

Advances in Mobile Cloud Computing

Timur Mirzoev, Amy Coleman, Robin Wach-
Bessert
Georgia Southern University: Information Technology
Statesboro, GA USA

Ben Lai, Douglas Olson
Clayton State University: Information Technology
Morrow, GA USA

Abstract— As advances in technology occur, mobile cloud computing is able to overcome the issue of resource poverty that occurs in mobile devices. Manufacturers now look at cloud computing as an asset because they can run their products better. The number of businesses and individuals that are investing in cloud computing services is anticipated to grow rapidly. Rapid growth of this nature will have a large impact in the IT industry. This study shows that cloud computing, including mobile computing, is a major contribution to the expansion of output and employment within the IT sector. An improvement in performance is making mobile cloud computing a better choice for consumers. In recent years, changes in the mobile cloud computing framework have enabled engineers to offload computational processing to other systems in the cloud that dramatically improve the mobile device experience.

Keywords- mobile cloud computing employment; advances in cloud computing; mobile cloud computing jobs; mobile cloud service; mobile cloud job growth.

I. INTRODUCTION

Csorny [1] states software developers and computer systems analysts are among the list of jobs cloud computing vendors employ to keep up with the increase in demand for cloud computing services. Furthermore, Csorny [1] notes that the application development field, in particular, is projected to grow fifty-seven percent from 2010 to 2020 due to the increased need for development of design software that is offered through mobile cloud computing. The rapid increase of smart mobile devices has given rise to a mobile app economy that brings new opportunities for employment. Fig. 2 presents the projected change in employment for years 2010 to 2020 in the computer systems design industry. In Information Week, LS Subramanian [2] noted that cloud computing can manufacture communication in a secure and simple way; he also noted that employees can maximize this potential by enhancing operations using their mobile devices.

Louis Columbus [3] from Forbes mentioned that Salesforce expanded manufacturing with their cloud platform automated ordering process. Columbus [3] thinks that manufacturers depend on their mobile devices more than past years. For manufacturers to benefit their mobile devices and take advantage of the automated process, they need to enter in the customer's personality on purchasing products into the system. Columbus [3] also states it is beneficial to figure out why the customer is purchasing such items.

Is mobile cloud computing growing enough to increase the demand for manufacturing jobs? Should businesses use more mobile devices to generate additional manufacturing jobs, or is it as simple as having more mobile devices built for sale by

those manufacturing mobile devices? Is mobile cloud computing growing fast enough to increase the demand for mobile devices to generate manufacturing jobs? Further study by Staten, Csorny, and Minnick show why advances in mobile cloud computing exists and the answer is businesses using more mobile devices as stated by Subramanian and Columbus. As a solution, more mobile devices may need to be manufactured in order to keep up with customer orders as mentioned by Columbus.

Mobile cloud computing is part of the expansion that is a leading contribution to the increased growth in output and employment in the IT industry. One avenue for mobile cloud computing is that rapid growth is expected to have high in-demand service in markets such as software, hardware, and IT outsourcing. The performance of mobile devices assists with the offload of heavy computer processing by the use of mobile cloud technology.

This study does not demonstrate exactly how people gain employment even if reliable Internet connections are available. This study also does not address how to provide access to cloud computing, or show how to maintain payment for subscription services of cloud computing, give investment tips for cloud computing, or resolve how security breaches are mitigated.

II. MOBILE CLOUD COMPUTING ADVANCES INCREASE MANUFACTURING AND EMPLOYMENT

A. Technology Leads to Growth

The proposed avenue for mobile cloud computing is to have rapid growth as a high in-demand service in markets such as software, hardware, and IT outsourcing. Staten [4] states the cloud market has the potential of reaching \$191 billion by the

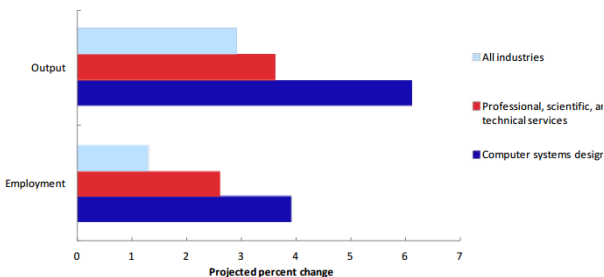
year 2020, from \$58 billion in 2013. The expansion of cloud computing, including mobile cloud computing, is a leading contribution to the increased growth in output and employment in the IT industry. Csorny [1] mentions that output in computer systems design and other related services is on target to grow 6.1 percent from 2010 to 2020, while employment is expected to grow 3.9 percent annually. Fig. 1 presents the projected average annual percent change in output for 2010 to 2020.

Mobile devices are designed to run on batteries with slower and less powerful processors than traditional computers. Applications that demand high computation and graphic manipulation need more processing power than is usually supplied by a mobile device. According to Ali et al. [5], mobile devices that run these high computation applications tend to heat up and drain the battery power sooner. In recent years, Kovachev & Klamma [6] note that mobile cloud computing framework has enabled engineers to offload computational processing to other systems in the cloud, dramatically improving the overall mobile computing experience. By allowing mobile devices to offload heavy computer processing using mobile cloud technology, mobile device designers are able to mimic traditional computer performance. This in turn enables mobile devices to use less battery power and increase uptime.

The increasingly rapid use of mobile cloud computing not only gives rise to the need for employment in manufacturing jobs, but also brings the need for other employment opportunities. According to Csorny [1], cloud computing and mobile networking are among the areas expected to lead employment increases in the computer systems design and related services industry over the next decade. The expansion that has occurred in cloud computing, which includes mobile cloud computing, is a leading contributor to the growth that results in the IT industry output and employment. Fig. 2 presents data on the projected percent change in employment for various industries. Included in the list of occupation increases are application developers for mobile cloud computing.

With rapid growth and advancements in mobile cloud computing, there may be a need to increase the production of mobile devices that could generate manufacturing jobs. This

Projected average annual percent change in output and employment in selected industries, 2010–2021



Source: U.S. Bureau of Labor Statistics, Employment Projections Program

Fig. 1. Growth of output and employment in the computer systems design industry. Adapted from “Careers in the growing field of information technology services”, *Beyond the Numbers: Employment and Unemployment*; U.S. Bureau of Labor Statistics, by L. Csorny [1].

circumstance rises from an increased use of mobile cloud

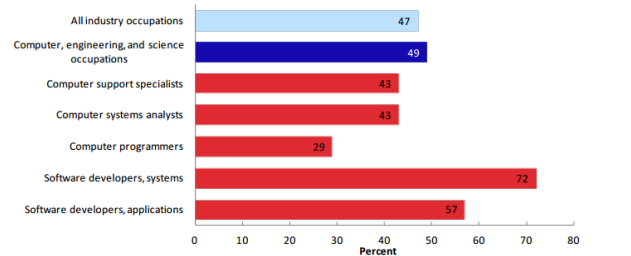
computing by consumers and businesses. A solution to the growing need for greater access to such mobile devices is to manufacture more of these products. In an interview with Manufacturing Business Technology conducted by Minnick [7], Sanjay Rav, Director of Manufacturing at Microsoft, notes that manufacturers are implementing cloud computing into their products to run high quality models for their product development rather than emphasizing on manual sources for testing purposes.

Improved performance with mobile devices, including the offloading of computational processing to the cloud, accommodates the need for more reliable devices and results in an improvement in the entire mobile computing experience. Kovachev & Klamma [6] notes this offloading method overcomes the limitations of mobile devices in relation to computation, memory, and battery power and is essential to the expansion of mobile cloud computing. By permitting mobile devices the ability to offload large amounts of computer processing by the use of mobile cloud technology, the designers of mobile devices are able to imitate the conventional computer performance. This technique expands the capabilities of the existing mobile device, and as a result, making it a more sought after product, proving the need for greater manufacturing. According to Ali et al. [5], a technical survey shows that offloading mobile device code execution to the mobile cloud is a very promising technique to increase overall mobile device performance.

B. Review

Smart mobile computing devices have limited processing capabilities and power supply resources. According to Kumar et al. [8] in the 2012 study, A Survey of Computation Offloading for Mobile Systems, researchers are focusing on ways to offload mobile device processing to other systems. According to Kumar et al. [8], this research timeline goes back to the mid 1990’s, but it was not until around 2010 when mobile cloud offloading algorithms started to be commonly used. Kovachev & Klamma [8] state offloading processing proved to increase processing performance 20 times and increase device battery life greatly. In addition, with the 2007 announcement of the Apple iPhone, DeGusta [9] mentions there was an explosion of smart mobile device manufacturing. According to Boston Consulting Group [10], improved mobile

Projected percent change in employment in selected occupations in computer systems design and related services, 2010–2020



Source: U.S. Bureau of Labor Statistics, Employment Projections Program

Fig. 2. Projected percent change in employment, 2010-2020. Adapted from “Careers in the growing field of information technology services”, *Beyond the Numbers: Employment and Unemployment*; U.S. Bureau of Labor Statistics, by L. Csorny [1].

computing processing sparked an increase in employment

opportunities related to this technology. As Boston Consulting Group [10] states that in 2014 global tablet sales are estimated to surpass 260 million units, mobile cloud computing offloading technology may have supplemented a significant impact in the number of new mobile cloud computing related jobs.

The convenience and accessibility of mobile cloud computing is quickly becoming an essential part of everyday life for many consumers and businesses. According to Dinh et al. [11], mobile cloud computing provides users with extended battery life with computation offloading, improved data storage capacity and processing power with wireless networks, and improved reliability with data and applications stored and backed up on the cloud. Dinh et al. [11] states mobile cloud computing also inherits other advantages such as dynamic provisioning, scalability, multi-tenancy, and ease of integration, which makes available the use of mobile applications including mobile commerce (m-commerce), mobile learning (m-learning), mobile healthcare, mobile gaming, and other practical applications. By providing optimal services for mobile users, mobile cloud computing is swiftly becoming a top trend as a profitable business option. ABI Research [12] predicts that cloud platforms revenue is capable of generating \$3.6 million in mobile enterprise applications by the year 2019. With increased use of mobile devices, including smart phones and tablets, by consumers and businesses, it is no surprise that mobile cloud computing has the capacity to impact the growth in employment concerning the IT industry.

Boston Consulting Group [10] notes that approximately 3 million people in about 13 countries had jobs created which included manufacturing of mobile devices in Asia. As stated in the Information Management Journal by Frost & Sullivan [13], increased contact with cloud technologies may lead to wider adoption. Has wider adoption of cloud technologies in manufacturing spurred employment growth to create new jobs? As additional findings in the next section provide insight into employment, manufacturing, and mobile devices, read on to see what the findings are.

III. IMPROVED TECHNOLOGY LEADS TO JOB GROWTH

As Mestchersky [14] mentions that mobile applications are aiding in the transformation of all business operations, another part that is associated with the digital revolution is both energy to fuel an economy such as Europe and the jobs delivered by such energy. At present, Mestchersky [14] notes that 1.8 million European jobs exist in 2013 with revenue reaching €17.5 billion by the end of the year and the growth expectation is 300%, which is €63 billion by the year 2018.

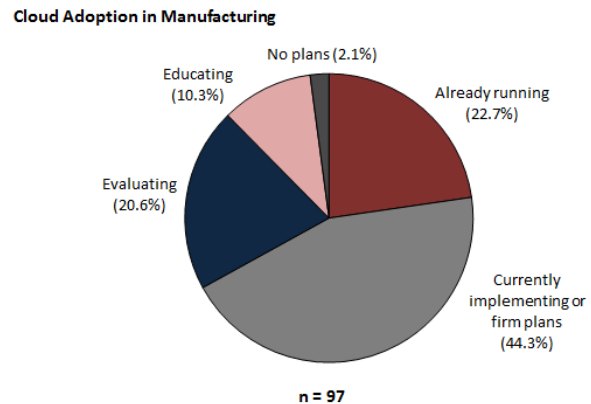
In 1964, Manyika et al. [15] noticed the economy worldwide registered at \$14 trillion dollars. Five decades later, Manyika et al. [15] mentioned it has jumped up dramatically by \$70 trillion to \$84 trillion dollars. According to Manyika et al. [15], transitioning from the West of Europe and the United States to Asia caused this economically. In addition, Manyika et al. [15] noted a jump of how many people have employment and productivity especially with the people employed caused the GDP to rise for the past 50 years.

David Greenfield [16] projects that cloud computing is projected to grow immensely within two years in an attempt to improve capabilities and concentrate less on budgeting for not just hardware, but also software in IT. Greenfield [16] states according to ninety-seven respondents who participated in a survey as demonstrated in Fig. 3, provided by IDC Manufacturing Insights, forty-four percent believe that manufacturer firms now evaluate either deploying clouds or implementing those clouds. According to Greenfield [16], twenty-three percent of the ninety-seven respondents claimed that they have previously implemented cloud computing.

IDC Manufacturing Insights took another survey according to David Greenfield [16] and Fig. 4 notes that private clouds project expansion from 9.4 percent to 14.6 percent within the next two years. In addition, Greenfield [16] notes that public clouds are capable of growing amid manufacturers and public clouds and expand from 9.5 to 12.7 percent within the next two years.

Chunlin Li and Layuan Li [18] stated mobile cloud computing helps to combine cloud computing and wireless access service; this allows the performance of mobile applications to improve. As Darrell M. West [19] discusses mobile revenues in relation to mobile devices, he mentions that businesses that provide applications and services are listing potential revenues to rise above 1.6 trillion to \$2 trillion by 2017. Another reason for the growth is that West [19] mentions mobile technology has sparked growth in new industries and has created opportunities for billions, which were facilitated by breakthroughs in research and development. One of the most important findings that West [19] states is mobile technology adds to the overall economic growth every year in a significant manner.

As advancements in mobile technology continue, Gartner [20] predicts that mobile data traffic will grow to 59 percent this year; the key driver of this growth on a global scale is mobile applications. To keep up with the growing need for mobile application platforms, cloud based development solutions have evolved and according to ABI Research [12],



Source: IDC's Cloud Survey, 2011

Fig. 3. IDC's Survey in 2011. Adapted from "Cloud Computing in Manufacturing" by Bob Parker, 2011 [17].

cloud deployments will grow faster than on-premise solutions

Cloud Share of Infrastructure Wallet in Manufacturing

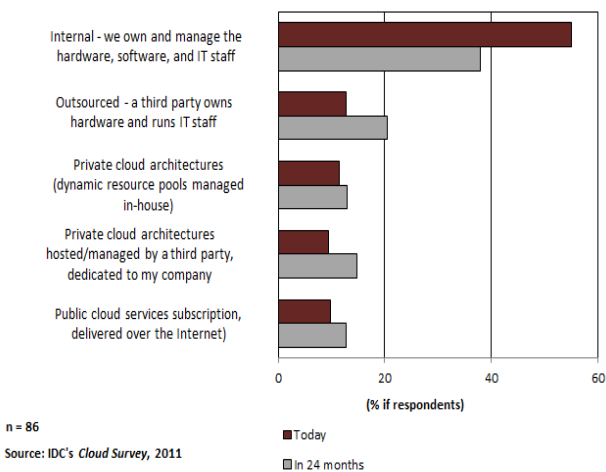


Fig. 4. IDC's Survey about Private and Public Cloud. Adapted from "Cloud Computing in Manufacturing" by Bob Parker [17].

with a compound annual growth rate (CAGR) of 42.5 percent from 2014 to 2019. This year, Gartner [21] expects the mobile phone market to total 1.9 billion units and grow 3.5 percent, and the ultramobile market, which include tablets, to total 237 million units and grow 4.3 percent.

Mobile cloud computing is giving rise to new business opportunities. According to McKendrick [22], Cisco Corporation, a leading computer networking company, reports, "As many business models emerge with new forms of advertising, media and content partnerships, and mobile services including M2M, live gaming, and augmented reality, a mutually beneficial situation needs to be developed for service providers and over-the-top providers. New partnerships, ecosystems, and strategic consolidations are expected as mobile operators, content providers, application developers, and others seek to monetize the video traffic that traverses mobile networks".

IV. CONCLUSION

As Frost & Sullivan [13] mentioned that increased contact with cloud technologies could lead to wider adoption, adoption of cloud technologies occurred by the spurred employment growth from manufacturing more mobile devices. Furthermore, Mestchersky [14] noted that growth expectation is 300% by the end of 2013. As the economy worldwide had revenues go from \$14 trillion dollars to \$84 trillion dollars, Manyika et al. [15] noted that there was a jump in productivity and employment that impacted the GDP to increase during the past 50 years. From the study, our group agrees with Chunlin Li and Layuan Li [18] when they stated that mobile cloud computing has helped to combine cloud computing and wireless access service; it truly has allowed the performance of mobile applications to be improved.

Mobile cloud computing has proven to be a very active computer science field. Over the past decade, mobile cloud computing went from experimental to everyday use. Most of the growth of mobile cloud computing has occurred over the last five years. Improvements in offloading processing of mobile devices to cloud servers have helped to make mobile

device applications comparable in performance to traditional computers. This makes resource starved mobile devices much more desirable for personal and business use. Offloading also improves mobile device battery life, which can give the user a better experience. Along with improved performance, mobile cloud computing has contributed to major job growth worldwide.

According to Greenfield [16], cloud computing has seen a surge in technology because it has helped the expenses of infrastructure decrease thanks to improving its power in the cloud when it comes to manufacturing. As the data presented in this study has shown how growth in the manufacturing of mobile devices has helped to create jobs, Mestchersky [14] noted that at least 1.8 million jobs came from Europe and had revenues towards €17.5 billion by the end of 2013. Minnick [7] noticed that not only cloud computing created jobs created in manufacturing of mobile devices, but also mobile cloud computing had rapid growth occur as well as advancements, which occurred partly due to implementation of cloud computing during manufacturing.

REFERENCES

- [1] L. Csorny, "Careers in the growing field of information technology services," *Beyond the Numbers: Employment and Unemployment*; U.S. Bureau of Labor Statistics, vol. 2, no. 9, pp. 3-7, available at <http://www.bls.gov/opub/btn/volume-2/pdf/careers-in-growing-field-of-information-technology-services.pdf>, Apr. 2013.
- [2] L. Subramanian, "How cloud computing can revolutionize manufacturing", *InformationWeek*, available at <http://businessintelligence.com/bi-insights/how-cloud-computing-can-revolutionize-manufacturing/>, 15 July 2013.
- [3] L. Columbus, "How Cloud Computing Can Bring the Voice of the Customer Back Into Manufacturing," *Forbes*, available at <http://www.forbes.com/sites/louiscolombus/2014/05/22/how-cloud-computing-can-bring-the-voice-of-the-customer-back-into-manufacturing/>, 22 May 2014.
- [4] J. Staten, "Cloud computing enters its second stage, hypergrowth ensues," *ZDNet*, available at <http://www.zdnet.com/article/cloud-computing-enters-its-second-stage-hypergrowth-ensues/>, 24 Apr. 2014.
- [5] M. Ali, J. M. Zain, M. F. Zolkipli, and G. Badshah, "Mobile Cloud Computing & Mobile Battery Augmentation Techniques: A Survey," *Proc. IEEE* Scored (2014) available at http://www.researchgate.net/publication/270683821_Mobile_Cloud_Computing__Mobile_Battery_Augmentation_Techniques_A_Survey, 2014.
- [6] D. Kovachev, and R. Klamma, "Framework for Computation Offloading in Mobile Cloud Computing," *International Journal of Interactive Multimedia and Artificial Intelligence*, vol. 1, no. 7, pp. 6-15, 2012, doi:10.9781/ijimai.2012.171.
- [7] J. Minnick, "How Manufacturers Can Benefit From Cloud Computing," *Manufacturing Business Technology*, available at <http://www.mbtmag.com/articles/2013/05/how-manufacturers-can-benefit-cloud-computing>, May 2013.
- [8] K. Kumar, J. Liu, Y.-H. Lu, and B. Bhargava, "A Survey of Computation Offloading for Mobile Systems," 10 Apr. 2012, doi:10.1007/s11036-012-0368-0.
- [9] M. DeGusta, "Are Smart Phones Spreading Faster than Any Technology in Human History?" *MIT Technology Review*, available at <http://www.technologyreview.com/news/427787/are-smart-phones-spreading-faster-than-any-technology-in-human-history/>, 9 May 2012.
- [10] W. Bock, D. Field, P. Zwillenberg, and K. Rogers, "The Growth of the Global Mobile Internet Economy," *Boston Consulting Group*, available at https://www.bcgperspectives.com/content/articles/telecommunications_c

- onected_world_growth_global_mobile_internet_economy/, 10 Feb. 2015.
- [11] H. T. Dinh, C. Lee, D. Niyato, and P. Wang, "A survey of mobile cloud computing: architecture, applications, and approaches," *Wireless Communications and Mobile Computing*, vol. 13, no. 18, pp. 1587-1611, 25 Dec. 2013, doi:10.1002/wcm.1203.
- [12] ABI Research, "Cloud Application Development and Management Platforms to Drive US\$3.6 BN in Mobile Enterprise Application Revenues by 2019," available at <https://www.abiresearch.com/press/cloud-application-development-and-management-platf>, 8 July 2014.
- [13] "Study: Mobile Users Shape the Cloud Computing Landscape," *Information Management Journal*, vol. 48, no. 5, pp. 11, Sept/Oct 2014, available at <http://connection.ebscohost.com/c/articles/98472669/study-mobile-users-shape-cloud-computing-landscape>, Sept. 2014.
- [14] S. Mestchersky, "How Europe can win in the global app economy," *EurActiv.com*, available at <http://www.euractiv.com/sections/innovation-enterprise/how-europe-can-win-global-app-economy-311788>, 2 Mar. 2015.
- [15] J. Manyika, J. Remes, and J. Woetzel, "A productivity perspective on the future of growth," *Mckinsey Quarterly*, no. 3, pp. 136-146, 2014.
- [16] D. Greenfield, "Manufacturers Invest in Cloud Computing," *Automation World*, available at <http://www.automationworld.com/manufacturers-invest-cloud-computing>, 1 Oct. 2011.
- [17] B. Parker, "Business Strategy: Cloud Computing in Manufacturing," *IDC Manufacturing Insights*, Report MI228939, pp. 2-6, available at <http://www.controldesign.com/assets/11WPpdf/111004-icd-cloud-computing-manufacturing.pdf>, June 2011.
- [18] C. Li, and L. Li, "Phased Scheduling for Resource-Constrained Mobile Devices in Mobile Cloud Computing," *Wireless Personal Communications*, vol. 77, no. 4, pp. 2817-2837, Aug. 2014, doi: 10.1007/s11277-014-1669-3.
- [19] D. West, "The State of the Mobile Economy, 2014: Its Impact and Future," available at http://www.brookings.edu/~media/research/files/papers/2014/09/10-state-of-mobile-economy-west/state-of-mobile-economy_v13.pdf, Sept. 2014.
- [20] J. Ekholm, "What's Driving Mobile Data Growth?" *Gartner*, available at <http://www.gartner.com/newsroom/id/2977917>, 5 Feb. 2015.
- [21] "Gartner Says Global Devices Shipments to Grow 2.8 Percent in 2015," *Gartner*, available at <http://www.gartner.com/newsroom/id/3010017>, 19 Mar. 2015.
- [22] J. McKendrick, "Mobile computing eats the world, in exabyte-size chunks," *ZDNet*, available at <http://www.zdnet.com/article/mobile-traffic-gets-smarter/#ftag=RSSbaffb68>, 15 Feb. 2015.