

## Expert Opinion

Dr. Raj Jain, Professor of Computer Science and Engineering at Washington University in St. Louis

### Biography



Raj Jain is a Fellow of IEEE, a Fellow of ACM, a Fellow of AAAS, a winner of ACM SIGCOMM Test of Time award, CDAC-ACCS Foundation Award 2009 and ranks among the top 90 in Citeseer's list of Most Cited Authors in Computer Science. Dr. Jain is currently a Professor of Computer Science and Engineering at Washington University in St. Louis. Previously, he was one of the Co-founders of Nayna Networks, Inc - a next generation telecommunications systems company in San Jose, CA. Further information about Dr. Jain including all his publications can be found at <http://www.cse.wustl.edu/~jain/index.html>.

### **JITCAR: What is IoT and why should CIOs worry about it?**

Internet of Things (IoT) is concerned with connecting all “things” to the Internet. Almost all computers are already connected to the Internet and so the next challenge is to connect all non-computing objects such as heating systems, air conditioners, refrigerators, doors, manufacturing plants, etc. The term “things” refers to everything whose primary purpose is not computing. IoT started with smart grid where the electrical generation and transmission industry wanted to connect their metering, transmission, and generation equipment to the Internet. Now it covers phones, watches, thermostats, cars, TVs, and more. The list is endless. Cisco calls it “Internet of Everything” and IBM calls it “Smarter Planet.”

If you assume that 99% of the objects in a business are such non-computing things, then once these things are interconnected, their security and operation will be responsibility of the CIOs and so this creates some new opportunities and challenges for the CIOs. The responsibility of CIOs will grow 100 folds and more. It is very important that the CIOs be prepared and knowledgeable about this coming tsunami.

In the past, the term “Smart” used to mean devices that could compute. The definition has now changed. Now smart means “able to communicate.” The computation is not critical. It can be easily off-loaded to cloud services as long as the information can be communicated. So the networking ability is the key.

### **JITCAR: Please name and briefly describe some of the strategic IoT applications.**

Smart buildings are good examples of IoT. Almost all businesses have buildings that require heating, cooling, lighting, etc. Imagine what would happen if every device in the building is smart and, therefore, can communicate its state to a central place and be controlled from a central place. This will reduce the operational expenses (OpEx) significantly.

The same applies to manufacturing plants where all machines will be able to communicate their status and get commands remotely.

Actually, most of the building operation and manufacturing may already be automated. However, the problem is that each device uses a separate proprietary protocol to communicate. The operation personnel have domain-specific knowledge of these devices and these proprietary protocols. The new IoT challenge is for the CIO to be able to work with these domain-experts and help them transition to the new Internet-Protocol (IP) based communication. CIOs know more about routers and clouds and need to work with all aspects of building or manufacturing operations so that all parts of the business can inter-operate most efficiently.

### **JITCAR: What are the factors that have led to the recent euphoria about IoT?**

The reasons for this euphoria are both technological and financial.

Technically, IoT requires sensing the state, communicating it, and computing the new desired state. There have been significant recent advancements in all three - sensing, communications, and computation. Low cost micro-sensors are now available for temperature, moisture, pressure, air-quality, etc. Radio-frequency identifiers (RFID) and Quick Response (QR) codes allow even passive objects to be able to communicate their presence. Energy efficient communication protocols such as Bluetooth-Smart have been designed that allow even small batteries to last several years. Micro-computers that have computing powers of past supercomputers can be easily and cheaply embedded in objects. Cloud computing provides facilities to analyze vast amount of data that can be generated by these objects. All these technical developments have made IoT feasible.

Another reason is financial - research investments followed by industry investments. European Union started by funding IoT European Research Cluster (IERC) in 2009. Around the same time, President Obama authorized \$4 billion investment in Smart Grid research as a part of American Recovery and Reinvestment Act. In 2014, Google bought an IoT startup “Nest” for \$3.3 billion. That woke up the venture capital (VC) community that is now investing heavily in IoT startups.

IoT market is expected to be worth over \$14 trillion over 10 years. All networking and computing companies including Cisco, IBM, Google and Microsoft are eyeing this market and their products will surely impact the CIOs.

### **JITCAR: What is Fog Computing and how is it related to IoT?**

Cloud computing requires racks of machines located in a large data center to communicate with each other. IoT, on the other hand, requires all devices to communicate and so it is opposite of cloud computing in the sense that computation is done in the edge. Computing everywhere resulted in Cisco coining the term “Fog Computing”. Fog computing is geographically distributed real-time computing and is just another name for IoT.

### **JITCAR: What are the new challenges brought in by IoT?**

IoT allows every event to be monitored and recorded. Whether it is a manufacturing plant, a building, or a car, IoT will generate huge amounts of data that can be analyzed and used in new ways. Big Data analytics will allow service providers to predict their client’s needs and provide

customized services to their clients. Machine's failures could be predicted and accidental stoppages avoided. The key challenge is the scale of data - finding information in a mountain of irrelevant data.

The second challenge is privacy. It is not clear what part of the data is confidential to the person or the organization. For example, should the driving record of a car be provided to the car manufacturer without jeopardizing the privacy of the driver? The same applies to manufacturing plant appliances.

The third challenge is security. CIOs are having tough time maintaining security of their computational infrastructure. IoT will increase that risk 100 folds simply because there will be 100 times more devices connected. At a recent "Black Hat" conference, they showed how a hacker could remotely flush a "smart toilet" repeatedly resulting in a "Denial of Service" attack.

This is just the tip of the iceberg. The list of IoT challenges includes cross-department cross-domain collaborations, sensor energy management, and so on. IoT is a billion dollar opportunity and also billion dollar worth of challenges.

JITCAR: Thank you so much for your time and insightful responses!

[Interviewed by Dr. Mahesh S. Raisinghani](#)

Dr. Mahesh S. Raisinghani is a professor in the Executive MBA program at the TWU School of Management. He is a Certified E-Commerce Consultant (CEC) and a Project Management Professional (PMP). Dr. Raisinghani was awarded the 2015 Excellence in Online Education award, 2008 Excellence in Research & Scholarship award and the 2007 G. Ann Uhler Endowed Fellowship in Higher Education Administration. He was also the recipient of TWU School of Management's 2005 Best Professor Award for the Most Innovative Teaching Methods; 2002 research award; 2001 King/Haggard Award for excellence in teaching, research and service; and a 1999 UD-GSM Presidential Award. His research has been published in several academic journals such as IEEE Transactions on Engineering Management, Information & Management, Information Resources Management Journal, International Journal of Innovation and Learning, Journal of IT Review, Journal of Global IT Management among others and international/national conferences. Dr. Raisinghani is included in the millennium edition of Who's Who in the World, Who's Who among Professionals, Who's Who among America's Teachers and Who's Who in Information Technology.