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Challenges of Creating a Knowledge-Based Society: Education & Research for India & Gujarat

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Strategic Importance of Higher Education and Research in Positioning Gujarat to win in the Knowledge Economy¹

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“Education is the most powerful weapon which you can use to change the world,” said Nelson Mandela. It is also the most powerful weapon for Gujarat (and India) to win its rightful place in the next phase of Global economy, recognized by many as the “knowledge economy.”

Let me start with a celebration of Gujarat’s remarkable progress and success. Gujarat has done well in terms of its share of GDP and in terms of economic growth, particularly in comparison to other states. I was impressed with the vision outlined in the IT Policy and Biotechnology Policy posted at <http://dst.gujarat.gov.in/>, and certain targeted areas such as nanotechnology. The leadership of the CM, the policymakers and administrators, ought to be commended. The fast track process CM has instituted to start new ventures is laudable.

This success lets us set our sight even higher. As observed by the CEO of Infosys and persuasively articulated by Thomas Friedman, the world is indeed flat in the sense that financial capital and a good bit of work can easily move around the globe. So our competition is not just the next state or an average state; it is all the progressive regions of the world. However, human expertise is not so mobile, and hence the capital and work move where human capital is available. The availability of qualified information technology (IT) personnel was the primary reason behind the growth of IT industry in and around Bangalore, Hyderabad, Chennai, and Pune. In the emerging global economy centered on knowledge, IT was only the first and small beachhead. There is lot more to come, and we have the potential to rise above the average, bringing broader and more even development to Gujarat.

Success for the long haul will require that we complement our success in business and certain industry sectors by building capacity for long-term and broad-based growth and by moving up the value chain so as to increase per capita economic output. The key to increased value is the ability to create new intellectual property and provide an educated workforce. A component of the strategy is to clearly identify business and social drivers and understand the role of the specialized knowledge worker, both to enable Gujarati/Indian enterprises to climb the value chain and to bootstrap value

¹ This paper complements the plenary talk given at the International Conference on "Global Gujarat and its Diaspora"(January 17-19,2008), Patna, Gujarat. The associated talk is at: <http://knoesis.wright.edu/library/download/AmitSheth-Global-Gujarat.ppt>

creation processes that can sustain an internal economy over the long run. This strategy would also include identifying gaps in social and infrastructure investments at the governmental and policy-making level that could inhibit or negate the value generated by the knowledge economy. The primary example is the lack a qualified knowledge workforce that is hurting Gujarat and Indian competitiveness. **In this context, I also offer a proposal for a Research University of Knowledge Sciences & Technologies (see Appendix).**

As we move into the Knowledge Economy

World economies have moved from agriculture to industries to services. Figure 1 shows the changes in the respective contributions of the three components in various economies.

Nation	World Labor (% of total)	Agriculture %	Goods %	Services %	Services growth (% increase in last 25 years)
China	21.0	50	15	35	191
India	17.0	60	17	23	28
U.S.	4.8	3	27	70	21
Indonesia	3.9	45	16	39	35
Brazil	3.0	23	24	53	20
Russia	2.5	12	23	65	38
Japan	2.4	5	25	70	40
Nigeria	2.2	70	10	20	30
Bangladesh	2.2	63	11	26	30
Germany	1.4	3	33	64	44

Source: www.nationmaster.com

Figure 1: Service Growth in various economies

Corresponding to these changes, the notion of work has changed and so have key enablers, catalysts, and how we measure output (see Figure 2).²

	1800s	1900s	2000s
Notion of Work	Physical System	Information System	Service System
What is transformed	Matter and Energy	Information	People, Technologies, Organizations, Information
Example (Measurement)	Steam engine (Mass, Distance, Time)	Search engine (Computational Complexity)	Offshore call center (Time, Cost, Skill level)
Compliance Laws	Physical	Logical and Mathematical	Legal, Cultural, and Contractual

Figure 2: Enablers and Catalysts over time

A study of the trends tell us two things: (a) new economic drivers and paradigms come at faster rates; and (b) the importance of skilled people has increased and will continue to increase further. Many futurists and economists believe that the onset of a new economy, described as the

² P. Maglio, S. Srinivasan, J. Kreulen, J. Spohrer, [Service systems, service scientists, SSME, and innovation, Communications of ACM, July 2006](#), Pages: 81 - 85

"knowledge economy," is behind us. As we move farther into the knowledge economy, we will need to recognize the increasing importance of knowledge and services over manufacturing, technologies, and products. It is knowledge-driven services and science that will bring the highest value. Whereas raw material, financial capital, and technological prowess drove earlier economies, in the knowledge economy the ability to innovate and create new intellectual capital will be the key factors to progress and growth. Innovation will be the driver and the measurement, and it will require people with higher and specialized skills. In particular, we will need to match Gujarat's entrepreneurial culture with domain knowledge to identify opportunities for "leapfrogging" and value creation on one hand and also to leverage specialized knowledge for addressing key socio-infrastructure gaps and business/market needs. Already we can observe that the creation of new economic value (e.g., through creation of new companies) is highest where the most highly educated and innovative workforce is available, as in the Silicon Valley. In the information age, information technology skills played a key role, as in the progress of Indian IT industry, but we realize that global sourcing of technical talent enables work to move freely in the flat world. So, as the technically skilled work force is stretched thin in India, Indian IT has increasingly started to outsource the outsourced work!

To have a significant payback and really spur the development of the Indian economy, processes should be developed to align the capabilities of the knowledge workforce with key socio-infrastructure needs and business/economic challenges being faced by Gujarat and by India. As for Gujarat, many believe that it missed out on the first phase of the IT revolution, in which Bangalore, Hyderabad, Chennai, and Pune succeeded because they possessed the technical work force. The same can happen again if Gujarat does not get busy to build the human capital that the knowledge economy will demand. At the same time, there are significant opportunities as new value creation processes can be bootstrapped at the confluence of Information Technology, Healthcare and Life Sciences, which have the potential to increase the competitiveness of Gujarati/Indian enterprises on one hand and to address socio-infrastructure needs on the other.

The type of human capital we will need for Knowledge Economy

At each stage of evolution, we have needed an increasingly educated and better-skilled workforce. Whereas a great deal of work in the information age, such as in back offices or call centers, required a bachelor's degree with good communications skills, the same will not be true for the knowledge economy. To innovate and to develop intellectual property, we will increasingly depend on a work force with higher, postgraduate education. Rather than the skills one gets in bachelor-level education, the new worker will need to "learn how to learn" to keep up with increasing rapid change in technologies and trends. We will need people with strong skills in communication, and design, which require a master's and PhD level of

education. Just as getting an MD is not sufficient and residency training is required before a doctor practices independently, master's and PhD degrees in which research is an integral component of the education and training will better prepare the worker needed for the knowledge economy.

Agriculture	Manufacture	Service	Knowledge
Land, seeds, labor	Labor, machines, raw material	Skilled people	Highly educated people who can innovate

Figure 3: Key resources that drive each of the economies

I foresee that the knowledge economy will also require more people with better basic and advanced education in science and engineering. Take two examples of most attractive growth areas: nanotechnology and biomedicine. For nanotechnology, which may related to fields such as manufacturing and electronics, it is necessary to have a firm background in corresponding engineering discipline. For biomedicine, it is necessary to have a firm background in a basic science such as chemistry or biology. As observed earlier, the levels of skill, education, and training required for the growth areas that will make up the knowledge economy will be significantly higher than what was required for most work in previous generations.

Degree	Typical Time/Starting Salary in US (in US\$)/Starting Salary in India*	Features and Capabilities	Job Characteristics
BS/BE	4 years/ 40K-55K/2-4 lakhs	General skills. Ability to perform under supervision. Usually perform development tasks or well defined services	Mostly routine work under supervision for 5 or more years.
MS/ME	2 years/ 60-80K/5-10 lakhs	Advanced learning. Skills with a focus on a subarea of the discipline. Exposure to research. Able to perform independently. Some may be able to perform design and management tasks.	Mix of creative and routine work with supervision for first few years. Then progress as team/project leader, etc.
PhD	4 years/ 110+K/20-35 laks	Learn how to learn. Leadership skills. Significant research	Lead creative and innovative activities from

		experience. Able to conceive and innovate. Advanced skills to communicate and collaborate.	the beginning. Work with higher management. High level of control on work and independence.
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Table: An overview of skills and capabilities by education levels (* salary in India is for those from high-quality institutions; the gap between students from mediocre institutions and from top institutions is considerable)

Three decades ago, there were plenty of good jobs for people with high school diplomas. The last decade and this decade have seen a robust demand for people with bachelor's degrees' in developing economies such as India and China; but in more developed economies, a master's degree is often required for better quality jobs, and PhDs are also in high demand. Note that a PhD is often required for the most sought after jobs in developed countries—those involving research and university professorships. The same will be increasingly the case even in India. For example, IBM Research in New Delhi employs PhDs almost exclusively with the starting pay of about 35 lakhs per annum. Currently, because of the shortage of high-quality PhDs from India, a large majority of its employees are PhDs of Indian origin who got their degrees in the West, mainly in the US.

As we will discuss below, Gujaratis will likely need an economic argument to pursue higher education. And a study of starting pay can help make this argument. In the US a new graduate with a BS/BE degree in a technical field (such as engineering and computer science) fetches \$40K–\$55K US , a new MS/ME can earn \$60K-\$80K, and a PhD is worth over \$100K in annual pay. Furthermore, in the US, many graduate students and practically all those pursuing PhDs get stipends and tuition waivers and hence do not require family support during their studies. As India rapidly catches up with the West and as the effect of the flat world spreads, salaries will be globalized: the work will chase the highly skilled people who will command higher pay regardless of where they work and live.

Let me attempt to summarize some of the features of the knowledge economy:

- It will require people with higher level of education, skills, and training than before. Correspondingly, we will need larger number of people with higher (postgraduate) education.
- The income gap between people with higher education (MS and PhD) and those people with a bachelor's education will widen.
- Availability of highly skilled work force will determine where new companies are founded and corresponding economic growth. Financial capital will chase new innovation-based companies rather than the other way around. As for basic skills (such as those associated with a

bachelors' degree), since the work performed at this skill level can be packaged and distributed/integrated, the principle of "global sourcing" will apply; that is, this work can be performed at different places and will demand less premium.

Gujarat and Knowledge Economy

Gujarat largely missed out on the IT revolution that defined the transformation of Bangalore, Hyderabad, Pune, and Chennai. Can Gujarat afford to miss out on the upcoming knowledge economy? If we want to succeed this time, higher education and research will be the key. However, the common refrain I have heard in talking to policymakers in the State Government and higher education leaders is that Gujaratis value money and do not have the culture of education. I believe we can break this mindset, which will only make us lose new opportunities, with two things. The first is leadership. Did we think Surat could be made clean and beautiful before Mr. Rao showed that it could, and in a short time too? I think this Chief Minister has the leadership skills to do the same thing for higher education if he sets his mind to it. I believe he has already started to provide leadership in the area of primary and secondary education, so it is a matter of his being convinced to extend this leadership to higher education. The second is education about education. Since Gujaratis understand economic arguments, we need to provide Gujaratis the economic argument in favor of higher education, such as one shown in table above. We must appeal to the "entrepreneurial instincts" of Gujaratis and help identify and educate about the strong correlation between socio-infrastructure needs, value creation processes, and return on investment from a long-term perspective.

Capitalize on transformational and generational changes:

We can choose to skip a generation. During the last decade IT and software were key growth areas in which Gujarat aspired to lead; several other states and regions of the developing world were more successful. But just as in telecommunications we can afford to let go deployment of fixed line in favor of a newer generation of wireless and cellular technologies, in knowledge and services we can identify the next major growth area and position ourselves for success. There is a good chance that the next decade will belong to the life sciences and health care. In particular, there appears to be an unexploited opportunity related to innovative use of information technologies in the context of healthcare research and delivery: deploying the latest IT infrastructure where none exists could provide an opportunity to lower the cost and increase the reach and the efficacy of healthcare and life sciences in Gujarat and India. And we have the potential to be a leader in this area.

Invest in capacity to change, not just change: No one knows what all the future opportunities will be. How do we position ourselves for that uncertainty? We need to embrace the educational philosophy not just of

learning but of “**learning how to learn,**” so that educated persons can compete, evolve, and adapt. Basic infrastructure (e.g., roads and bandwidth) are critical, but rather than invest in specialized infrastructure, capital-intensive projects, and incentive to businesses, we must invest in educating the workforce, developing capacity to innovate, improving work ethics, and developing progressive policies. An example of specialized infrastructures is healthcare IT, which over and above the promise of addressing key social and infrastructural needs can also increase the potential of Gujarati enterprises to compete in the nascent medical tourism space. Today, companies will come and bring along their capital if we have people with knowledge and a positive work culture.

A case for science: Investment in science and the quality of science education leaves much to be desired. Whereas technology was key to success in the recent past, the future will belong to science and engineering. Dr. Kalam said, “Science brings two changes in life. One is a way of thinking—it elevates people. The second is that, as science transforms technology, it brings faster development to the nation.” To get good fruits from a plant, one must focus on soil and roots first. The same goes for technology—strong science and engineering is key. India’s current investment in science is less than 2%, way below its competitors. I commend Gujarat Council on Science and Technology (GUJCOST) for investing in Community Science Centres, and yet I was shocked to see the condition of Vikram Sarabhai Community Science Center in Ahmedabad. It had lost much of its funding from the national government, and the library where I spend many hours to learn had bought virtually no books in the last several years. The center had lost salary support for its faculty, who were volunteering their time for what they loved.

Investing in science and education now would be particularly valuable. Current education is too focused on technical, applied, and vocational skills. Very few educational institutions are world class (IITs, IISc, IIMs, BITS, IIITs); after the top tier, there seems to be a steep downward slope. No educational institution from Gujarat in science and engineering is internationally recognized. Only one engineering or IT university or institute (the DaIICT) talks about and is partially capable of “research-driven teaching.” Other universities and colleges, such as Nirma, may be reasonable for a bachelor degree education but have practically no research or postgraduate activities. Public funding for competitive research (on the lines of the National Science Foundation and equivalent agencies in the US, Canada, and China) would be highly desirable.

Need for medium- to long-term research: Current policies seem to favor research that can yield technologies and products in the near term. Industry and academic collaboration is also encouraged. This is good but not sufficient. First, India trails significantly behind others in research. For example, per one million of population, India has 157 researchers, China has 633, and USA has 4,526. Gujarat almost certainly has significantly fewer

researchers than some of the states with more high tech jobs. I would also add that the US's dominance in technology was not built on short-term research but on basic research in science and engineering, which entrepreneurs and industry then exploited. Observing a model of research universities in the US might be instructive. Here, higher education involving doctoral students and postdoctoral fellows is closely tied to fundamental research involving collaboration between faculty advisers and these young researchers-in-training. Industry cannot and will not support such research and training, so it must be done primarily with public funding. And to encourage students to consider higher education beyond bachelor's and master's degrees will require that we can provide the appropriate value proposition. Students need support (as medical students are supported during their residencies) and need to see significant benefits in return for their investment of an additional three to five years. That means research and academic careers will need to be more appealing. Good college and university faculties are routinely attracted to industry by significantly higher salaries. This trend must be arrested.

Invest in Quality above Quantity

No doubt we need many more highly educated people. But research shows that the current quality of graduates (at the bachelor's level) is not very good. Nasscom: one in four engineering graduates is employable. The best and most selective universities generate excellent graduates often because of the excellent quality of incoming students, but they generate too few graduates to contribute adequately to our rapidly growing economy. Alumni of IITs, BITS, IISc and IIITs are the brains behind many successful Silicon Valley startups and are leaders at some of the major corporations. On the other hand, new private colleges are producing graduates of uneven quality. As noted in a recent *New York Times* posting, "most of the 11 million students in India's 18,000 colleges and universities receive starkly inferior training, heavy on obedience and light on useful job skills."³ According to Nasscom one in four graduate in employable and practically none can carry out international-quality research without additional education and training.

We increasingly notice that students crave better education in India. So the biggest challenge is that of recruiting and retaining high-quality educators. Both Chinese academic institutions and IBM Research in India have been able to recruit top talent from returning (former) nonresidents. That may be the best source to start with, since too few qualified PhDs are produced in India (say at IISc, Bangalore). It will be necessary to provide competitive salaries, matched by appealing work environments that allow enough time to do world-class research along with their graduate students.

³ Based on the *New York Times*: [A College Education Without Job Prospects.](http://neweconomist.blogs.com/new_economist/economy_india/index.html)
http://neweconomist.blogs.com/new_economist/economy_india/index.html

Co-opting good higher education models: I have had the chance to observe the US system of academic research for more than 25 years. And there are some great things to learn from the system. The main feature I would like to identify is that of a research university. To enable strong higher education, research is a significant component. Competitive research funded by federal agencies such as National Science Foundation and National Institutes of Health uses a peer-review model based on quality of research proposed. This funding is complemented by Department of Defense and state funds and to a lesser extent industry funds. The moneys primarily support graduate students and also faculty time for research. A typical research faculty member spends about half of his or her time on research and the rest on classroom-based teaching. This research time enables the faculty to guide MS and PhD advisees.

I recently had a chance to see China's growth in education and research during a visit to Tsinghua University in Beijing and SJTU in Shanghai. What I saw was startling. Not only did the facilities surpass anything I had seen in the West, but fairly progressive policies are being adopted, such as using faculty research published in high-quality international journals and conferences as a key performance measure. China also has a strong federal funding agency that is equivalent to the US National Science Foundation.

I propose that Gujarat consider starting a graduate research institution with initial focus in some areas of most significance to Gujarat's economy or with the most strategic significance to the emerging knowledge economy. The institution should stress on graduate studies with faculty divided roughly equally between postgraduate (MS/ME and PhD) education and research. I would suggest using a major Western research university as a model with some changes to adapt to India's needs and conditions. Faculty compensation and work conditions need to be highly competitive with industry (e.g., alternative work for potential faculty could be IBM research, so that the compensation should be comparable). At the same time, the faculty should be held to internal standards of work output and work ethics. This preclude this institute from being a public university. Yet the state government can do several things to make this institution a reality, such as:

- Use its leadership to engage a successful foundation to promote this institution
- Provide land in a knowledge park
- Facilitate and simplify regulatory issues
- Work with the federal government and in the short term complement federal government with competitive research grants, especially to support graduate students and faculty research (including travel and foreign collaborations) through funding competitive, peer-reviewed grants (possibly with the use of an advisory committee consisting of some NRG/NRI senior faculty members)

- Facilitate and develop mechanisms for engaging institute's faculty in training for faculty of other state universities (e.g., require that faculty in undergraduate granting colleges and universities engage in research or get PhD in 5 years)

The institute must be led by strong and visionary leaders at both the director and department head levels with significant mandate matched by independence.

Engaging the Gujarati diaspora: The Gujarati diaspora is huge, over 60 million strong. The proclivity of this group to commerce and business is well known. We can also find a fair number of Gujaratis who are successful entrepreneurs and professionals, particularly among doctors and technologists. However, Gujaratis are significantly underrepresented as academics or researchers. In this, perhaps the diaspora mirrors what we find in Gujarat itself. In my field of computer science, for example, I would be hard pressed to name a few top academics in the US (those who are fellow of professional societies, endowed or chair professors, recipients of major international awards, etc.) who are Gujaratis. A good starting point might be to create a network as a follow on to this event, perhaps using a social networking service such as LinkedIn. Once an appropriate expert is found, engaging them should not be difficult. Most Gujaratis would love to collaborate and contribute. They can be invited to serve on expert committees (such as that for the Dr. Sarabhai award or a Centre of Excellence selection committee), boards of universities and research institutions, and so on. Departments of science and technology may also want to fund faculty sabbaticals or visits of a few months at top educational and research institutions abroad, internships abroad for students wishing to pursue doctoral studies, and invited talks at universities in Gujarat when an NRG is visiting Gujarat and can make side trips for such purposes.

Traditionally, India has looked at NRIs/NRGs for their investments in new ventures in India and Gujarat. Here I would like to bring up an important observation made by Lord Bhikhubhai Parekh, that only about 2% of NRIs may be wealthy enough to invest, so what about the rest of 98%? It is their skills and experience that we need to look for and capture.

So here is a summary of my observations for an even stronger Gujarat:

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- Realize the role of science and engineering in fostering long-term technological progress; realize the value of knowledge and services
 - Provide a better workforce and progressive policies and the companies will come with their own financial resources
 - Leapfrog to the next major growth area
 - Make higher education and research more appealing and more rewarding
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- Measure progress against international standards and norms; make intellectual property creation as a key measure for research outcome; invest in quality
- Co-opt some of the great tools and policies that have worked including public support for competitive research and collaboration with international research universities and visit abroad programs
- Establish one or more world-class institutions based on the model of a successful research university in the West
- Attract top talent (most professor level appointments are not filled)
- Give independence, make it worth while for top talent to invest their time and energy
- Make it competitive through increasing competitive research grants and study abroad
- Make research and graduate training part of faculty job requirements
- Adopt policies that require and value higher achievement (international achievement)
- Start at early stage (invest in VASCSC, CSCs) and invest in changing the culture that does not place education and research high on the list of what is considered to be success by Gujaratis
- Develop an international class research university that focuses on new multidisciplinary science and technology areas of relevance to knowledge economy (see appendix) which can be an exemplar for the high international level post-graduate education and research for the rest of the state and country, and can also demonstrate how to prepare next generation of leaders that can steward the growth of knowledge economy in the state

The leadership by political leaders and policymakers is important, especially in providing land, regulatory support and in inviting successful industry house to set up research-based institution. I believe the current Chief Minister and his government gives me all the confidence that this is possible more than ever.

Appendix: A Recommendation to set up a Research University focused on post graduate education and research in science and technology enablers of the Knowledge Economy

My key recommendation is for Gujarat to establish a “**Research University of Knowledge Sciences and Technologies**,” with a primary focus on science, engineering, and technologies that are most likely to provide an international-quality educated workforce for knowledge-economy-based development in Gujarat. A secondary emphasis on economics, finance, policy, and management may also be considered. Proposed characteristics, partly based on the US research university model, are as follows.

- Public-private partnership, or privately funded (possibly by one of the major industry houses) but facilitated by the government (e.g., with land near Gandhinagar and appropriate infrastructure support), with funding support from multiple industry groups
- Primary focus on research and postgraduate education, mainly training PhDs for other educational institutions and for industry, with a mix of admissions from National and Gujarat level competitions
- Majority of research funded by competitive research grants from federal and state government, complemented by research-oriented projects funded by industry and international sources
- A Director of high international reputation, leading an administration that can provide competitive research grants and some shared computing and research infrastructure. The Director may also optionally lead technology transfer, entrepreneurship, and government liaison activities.
- 6 to 12 Institutes (each similar to a department but with high degree of autonomy such that each can be a world-class unit and have significant control of its own budget), each headed by a chair professor of high international reputation with a mandate to develop a world-class research program, and each with small faculty (average of 5, with max. of 10), in areas such as:
 - Internet Computing/Web Science
 - Scientific Computing/eScience
 - Services Computing
 - Healthcare informatics &/or Public Health
 - Pharmaceutical Sciences and Informatics
 - Biomedical Informatics
 - Clean Energy
 - Service Economy and Knowledge Services
 - Environment Monitoring and Land Management
 - Cyberinfrastructure, Cybersecurity and Information Warfare

(Notice that unlike traditional Computer Science and Biomedical Engineering these areas are decidedly nontraditional and sometimes multidisciplinary, which will make this University very different from traditional universities). Sponsorship and endowment of each institute may be provided by a different industry group. Each institute may also develop independent tie-ups and collaborations with top international groups and universities in their respective areas.
- Director and chair professors are of international repute, each with an industry funded named endowments. Faculty package such that successful NRI/NRG may find it attractive.
- Typical faculty may have five MS students and five PhD students. Institutes are encouraged to collaborate with other universities and colleges in the state (e.g., students and faculty may come for internships and sabbatical, respectively; competitive grants can support these activities).

I would be happy to provide more detailed blueprint as needed.

About the author

Amit Sheth (<http://knoesis.wright.edu/amit/>) is an Educator, Researcher and Entrepreneur. He is the LexisNexis Ohio Eminent Scholar, a fellow of the Institute of Electrical and Electronics Engineers, and the director of the Knowledge enabled Information & Services Sciences ([Kno.e.sis](#)) Center in the Computer Science and Engineering department of the Wright State University, Dayton, Ohio. Earlier he was at the University of Georgia where he started the LSDIS lab in 1994 and he served in R&D groups at Bellcore, Unisys, and Honeywell. He received his BE from BITS, Pilani and his MS and PhD from the Ohio State University

Prof. Sheth's research has led to two commercial companies which he founded and led as President/CEO, several Enterprise and Web based products and many deployed applications in industry, health care and in scientific research. His is one of the best cited authors in Computer Science (250 publications, over 12,000 citations, h-index of 50), has given over 200 invited talks and colloquia including 30 keynotes, (co)-organized/chaired over 40 conferences/workshops, and served on over 125 program committees. He is on several journal editorial boards, and serves as the Editor-in-Chief (EIC) of the International Journal on Semantic Web and Information Systems (IJSWIS), joint EIC of Springer's Distributed and Parallel Databases- an International journal, and editor of two Springer book series.

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