

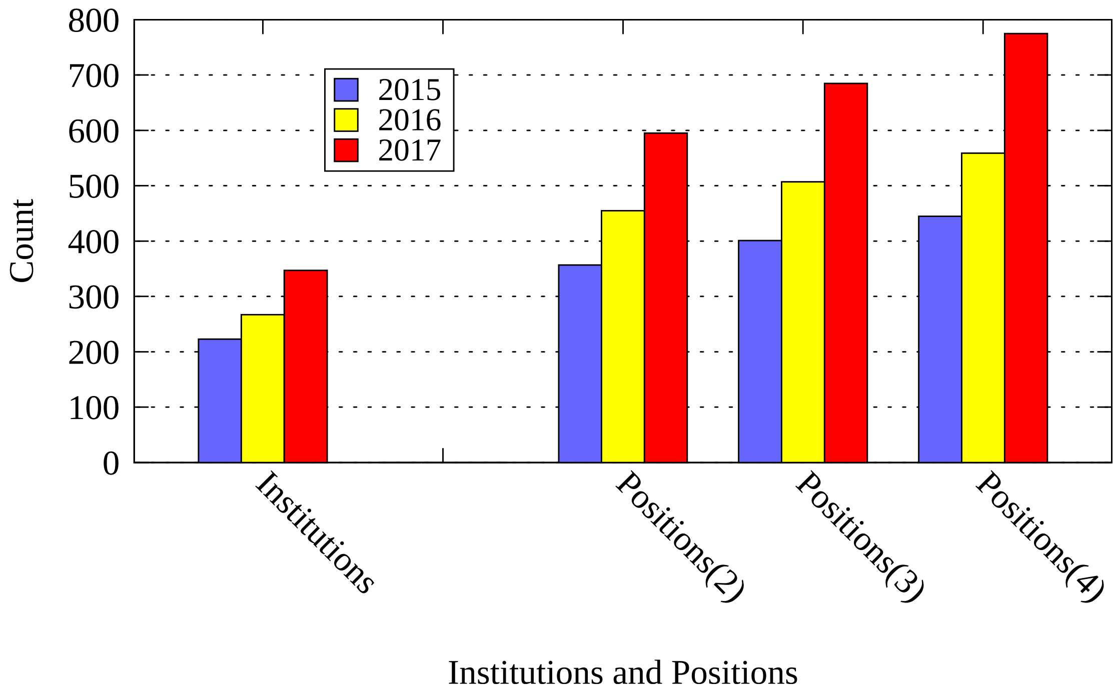

Figure 1: Three-Year Numbers of Number of Institutions Searching and Total Number of Positions (Using Values of 2, 3 or 4 for "Multiple Positions")

In terms of the total number of positions, we experimented with treating such "Multiple Position" searches as meaning two, three or four positions. The right-side of Figure 1 shows the total number of positions searched for using the three different values for "multiple positions." There are between 595 and 775 total positions for 2017 depending on the value used for translating "multiple positions" into a specific count. The midpoint total is 685 positions using a value of three for multiple-position searches. This value represents a 35% one-year and a 71% two-year increase in the number of positions being searched for.

Finally, in terms of institutions and positions we did encounter additional ads for Computer Scientists that were noted, but not considered in our analysis. A summary of these are shown in Table 1 with 20 Dean and Chair searches as well as 85 faculty searches in other departments. We do not represent that this list of additional searches is complete because it based only on ads in the venues we describe in our methodology. Ads appearing in other venues were not considered.

Table 1: Additional Searches with Interest in Computer Scientists Not Considered in Analysis

Search Type/Area	Number of Institutions
Computer Science Dean	6
Computer Science Chair	14
Bio/Health Sci/Engr Faculty	10
Electrical/Computer Engineering Faculty	32
Information School/Science Faculty	17
School of Business Faculty	12
Other Non-CS Faculty	14

The additional departments are not surprising as they primarily involve Computer Engineering, an Information School or a School of Business. We did observe ten additional searches interested in Computer Scientists for Bio- or Health-related departments as well as 14 in variety of other departments.

3.2 Results by Area

In the same way that not all ads list a specific number of positions, it is also the case that not all ads list specific or preferred areas of interest. 246 (71%) of the 347 institutions listed specific areas, which is a comparable percentage as last year. In studying particular areas of interest, we only considered the ads from these institutions for our analysis.

In the initial step of our study, we determined the number of times that a specific area was mentioned in an ad. Thus an ad for a single faculty position with preferred interest in the areas of HCI, Security, Machine Learning and Robotics would count one "mention" for each of these four areas. Another institution looking to focus three positions in the area of Security would be one mention for Security. A total of 1074 specific areas are mentioned in ads (versus 739 last year).

While mentioned areas are one metric, another approach is to consider a faculty search as a "vote" for an area of current and future need. Using this approach a single position with four areas of interest would be investing 0.25 positions for each area, while three positions focused in a single area would invest 3.0 positions in that single area.

The problem with weighting areas based on the number of positions is that not all ads list a specific number of positions. Based on results in Figure 1, we use the fixed value of three for multiple-position searches resulting in a total of 685 "positions" being searched for with 513 (75%) of the positions indicating preferences for specific areas. Figure 2 shows the percentage of mentions and positions for areas with at least one percent for either mentions or positions. They are shown in rank order based on the number of positions.

The results show that the area of Security accounts for the highest percentage of both mentions and positions, although it accounts for relatively more positions. Security was also the top area for both metrics last year. Data Science is the area with the second most number of mentions and positions, moving ahead of Software Engineering and Machine Learning from last year's results.

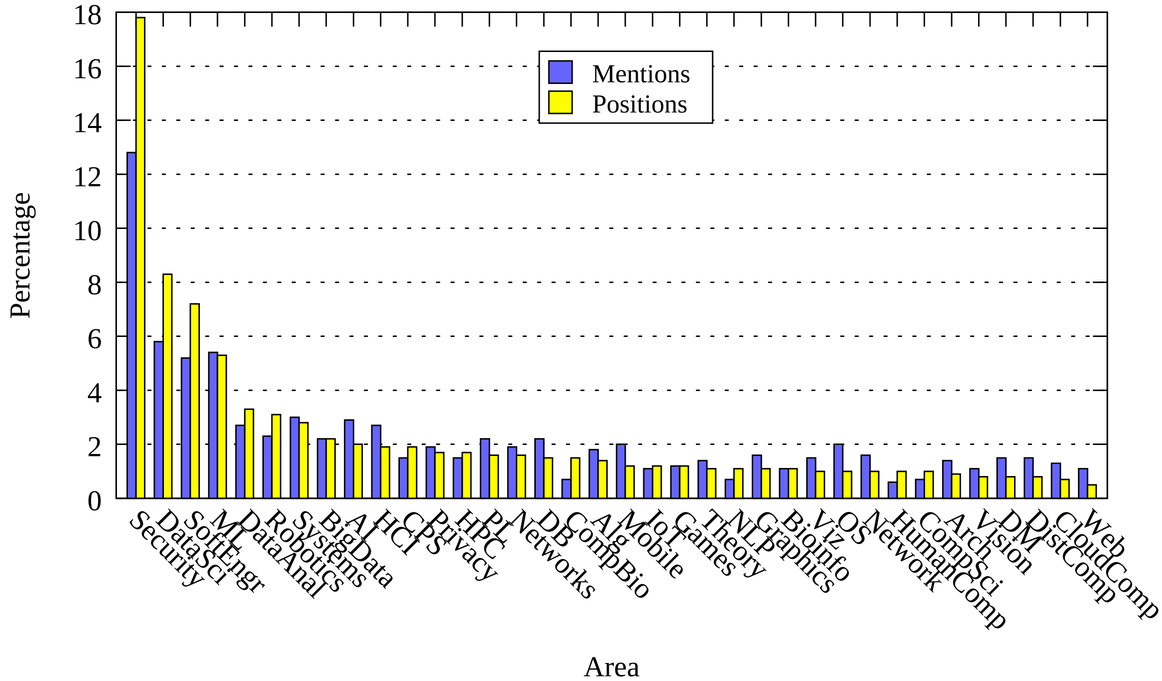

Figure 2: Area Percentage by Mentions and by Positions

3.3 Results by Area Cluster

Figure 2 does not show areas that appear less frequently in ads nor does it group similar areas, such as Data Science and Big Data. To address these issues, we grouped areas into clusters. These area clusters and the set of areas constituting the cluster are shown in Table 2. Areas with a small number of mentions and not clearly fitting into a cluster are included in two other clusters—one with areas in traditional Computer Science (OtherCS) and one with areas more interdisciplinary in nature (OtherInter). These are the same clusters used in our previous studies [1, 2] with two small changes where the cluster named "Big Data" is changed to "Data Science" and the former Artificial Intelligence cluster name has been expanded to "AI/DM/ML" indicating the prominence of Data Mining and Machine Learning in the cluster.

Figure 3 shows the same results as Figure 2 using the clusters from Table 2 rather than the areas directly. It shows that the Security area cluster has the highest percentage of mentions and positions. Data Science has the next highest percentage of positions with Systems/Networking having the second highest percentage of mentions. These three area clusters were also the top three by percentage last year.

3.4 Results Comparison with Previous Years

Figure 4 shows a more complete comparison of clustered area results based on percentage of positions for the previous year searches of 2015 and 2016 with the current year searches for 2017. Clustered areas are ordered based on 2017 percentages. The results show a comparable percentage of positions are being targeted for Security hires with a bit higher percentage of positions for

Table 2: Areas Grouped in Each Area Cluster

Area Cluster	Constituent Areas
AI/DM/ML	Artificial Intelligence, Computational Linguistics, Data Mining, Machine Learning, Natural Language Processing, Text Analytics
Arch	Architecture, Computer Organization
Bioinfo	Bioinformatics
Compiler/PL	Compilers, Programming Languages, Object-Oriented Languages
CompSci	Computational Biology, Computational Life Science, Computational Medicine, Computational Neuroscience, Computational Science, Neuroscience, Scientific Computation
DataSci	Big Data, Data Science, Data Analytics, Data Computation/Systems, Information Analysis, Knowledge Representation, Visualization, Visual Computing
DB	Database, Data Management, Information Retrieval, Information Systems
Games	Animation, Computational Media, Games, Interactive Media, Digital Media
HCI	Accessibility, HCI, Immersive Systems, Interactive Computing, Virtual Reality
ImageSci	Graphics, Image Processing, Pattern Recognition, Vision
Mobile	Human-Centered Computing, Mobile Systems, Ubiquitous/Pervasive Computing
Robotics/CPS	Autonomous/Vehicular Systems, Cyber-Physical Systems, Embedded Systems,Human-Centered Computing, Internet of Things, Reconfigurable Systems, Robotics, Sensors
Security	Cryptography, Forensics, Information Assurance, Privacy, Security
SoftEngr	Software Assurance, Software Design, Software Engineering, Software Systems
Sys/Net	Cloud Computing, Distributed Computing, High Performance Computing, Experimental Systems, Networking, Network Science, Operating Systems, Parallel Computing, Systems
Theory/Alg	Algorithms, Computational Complexity, Discrete Math, Foundations, Formal Methods, Logic, Theory
OtherCS	Applied Areas, Complex Systems, CS Education, Data Structures, Informatics, Information Technology, Intelligent Systems, Introductory CS, Modeling, Numerical Computation, Software, Social Computing, Social Networking, System Administration, System Design, System Verification, Web Technologies
OtherInter	Bioscience, Biomedical, Business Analytics, Cognitive Science, Communications, Economics, Energy Awareness, Geographic Information Systems, Green Computing, Health Informatics, Interdisciplinary, Learning Science, Medical, Social Computing, Sustainability, Urban Informatics

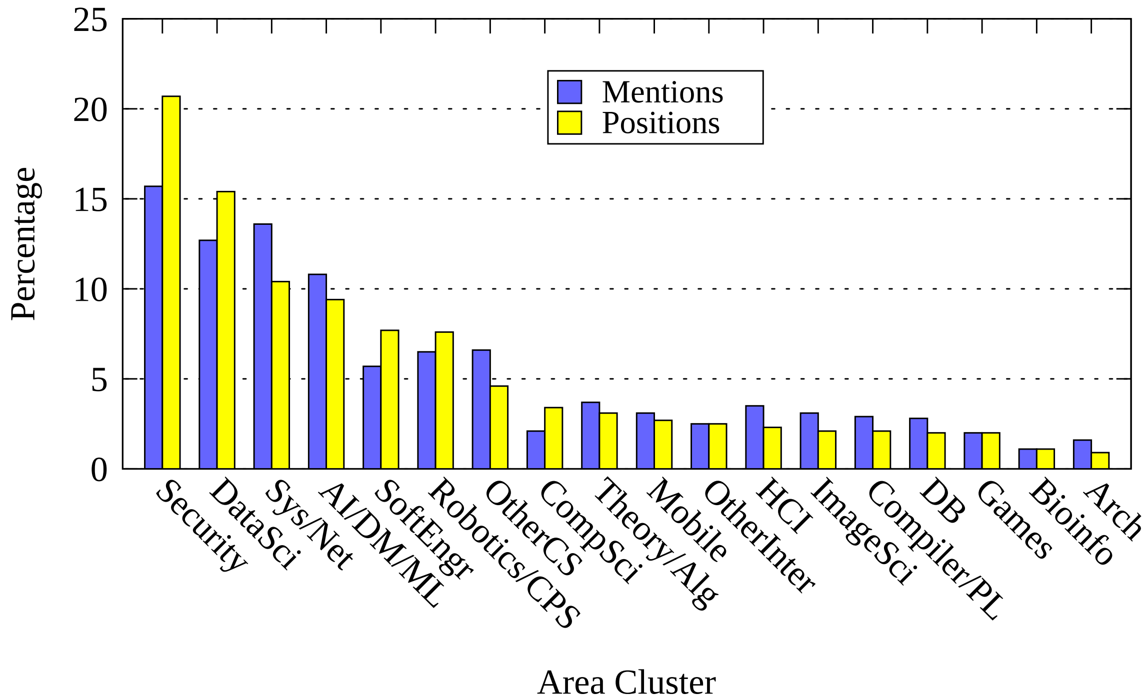

Figure 3: Clustered Area Percentage by Mentions and by Positions

the Data Science cluster. The Systems/Networking cluster is still third by percentage, but the proportion has dropped. Other area clusters with a relatively larger year-over-year increase are Robotics/CPS, Other Computer Science, Computational Science, and Mobile. Theory/Algorithms and Human-Computer Interaction have the largest year-over-year decreases.

In terms of longer-term trends, Figure 4 shows that four area clusters have increased their contributions each year. These are Security, Robotics/CPS, Other Computer Science and Computational Science. In contrast, four clusters have decreased their contributions each year. These are Systems/Networking, Software Engineering, Databases and Architecture.

3.5 Results for Interdisciplinary Area Clusters

Another question we again examined is how the interdisciplinary nature of Computer Science is affecting hiring. Specific clusters in Table 2 that are more interdisciplinary include the Data Science, Robotics/CPS, Bioinformatics, Games, Computational Science, and Other Interdisciplinary clusters. Combining the results for these clusters from Figure 3 shows that 27% of the mentions and 32% of the positions are for these more interdisciplinary areas. Moreover, other clusters such as AI/DM/ML and Security either support interdisciplinary work or may include work with other disciplines. Including these two clusters, which have some amount of interdisciplinary nature, results in up to 53% of the mentions and 62% of the positions being interdisciplinary in nature. These numbers are a bit higher compared to the previous year results of 52% and 59%.

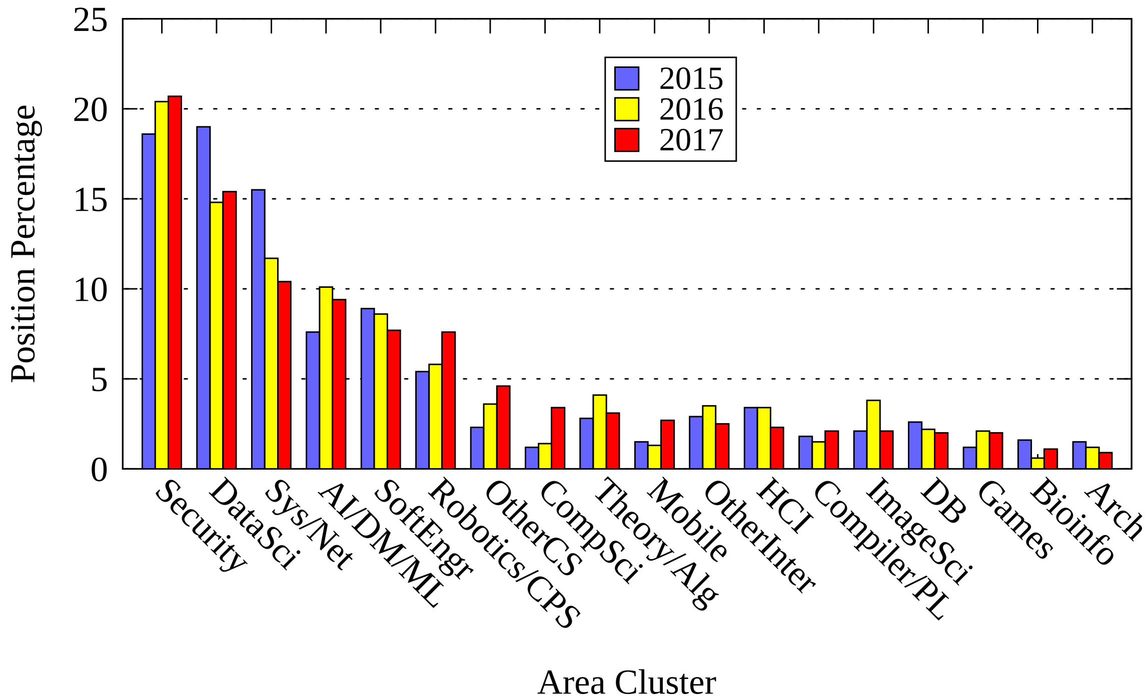

Figure 4: Clustered Area Percentage by Positions for 2017 in Comparison with Previous Years

4 Results By Type of Institution

We repeated our analysis based on the type of the program at each institution. For example, undergraduate-only programs may not have the same needs as PhD programs. For this portion of the study we augmented our dataset to include the highest degree offered by each program—BS, MS or PhD. Our dataset includes 165 PhD institutions—up from 146 last year. In order to study faculty investments at the most prominent U.S. programs, we further subdivided this group by using the U.S. News Rankings of the 100 Best Graduate schools[4]. This "PhD100" list account for 86 (vs. 85 last year) institutions in our dataset. The remaining PhD programs, including the 34 non-U.S. based, are denoted as "PhDOther". Table 3 shows summary results based on the four institution types. The left-side of Figure 5 shows three-year results for the number of institutions searching where there is a one-year increase for all types with the number of PhD100 institutions up by 1%, PhDOther by 30%, MS by 54% and BS by 49%.

Table 3 reveals differences between the different types of institutions. Ads for 88% of the BS institutions are for a single position while 56% of the ads for PhD100 institutions are for multiple positions. The overall percentages are generally comparable as last year.

As shown, the distributions translate into a total number of 269 positions for PhD100 institutions, which is a 25% increase from last year. We note that this number is particularly sensitive to the number of positions assumed for "multiple position" searches as over half of these searches are not specific in the number of positions being sought. The right-side of Figure 5 shows three-

[4] `http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-science-schools/computer-science-rankings`

Table 3: Summary of Position Searches by Institution Type

Institution Type	Number of Institutions	Advertised Number of Positions 1	2	3+	Multiple	Total Positions	%Specific Area
PhD100	86	13 (15%)	18 (21%)	7 (8%)	48 (56%)	269	76%
PhDOther	79	29 (37%)	13 (16%)	12(15%)	25 (32%)	171	86%
MS	71	39 (55%)	22 (31%)	5 (7%)	5 (7%)	118	78%
BS	112	99 (88%)	11 (10%)	2 (2%)	0 (0%)	127	55%
All	347	180 (52%)	64 (18%)	25 (7%)	78 (22%)	685	75%

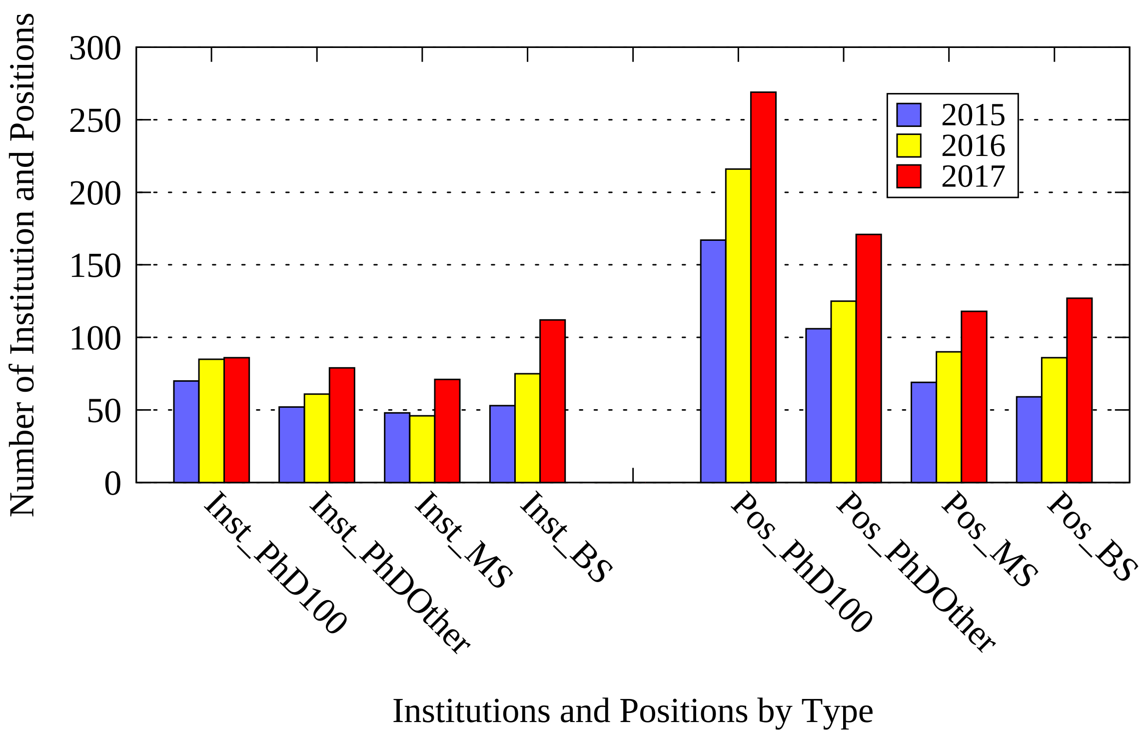

Figure 5: Three-Year Numbers of Institutions Searching and Positions Being Searched For Based on Type of Institution

year results for the number of positions being searched for by the PhD100 and other types. The additional position counts and relative change from last year are 171 positions (37% increase) for PhDOther, 118 positions (31% increase) for MS and 127 positions (48% increase) for BS institutions.

The last column of Table 3 shows that only 55% of positions from BS institutions identify specific areas of interest while 86% of PhDOther institutions do so with the percentages for the other institution types in between. In order to understand differences on areas of interest between different types of institutions for 2017 searches, we break down the results in Figure 3 based upon the type. Figure 6 shows the results (in the same rank order as Figure 3) grouped by the four types of institutions.

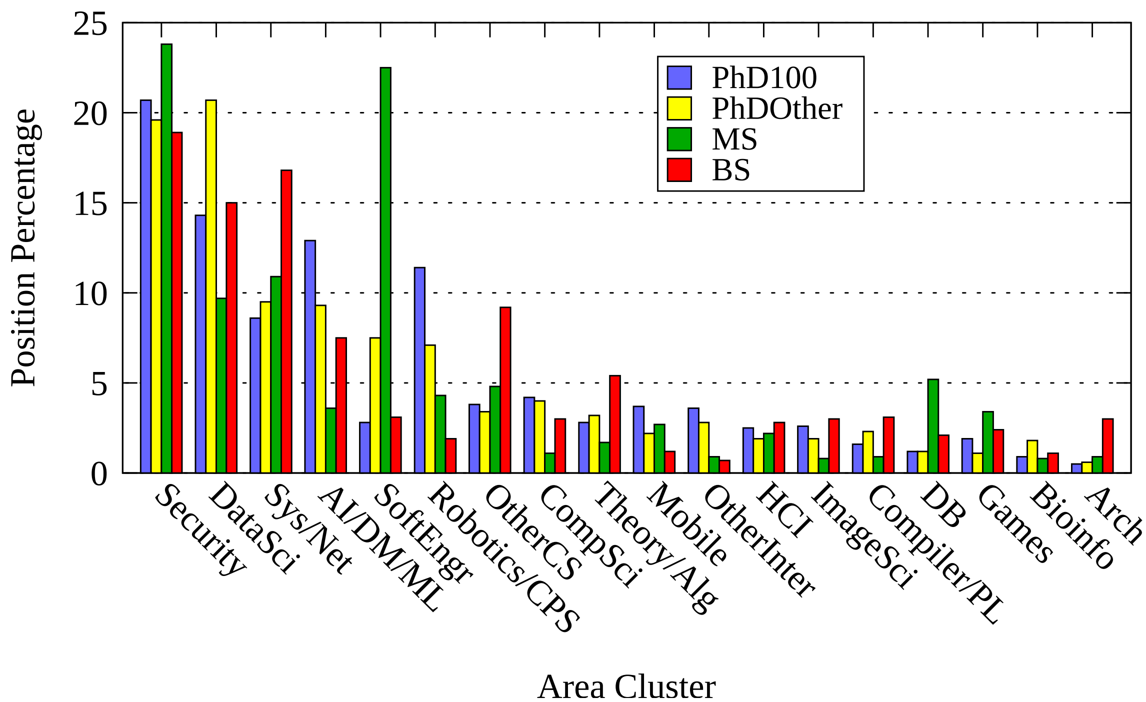

Figure 6: Area Cluster Percentage by Institution Type

The figure shows a number of interesting results. Positions related to Security have the highest percentages for all but PhDOther institutions. Data Science is of most interest for PhDOther institutions and is also of much interest for PhD100 and BS institutions. AI/DM/ML and Robotics/CPS are also of high interest to PhD100 institutions. The Software Engineering and Databases clusters are of much higher interest to MS institutions than the other institution types. Systems/Networking and Other CS are of relatively higher interest to BS institutions in comparison with other types.

Finally, Figure 7 shows the three-year percentage of positions devoted to areas that are more and some amount of interdisciplinary in nature. The 2017 results show that the impact of interdisciplinary areas is even more pronounced for PhD institutions with at least 35% and up to 70% of all positions devoted to these areas. These percentages are higher than last year for these institutions. In contrast, MS and BS institutions have a range of 20-50% of positions devoted to interdisciplinary areas. These percentages are decreased from last year for MS and increased for

BS institutions.

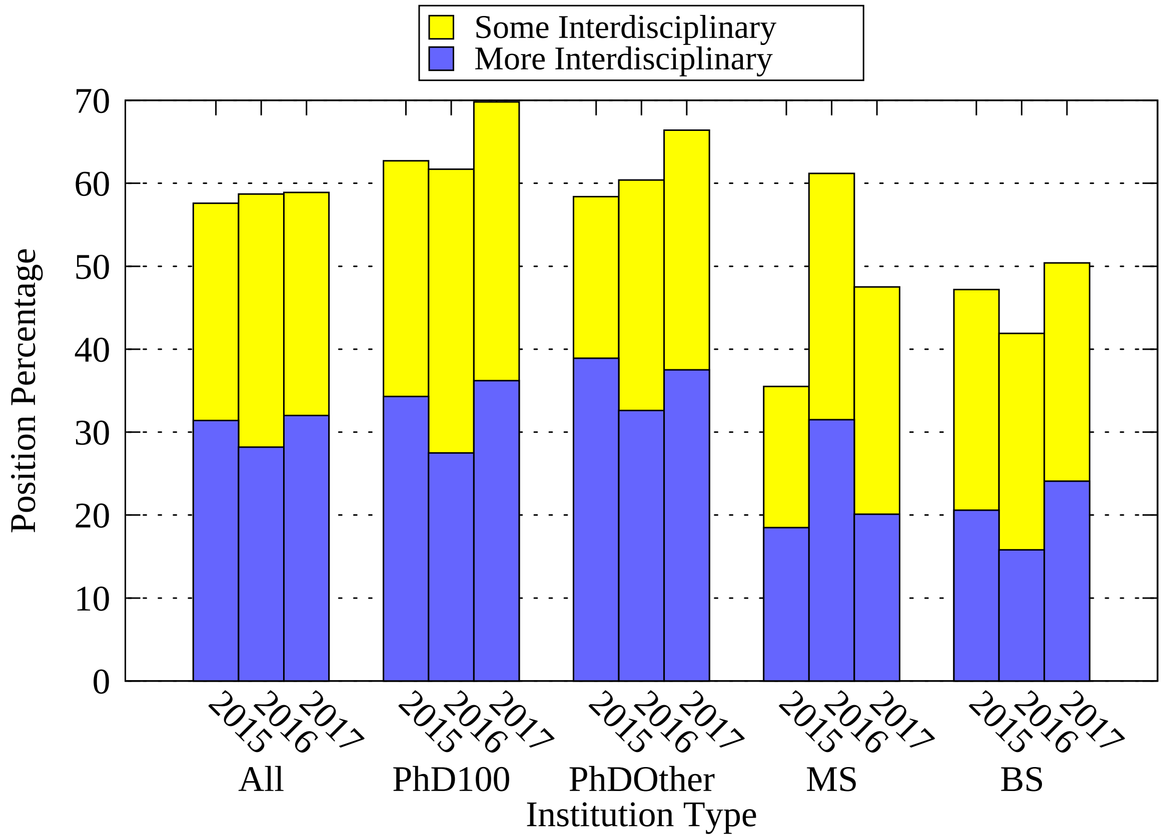

Figure 7: Investment in Interdisciplinary Area Clusters by Institution Type

5 Summary and Future Work

This work uses the same methodology as work from previous years to study where Computer Science departments are choosing to invest faculty positions by examining data obtained from advertised faculty searches for the current hiring season. While the number of and areas for faculty searches does not necessarily translate into the same for faculty hires, we believe that they provide insight into current and future needs within the discipline.

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A direction for future work is to examine how these searches translate into actual hires. Such work would look both at numbers of actual hires as well as the areas in which these hires occur.

References

[1] Craig E. Wills. Analysis of current and future computer science needs via advertised faculty searches. *Computing Research News*, 27(1), January 2015. Full report at `http://web.cs.wpi.edu/~cew/papers/CSareas15.pdf`.

[2] Craig E. Wills. Analysis of current and future computer science needs via advertised faculty searches for 2016. *Computing Research News*, 28(1), January 2016. Full report at `http://web.cs.wpi.edu/~cew/papers/CSareas16.pdf`.