TESTIMONY OF

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BEFORE THE

HOUSE COMMITTEE ON OVERSIGHT AND GOVERNMENT REFORM

SUBCOMMITTEE ON INFORMATION TECHNOLOGY

HONORABLE WILLIAM HURD, CHAIR

BRIEFING ON

THE STATE OF THE CLOUD

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Chairman Hurd, Ranking Member Kelly, and Members of the Subcommittee, thank you for the opportunity to discuss the state of the cloud. I am Mauli Agrawal and I serve as the Vice President for Research here at the University of Texas at San Antonio ("UTSA"). In this role I oversee the research enterprise of the university and am responsible for setting forward-looking research strategies in consultation with our faculty. Prior to this role, I served as the Dean of the College of Engineering at UTSA.

With an enrollment of approximately 29,000 students, UTSA serves as an institution of access and excellence. It is a minority-serving institution with nearly 58% of our student body coming from underrepresented groups. It is consistently ranked by Hispanic Business Magazine as one of the best universities in the country for Hispanics. A rapidly growing university, UTSA has been identified by the State of Texas as one of the eight universities in the state primed to reach Tier I status.

In 2014, UTSA was named #1 in the country for cybersecurity education and outreach by Ponemon Institute in a survey sponsored by Hewlett Packard. UTSA is also a National Center of Academic Excellence in Information Assurance and Cyber Defense, as designated by the National Security Agency and the Department of Homeland Security.

UTSA is committed to becoming a nationally recognized research university to benefit our local and regional communities while also having global relevance and impact. To achieve the vision of becoming a Tier I research institution, UTSA is capitalizing on its research strengths in strategic cluster areas. One of the most important and exciting clusters is cloud, cyber, computing, and analytics (C3&A). The link between these four areas cannot be overstated as they are intricately intertwined.

While some may see cloud computing simply as a tool for storing, managing, and sharing data, cloud computing environments are increasingly used to host business and research applications and to enable the execution of advanced computation for analytics to understand big data and drive decisions. Underpinning the success of all of these areas is the security of data. This is why UTSA has decided to invest significantly in the C3&A cluster and provide leadership for the nation.

The Future of the Cloud
Advancements in cloud computing are making it a technology of choice for government, industry, academia, and private citizens. Cloud technology is truly a productivity enabler and a market disrupter. The quiet cloud revolution that is taking place is perhaps just as significant as the 1980's PC revolution that disrupted the mainframe computer era.

A future time can be envisioned when the cloud will make computational and data storage power available to *everyone* with minimal effort and cost just as water and electricity. This would be an enormous advantage for countries at the forefront of this technological change because in the information age, knowledge is power.

As with any evolving technology, dominant future directions still have to be determined for cloud computing. For example, would most cloud environments operate independently in silos or will there be a federation of clouds?

Also, would the cloud reside in large centralized data centers or it would be more optimum to have micro-grids of smaller container-sized units? Some have termed this the Fog instead of the Cloud. This architecture would provide for a more portable compute package that will expand the boundary of what we consider the cloud to include edge devices such as smartphones, robots and automobiles. The small footprint of compute, would allow for information packages to use the resources at the edge (processors, storage, sensors) instead of relying solely on the resources found in the data center. Thus, the cloud could become one of the largest true cyber-physical systems, with all the inherent challenges. Akin to the Internet of Things, this would be the *Cloud of Things*.

Research and Development Needed
Innovations such as those mentioned above require research into hybrid computing models, where the edge devices are seen as computation and storage nodes in the cloud. Power efficient computing and securing the endpoints, along with the communication channels between endpoints, will be big concerns as the resources of the cloud transcend the traditional boundary of the data center.

Clearly there is a need for more cloud research, especially in the areas of hardware optimization, software platforms, and targeted applications. For example, there is a need to optimize the cloud for high performance computing, which is still mostly conducted on supercomputers whose availability is limited to a few. However, there has existed a persistent barrier to such research: the lack of large-scale, open cloud research platforms. UTSA has recently partnered with several other US universities in a $20 million investment by the National Science Foundation to deploy two cloud computing test beds, called Chameleon and CloudLab, which will allow researchers to investigate novel cloud architectures.

In addition to developing talent, academia must be at the forefront of leveraging cloud platforms to support businesses as they attempt to consume, manage, and understand the large data sets being generated or captured during operations. Cloud platforms provide fast, reliable, and affordable access to computing resources, but additional software and algorithms are needed to marshal these resources to solve problems, answer questions, and convert data into value. Academia, leveraging the cloud, has an opportunity to support business by discovering new ways to analyze big data and make decisions based on the findings.

Business Trends
As cloud technology evolves and becomes more widely accepted, data as a service or business intelligence services (Data Analytics) will emerge. As more companies build cloud-based systems of record that capture corporate operational data, the inherent information therein is increasingly ripe for value mining.

We should anticipate a meteoric rise in cloud verticalization. As cloud platforms continue to mature and more organizations are drawn to the financial and innovative benefits, the cloud is spurring interest from even those industries that have been hesitant to evolve. Movement to vertical applications such as healthcare and government will become more common. It is likely that cloud providers are going to take the necessary steps to receive appropriate industry certifications, and creating more platforms designed to align to Sarbanes–Oxley, FDA, HIPAA, and others.

Work Force and Talent Development
The accelerated adoption of cloud may lead to a workforce shortage and a talent war. Finding cloud application developers will become an issue for companies hiring in 2015 and beyond.

Due to the emerging demand for cloud computing professionals many technology companies have developed their own courseware to more quickly onboard new employees. For academia this means applied science, computing, engineering, and information technology programs must leverage certificate programs to stay relevant in today's world. Also, industry collaboration is necessary to stay appraised of emerging education and research requirements. This collaboration could take the form of research partnerships, or, as has been done at UTSA, the hiring of industry professionals as adjunct faculty or non-tenured researchers.

Partnership between academia and industry is critical both for the evolution of the cloud and workforce development. This past February, UTSA announced the creation of the Open Cloud Institute (OCI), an initiative to develop certificate programs and spur research in cloud computing and to foster collaboration with industry. The OCI was founded with over $9M in donations from industry leaders such as Rackspace, AMD, and Intel. The OCI Cloud test bed consists of 500+ multi-core heterogeneous OpenCompute servers - the largest OpenCompute based cloud in academia, with 2-3 petabytes of total disk space.

To further illustrate the need for technical talent, Rackspace and Intel Corporation recently announced the opening of the OpenStack Innovation Center in San Antonio. This collaborative center of excellence will scale the number of programmers working on OpenStack. UTSA is collaborating with Rackspace and Intel to build a talent pipeline for the new center. During the next twelve months, UTSA's OCI will identify, educate, and train a diverse group of forty talented students with the goal of infusing them into the OpenStack Innovation Center as interns and employees of Intel. This effort is the first industry/university partnership to specifically grow cloud computing professionals.

Security Concerns
As a result of the concentration of data and computing resources, and the back and forth transfer of information, the security and resiliency of cloud infrastructures continue to be a necessary and critical area of concern. The cybersecurity threat is very real as can be seen from the recent security breaches at Target, Home Depot, BlueCross BlueShield, Anthem, JPMorgan Chase, Army National Guard and the US Office of Personnel

Management. As more of our federal agencies migrate their operations to the cloud, this becomes a national security issue.

Therefore there is a need for new ways of ensuring that devices communicating in the cloud are authenticated and their actions are authorized. To ensure this, new security paradigms will need to be created, such as Quantum Key Distribution (QKD). QKD has the promise of creating communications tunnels that are immune to eavesdropping, thus assuring devices are properly participating in the cloud-related activities.

Security should underpin every cloud-architecture from the start and not be bolted on later. Thus, research and development in area of cybersecurity as it pertains to the cloud cannot be seen as an option but rather as an imperative.

Targeted Approach Recommended
As stated above, the security of cloud environments is something we cannot ignore. Breaches in such security can have disastrous effects on our nation's businesses and our national security. Uninterrupted and uncompromised flow of data and information based on cloud platforms will be just as essential as the flow of electricity and should be considered as a component of the nation's critical infrastructure.

There is a need to take a targeted approach and establish a national entity where the federal government, industry, and academia can collaborate and focus on cyber security and the cloud. This could be in the form of a University Affiliated Research Center (UARC) created at UTSA.   UTSA holds the #1 ranking in the cybersecurity education, it has significant ongoing work (an award of a recent $11 million grant) with DHS for cybersecurity standards development, and along with several cybersecurity centers and institutes, it also houses the Open Cloud Institute in partnership with Rackspace and other industry leaders. Moreover, San Antonio is home to the 24th and 25th Air Forces, two Cyberspace Wings, and the National Security Agency. Thus, the foundation has already been laid for Congress to consider establishing a UARC in San Antonio (Cyber-Cloud City, USA). Such a center at UTSA could support the Air Force, NSA, DHS and other agencies, with a focus on cloud computing, cybersecurity, and data analysis, while also addressing the needs of the private sector.

End of testimony.

BIOGRAPHY
C. Mauli Agrawal, Ph.D., P.E.

Dr. Agrawal is the Vice President of Research at the University of Texas at San Antonio (UTSA). He holds the Peter Flawn Professorship in Biomedical Engineering. Prior to joining UTSA in 2003, he worked at the University of Texas Health Science Center at San Antonio (UTHSCSA). Before that he served on the faculty at Duke University. He obtained his Ph.D. from Duke University (1989), MS from Clemson University (1985) and a B. Tech. from IIT-Kanpur, India.

Prior to his latest appointment he served as the Dean for the College of Engineering at UTSA. During his 8 year tenure as the dean, the College of Engineering experienced a 40-50% increase in both student enrollment and faculty size, and a 400% rise in research funding. In 2010, working closely with the City of San Antonio and Mayor Julian Castro, he was instrumental in establishing the Texas Sustainable Energy Research Institute at UTSA which then received a $50m pledge of support from CPS Energy.

Dr. Agrawal has served on the editorial boards of various scientific journals including the Journal of Biomedical Materials Research, Journal of Biomedical Materials Research (Applied Biomaterials), Tissue Engineering, Journal of System of Systems (IEEE), Journal of ASTM International, and the Journal of Tissue Engineering and Regenerative Medicine.

He serves on the Board of Trustees of the Southwest Research Institute and as a member of Clemson University's College of Engineering Advisory Board. He also serves on the Boards of the following organizations in San Antonio: United Way's Master's Leadership Program, Alamo FIRST, Biomed SA, Texas Research Park Foundation, and the San Antonio Medical Foundation.

Dr. Agrawal's research specializes in the area of orthopedic and cardiovascular biomaterials/implants. During his professional career, Dr. Agrawal has been the recipient of several honors and awards, and has authored more than 300 scientific publications and 18 patents. His latest book, a textbook on biomaterials, was published in 2014. He was inducted as a Fellow of Biomaterials Science and Engineering (FBSE) by the International Union of Societies for Biomaterials Science and Engineering (IUSBSE) in 2008. He is also a Fellow of the American Institute for Medical and Biological Engineering and was elected the 2006 President of the Society for Biomaterials (SFB) – a worldwide organization. In 2013 he was awarded the Service Award by SFB.

Many of Dr. Agrawal's patents have been licensed to commercial entities. His bioengineering research group has been responsible for the launching of three companies in San Antonio. In 2007, he was awarded the Chancellor's Entrepreneurship and Innovation Award from the University of Texas System, and the Healthcare Hero Award for biomedical research by the San Antonio Business Journal. He is the 2010 recipient of the Julio Palmaz award for Innovation in Healthcare. He was appointed by Governor Rick Perry to serve (2008-2011) on the Advisory Board for the Texas Emerging Technology Fund (ETF). The $200 million ETF invested in start-up technology companies.