Humanware: The Critical Role of People in Supporting Research in the Cloud

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ABSTRACT

Cyberinfrastructure is generally defined as consisting of computing systems, data storage systems, advanced instruments and data repositories, visualization environments, and people, all linked by high-speed networks to enable scholarly innovation and discoveries. Usually, the "people" component is overlooked in favor of all the other "wares" ... hardware, software, vizware, and netware. The term "humanware" provides an analogous term to emphasize the important role that people play in supporting the use of cyberinfrastructure's other components. Humans have always been important to the deployment and effective use of technology. This paper seeks to provide historical perspective on the role of people in deploying technology, and to illuminate the challenges associated with emphasizing humanware's importance to the use of cloud-provided cyberinfrastructure.

CCS CONCEPTS

• **Human-centered computing**; • **Social and professional topics** → *Management of computing and information systems*; • **Computer systems organization** → *Cloud computing*;

KEYWORDS

cloud computing, cyberinfrastructure, support

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1 INTRODUCTION

Let's begin by providing a concise definition of the term. By "humanware" we simply mean the role that people play in supporting the deployment and effective use of technology.

Everyone is familiar with the general terms "hardware" and "software." As we examine the many parts of what has become a classic definition of cyberinfrastructure, we can also include the terms "Vizware" (referring to visualization tools), and "Netware" (referring to the high-speed networks that connect all the other physical components together). But what gets lost in all these tangible technical products and tools is perhaps the most important element – the people who support these technology components and, more importantly, who support the people who make use of them to do their work (teaching, learning, research, commerce, etc.).

Humans have always been "in the loop" when it comes to the deployment of technology. Today much of that technology has become intuitive to use, or through decades of exposure to pedestrian technology (smartphones, laptops, tablets, etc.), the people who employ these technological tools have developed skill and experience in their use. But there are more advanced technologies being used in advancing discovery, and these technological components are often quite intricate and complex. Grasping their use requires specialized skill and knowledge, and because the technology is constantly changing,advancing the role of human support is increasingly important in making effective use of available tools. Nowhere is this more apparent today than in the use of cyberinfratructure supporting research in universities. The challenge is also increasing as use of cloud-based cyberinfrastructure is evolving away from the use of premise/campus-based resources and "traditional" nationally provided resources (national supercomputing centers, etc.).

Our examination of the role of people in advancing research using (information) technology is only the latest chapter in this long story. Understanding where we came from may be instructive in better explaining where we are, and where we are going.

2 A BRIEF HISTORY OF HUMANWARE

Let's pick up the story with the arrival of distributed computing in the 1980s. As computers moved out of the data center and onto desktops, and as their use spread from very knowledgeable and technically savvy users to those perhaps more pedestrian (i.e., the rest of us!), a new challenge emerged. The devices we needed to do our work required technical support; we as users of these devices needed support in making effective use of them. Most people didn't have the knowledge and skills to actually take care of the technology that was becoming critical to performing their duties. In the movie *Kelly's Heroes*, the tank commander (Oddball, played by Donald Sutherland) uttered the famous line: "Hey man, I just ride them, I don't know what makes them go!" [1]. No better metaphor exists for the situation in which users of technology found themselves.

As the technology left the data center, those who supported their use were no longer co-located with the devices or the users of technology. The best support is always that which is right down the hallway, and increasingly the geographic spread and growing number of users stretched centrally located technical staff past the point of being effective. What was needed was a support model

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where technical staff (humans) were as distributed as the technical devices and people using them.

Universities (and enterprises of all types) wrestled with this problem. Indiana University was at the forefront of addressing this challenge, developing a "Distributed Support Program" in the early 1990s [14]. The program sought to place support providers within departments and units across campus. One challenge was determining how such increasing support would be funded, as the goal was not simply to redistribute existing resources in central IT (as there was not a "steady state" of technology use, with centralized functions also growing across administrative and academic applications). The Indiana initiative involved a two-year agreement, wherein central IT funded the distributed support fully in year 1, and the department and central IT equally shared funding in year 2. At the end of the second year, if the department saw value in having its own support, it would fully fund the effort. In all cases, this was the outcome, and a community of distributed support providers emerged, working in concert with central support, to meet the exponentially growing use of computing and technology across campus.

The Indiana program grew and evolved over time, building a Leveraged Support Model [13], in an effort to articulate and put into place a broader approach to supporting IT across campus. Central IT remained an important element, providing tools and services (such as the IU Knowledge Base, or KB [6], and education programs) designed to aid users to better support their own use of technology; offering tools, training, deep technology support, and community-building programs to the local support providers (LSPs) in the community (thus increasing their overall effectiveness); and handling the remaining centralized computing and IT functions required by the institution.

3 THE DAWN OF CYBERINFRASTRUCTURE

While a great many elements of information technology became distributed, one area that remained centralized was support for advanced computation and cyberinfrastructure (CI) services required by researchers. Those familiar with the separate evolution of the use of supercomputing and other tools are aware that this area has had its progression from data-center-centric paradigms, to distributed placement (so-called "closet clusters"), and back again to models of centralization (shared "condo-computing" approaches, large terascale high performance computing and storage resources, etc.). But throughout this process, one key element has always been the critical role people – humanware – play in the most effective, secure, and productive use of CI.

And yet, just because something seems intuitive doesnâĂŹt mean it is addressed (provided, funded, and supported)! Putting humans in the loop has always been a concern; policy and expertise supply issues aside, the biggest challenge involved finances and budgeting. One can buy all sorts of CI equipment out of grants, one-time funds, gifts and other suddenly available "miracle money," or other nonrecurring sources (especially if one leaves future replacement cycles out of the equation). But people require an ongoing commitment and that often proves difficult to achieve in institutional and research-project budgeting. For years, even grant funding agencies (like the National Science Foundation) were not amenable to providing much in the way of support for this critical element, eschewing staffing support for greater investments in capital equipment.

This began to change in this past decade. In 2011, the National Science Foundation Advisory Committee for Cyberinfrastructure (ACCI) Task Force on Campus Bridging [11] published its final report, wherein the need for address and funding of humanware was articulated. "Time and again, at all levels of the acquisition and deployment of information technology through the past several decades, we have seen that without this humanware component – the people who make all the other components work – investments made in those other components – however significant in amounts! – do not realize their full potential without attention to and investment in the support of their use by scholars. Scholarly productivity and knowledge breakthroughs and discovery, however enhanced they may be by advanced cyberinfrastructure do not reach their full potential without (to steal a phrase from a current commercial) 'the human element"' [12].

While the report highlights the importance of the need for humanware, it did leave open the question of where responsibility for support for its provision would rest: with funding agencies, or with the institutions that received funding? This key question remains, and further explanation and justification of the role people play is required to lead to resolution of this question.

The humanware challenge is now becoming more pertinent (and complicated) as CI moves from traditional provisioning on campuses to the cloud. For those institutions that have well-established campus CI centers, there may be the temptation to diminish those resources and any existing humanware reduced along with the capital elements. For those institutions that never established local CI resources (and thus may not have addressed the humanware element), such a need may not be readily visible. More work is needed to illuminate this challenge, and to tie it directly to the move to the cloud and the analysis of the return on investment (ROI) of such a move.

4 HUMANWARE ADVANCING RESEARCH IN THE CLOUD

In 2019, the Indiana University Pervasive Technology Institute (IU PTI) launched a project to explore, advance, and develop evidence of the impact of human resources – humanware – to support and increase the use of cloud-based CI by researchers in university environments [4]. The project seeks to demonstrate that the concepts established in this area (as described in the previous section) can be successfully applied to aid in the adoption and successful use of cloud-based resources supporting research. At the same time, the project also seeks to explore the potential positive impact humanware has on increasing the ROI in the use of cloud-based CI, as compared to using traditional campus-based or nationally-funded centers of computing resources. Hopefully, the project will not only provide information about how institutions can more effectively use the cloud, but also help cloud providers better understand how to provide and support services that will increase the ROI of research endeavors in higher education.

The first phase of the project (January-July 2019) involved selecting eight campus-based research support personnel (engaged as post-doctorate researchers on specific projects or in research associate roles at their institutions), who would provide use-case studies of outcomes of both the value of their engagement as humanware, and the effectiveness of cloud CI in the conduct of academic research projects. Projects span multiple disciplines: Neuroscience, City/Transportation Planning, Decision Support Systems, Security in Cloud Computing, Digital Humanities, Astronomy and Ecology, and general human support of campus researchers using cyberinfrastrcture across several disciplines.

The outcome of this first phase was presented as part of a workshop at the PEARC19 Conference in Chicago at the end of July 2019 [9]. The workshop also solicited related works from others not involved in the project, and peer-reviewed papers will be published by the Association for Computing Machinery (ACM) later in the summer of 2019 [7]. Our view is that the first phase of the project provides a foundation of academic information that will accomplish the goal of further illuminating two topics: humanware and ROI of cloud CI use.

The project's second phase will span the second half of 2019, moving into 2020. In this phase, we hope to further evolve the effort and broaden its impact. Further, we hope to establish a new program – Partners in Advancing Research in the Cloud (PARC) – which will have several specific areas where we seek further positive outcomes. Those include:

- Creating a community of humanware providers at institutions in the US/North America, and seeking to link similar efforts globally (Europe and Asia/Pacific);
- Raising awareness of the two core challenges (putting humans into the loop and ROI of using cloud CI), the results of the first phase exploration, and encouraging further investigation and illumination on the topics;
- Publishing additional academic papers, exploring the findings and adding more in-depth analysis of not only phase-1 efforts, but also of efforts by others in the two key areas;
- Seeking evidence of increased consumption of cloud resources for research, related to the effort, across multiple cloud vendors;
- Working with cloud vendors and the community to develop more effective means of cultivating cloud CI use skills in the workforce, linking programs provided by vendors and pedagogical programs offered by institutions; and
- Providing vital feedback to cloud vendors on ways to improve all facets of their service and support offerings that encourage effective and efficient use of cloud CI by the research community within higher education.

The overall project is funded through at least July 2020. As we make further progress in the second phase of HARC and produce outcomes that demonstrate the effectiveness of increasing the understanding of the role of humanware to the success of moving an increasing amount of cyberinfrastructure-enabled research to the cloud, we hope to find ways to continue the program in the future. While HARC is not the basis for a support structure itself, it may lead to improved services by cloud providers and increased understanding of the role of humanware to the research endeavor, so that institutions will be able to make more informed decisions regarding providing resources to put humans into the loop.

5 BROADER EFFORTS

There are several efforts underway intending to support evolving research use of cloud-based cyberinfrastructure. Two in particular of note have launched recently: Internet2's Exploring Clouds for Acceleration of Science (ECAS), and CloudBank.

Internet2 has launched Exploring Clouds for Acceleration of Science (ECAS). From the Internet2 ECAS Project Website: "The project involves partnership with representative commercial cloud providers to accelerate scientific discoveries. The effort demonstrates the effectiveness of commercial cloud platforms and services in supporting applications critical to growing academic and research computing and computational science communities, and will illustrate the viability of these services as an option for leading-edge research across a broad scope of science. The project helps researchers understand the potential benefit of larger-scale commercial platforms for simulation and application workflows such as those currently using NSF's High-Performance Computing (HPC), and explores how scientific workflows can innovatively leverage advancements in real-time analytics, artificial intelligence, machine learning, accelerated processing hardware, automation in deployment and scaling, and management of serverless applications in order to provide digital research platforms to a wider range of science. The project aims to accelerate scientific discovery through integration and optimization of commercial cloud service advancements with NSF's cyberinfrastructure resources; identify gaps between cloud provider capabilities and their potential for enhancing academic research; and provide initial steps in documenting emerging tools and leading deployment practices to share with the community" [2]. ECAS is funded by the National Science Foundation and at this writing is rolling out its first phase of projects – six in total – engaging researchers from George Washington University, the Massachusetts Institute of Technology, Purdue University, San Diego Supercomputing Center, State University of New York, and University of Wisconsin [10].

Recently announced and funded by a grant from the National Science Foundation (via solicitation NSF 19-510 âĂŞ Enabling Access to Cloud Computing Resources for CISE Research and Education) [8], the CloudBank project seeks to offer managed services to simplify cloud access for computer science research and education. The project is led out of the University of CaliforniaâĂŹs San Diego Supercomputer Center and Information Technology Services Division, with partners at the University of WashingtonâĂŹs eScience Institute and the University of California, Berkeley's Division of Data Science. From the project Website: "CloudBank will develop and operate CloudBank, a cloud access entity that will help the computer science community access and use public clouds for research and education by delivering a set of managed services designed to simplify access to public clouds. CloudBank will provide on-ramp support that reduces researcher cloud adoption pain points such as: managing cost, translating and upgrading research computing environments to an appropriate cloud platform, and learning cloud-based technologies that accelerate and expand research. It will be complemented by a cloud usage monitoring system that gives NSF-funded researchers the ability to easily grant permissions to research group members and students, set spending limits, and recover unused cloud credits. These systems will support multiple cloud vendors, and be accessed via intuitive, easy-to-use user portal that gives users a single point of entry to these functions" [5].

These efforts are largely focused on the important process of facilitating a move of research from "traditional" premise-based and national center cyberinfrastructure to cloud alternatives. This is important work to demonstrate the efficacy of cloud alternatives, but the key items addressed by the HARC project – the role of humanware and the return on investment of cloud alternatives – makes it an important companion effort.

6 BROADER CHALLENGES

While it is important that we examine the role of humanware in supporting the move of research to the cloud, one concern is that by focusing in this way, our need to understand use of the cloud by higher education extends beyond research. Generally speaking, there are three branches of higher education use of cloud services - Research, Teaching and Learning, and Enterprise. There are some common threads (e.g., contracts, training, and "orchestration") and some threads very specific to the individual elements. There have been efforts for several years to urge those involved in each element on campuses to grow, to share, and to learn from each other. The efforts of the EDUCAUSE Cloud Computing Community Group provide some evidence of efforts to pull the three separate elements into a more cohesive discussion [3].

There is a need to prompt cloud service providers to address the challenges that are being identified in all three elements. Teaching and learning is of particular importance, as it can turn out professionals (i.e., humanware) who understand and support the use of cloud platforms across all elements. The mission of the HARC project has the potential to advance these collaborative efforts to more broadly address the challenge cloud computing presents to higher education.

7 CONCLUSIONS

The move to use of cloud computing in support of research and discovery will be yet another evolutionary step in the role that information technology plays in higher education. As the infrastructure and services migrate away from the friendly confines of university campuses, the need for increased awareness, understanding, and investment in humanware seems critical to the ultimate success of the effective and efficient use of cloud cyberinfrastructure. While the role of "humans in the loop" has been important throughout the advance of technological tools, it remains somewhat misunderstood and unrecognized. The role of the HARC project is to improve that understanding, and help all involved – cloud providers, campus leaders, and researchers – grasp the need for humanware as a key element in which to invest resources.

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