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Business-driven Research at IBM Research India

While we are very driven by our business problems we try to make sure that we are doing work that is scientifically interesting.

— Manish Gupta

As the Director of IBM Research - India and Chief Technologist for IBM India/South Asia, Manish Gupta spent a lot of time traveling back to the U.S. IBM was where he started his professional career after getting his Ph.D. in computer science from the University of Illinois in Urbana-Champaign. He was a familiar face at the IBM Thomas J. Watson Labs in Yorktown Heights, NY, where he led the system software group for the Blue Gene supercomputer, which received the 2009 National Medal of Technology and Innovation from the President of the U.S. Gupta joined the lab in 2008 as Associate Director and took over as the Director in February 2010.

In many respects, IBM Research was the last of a cohort of great industrial research institutions founded in the first half of the twentieth century. While other large American industrial research operations like Bell Labs, the David Sarnoff Labs at RCA, or the Xerox Palo Alto Research Center had been spun-off, sold, or dramatically shrunken in scope, IBM Research continued to spawn innovations in fields ranging from solid-state physics and carbon nanotubes to human language processing systems like Watson, a machine that trounced the all-time human champions in the game show Jeopardy!

Like most industrial research labs, IBM Research had to manage multiple objectives when evaluating project selection and scope. A push by global lab management to re-emphasize the need for balance between exploratory research and the fulfillment of business needs when generating projects and judging the lab's work had met with resistance in some quarters. Many of Gupta's employees were accustomed to so-called *pure* basic research, which pursued new knowledge solely for the sake of understanding and without thought of practical ends. For these researchers, monetization strategies were considered outside the purview of basic research and they feared the

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emphasis on commercial success in lab decisions would short-circuit programs that had produced important breakthroughs. How could answering business questions generate novel ideas?

Gupta believed that having a business-driven thrust to their basic research distinguished IBM Research from the other industrial research labs that had faded away. Many of IBM's biggest hits, like copper interconnects in semiconductors and its high-performance computing systems, had come from research inspired by practical concerns. The "Spoken Web" project at the India lab, which aimed to develop an auditory equivalent to the (text-based) World Wide Web, was a perfect example. The project combined a real-world need with innovative research and novel science. By running over a telecom network, the Spoken Web could give hundreds of millions of people in places like India, China and Africa, who did not have access to data networks but did have mobile phones, a way to access information.

However, several years into the project and despite the success of small pilots, the business case for the Spoken Web remained unresolved. Lab management had recently begun pushing for research focused on developing use cases and other business concerns, narrowing the scope of some studies beyond what was scientifically compelling and causing some chaffing for members of the project team. How long should he allow his lab to pour research dollars into a project without a clear monetization strategy?

His questions about Spoken Web echoed many unresolved questions about the lab's strategy. What was the right mix between business-driven and pure research? How many years should a research project be allowed to run, and how much financial investment should the firm make, before seeing a clear case for business impact? Could companies like IBM continue to sustain pure research at all?

IBM Research

Research is the advance guard of progress ... One of the most important things in our business is research.
— Thomas J. Watson, Sr.¹

Founded in 1911, IBM invented many of the foundational technologies of the computer age and many of those inventions came out of the Research Division (see **Exhibit 1**). IBM's founder, Thomas J. Watson Senior, saw the significant role research played in the Allied war effort. He founded IBM's Research Division in 1945, operating out of a renovated fraternity on the campus of Columbia University in the City of New York. The firm made bold investments in pioneering computer architectures in the 1950s and 1960s. Additional IBM inventions included high level languages, instruction pipelining, the one transistor dynamic random access memory (DRAM), disk drives, direct memory access, reduced-instruction set architectures, and a host of others.

IBM invested substantial resources in Research, but beginning in the 1980s, the management in Research saw an increasing mismatch between their project results and the ability to utilize those results within the firm's product divisions. Sometimes this was because researchers designed products that couldn't be manufactured with existing infrastructure. In many cases it was also difficult for the business units to change their routines and internal processes to incorporate these new capabilities.

Out of frustration, Jim McGroddy, who at the time managed semiconductors and packaging at IBM Research at the time, tried a new collaborative development model in which Research and product group management were forced to plan programs jointly to qualify for funds. IBM Research

then executed the projects funded by the product groups. The forced alignment was so successful within Research that when McGroddy became Director of IBM Research in 1989, he extended the idea of co-funding to software and applications engineering. This was the beginning of business-driven research at IBM.

For McGroddy, business-driven research had its watershed moment in front of a key IBM customer. He recounted one of the experiences that shaped his thinking:

A couple of us went down to see people at CitiCorp, to talk to Colin Crook, who was the chief technical officer of Citi at the time. We had this meeting I'll never forget. We were talking about the value chain ... where you have physics and electrons and mathematics at the bottom of the value-chain, and you have customers doing IT stuff on top. And in between you have all these layers of silicon chips and operating systems and databases. When he thought about where they should buy stuff he said 'all this stuff below a certain point' and it was very near the top, 'that's all commodity' -- databases, servers, all that stuff. 'What's really important to me, if you want my business, is you gotta help me compete with that guy,' and he pointed across Park Ave to a big competitor. He said, 'you help me compete with them and you'll get all this business that sits down below. If you don't, I'll just find the cheapest supplier.'

What struck McGroddy at that point was that they had a slogan in IBM Research that they had been using for several years: "We said our goal is to be famous for our science and technology *and* vital to IBM." McGroddy went back to his office in Yorktown Heights and ordered a quick assessment. "Less than two percent was what you could legitimately say was stuff that helped customers compete with their competitors and most of what fit that category was applied mathematics. I committed at that point to raise that number to 20% by 1992."

Throughout the 90s and 00s, the role of IBM Research developed, largely in pursuit of this goal: creating value for IBM's customers. Research began to get more involved with customers, visiting them and bringing them into the labs for demonstrations. They weren't involved in sales, but instead were looking to understand what the biggest questions were for IBM's customers. One outcome of this shift was the First-of-a-Kind program (FOAK). FOAK projects were based on a customer problem that was both unsolvable by IBM's current know-how and expected to have a solution that was broadly useful to firms outside the customer that raised the issue. The FOAK program targeted cutting-edge questions that defined a competitive advantage for IBM customers in the future, and had IBM Research develop a solution.

The customer and solution focus drove an evolution in project funding models within Research. Because projects had different levels of customer focus or involvement, funding arrangements became much more heterogeneous. Bernard Meyerson, IBM Fellow and Vice President of Innovation at IBM, characterized the mix:

We certainly have core funding from corporate, and joint funding from divisions, but beyond the simple ones there are a vast array of contractual arrangements we engage in with external parties. We basically script each individually, being everything from work for hire to full partnerships, and everything in between. Basically you are looking at a near continuum.

IBM India and IBM Research in India

Driven by the global growth in its services business, the firm's India strategy had three major components (see **Exhibit 2**):

- Global delivery – which did traditional business process outsourcing, often referred to by Indian IT firms as the “global delivery model.”
- Indian domestic market – serving Indian businesses via a network of 2,500 business partners.
- Global innovation hub – including the India Research Laboratory, the India Software Laboratory, a Systems Technology Lab, a Global Business Solutions Center, and a Technology Assembly Center.

Though IBM began operations in India in the 1930s, India's Foreign Exchange Regulation Act of 1973 required foreign-owned companies to reduce their equity stakes. IBM chose to cease operations in 1978 and operate through local distributors. Liberalization of the Indian market came in 1991, and IBM re-entered the market with a joint venture with the Tata group, Tata Information Systems Ltd. This venture evolved into Tata IBM and finally IBM India in 1997.²

IBM Research India was established in Delhi in 1998, and expanded to Bangalore in August 2005. It was part of a network of 11 sites and approximately 3,000 researchers worldwide (see **Exhibit 3**). In its early years, the lab consisted of a few dozen researchers and the lab worked mainly on smaller parts of projects managed from other IBM Research labs. As the India lab started to build credibility and its researchers gained experience, it started to launch its own projects. Amit Nanavati, a researcher in the lab, recounted the evolution:

We have come a long way. As a young lab, we didn't have any credibility to pull off something that we had proposed. So initially, we used to not have projects that were conceived here. We would be working on projects where the ideas originated in the labs other than here. But then as time progressed, we found that more and more of our own ideas became proposals and started getting funded. That's a clear evolutionary thing that I have seen in my 11 years here.

Manish Gupta frequently reminded visitors that IBM India was part of IBM's Growth Markets Unit, which included China, India, Brazil, Russia, and other emerging markets. The company was planning 50% of its overall revenue growth between 2010 and 2015 to come from these markets. Global services delivery from India was a very important component of IBM's presence in the country, so research that contributed to service delivery was important.

The India lab focused on two broad categories of activities: services delivery and emerging market solutions. Services delivery included traditional IT services, application services, and contact center services with a focus on cross-cutting areas like workforce management. One project, called “voice of customer analytics,” focused on building a platform to integrate structured and unstructured customer data, such as customer transactions, call logs, e-mail transcripts, surveys, and data logged by customer service agents, to identify factors that drove customer dissatisfaction. The goal was to analyze the mountains of information that companies had access to about their customers, and figure out how to improve satisfaction and increase sales. Another project looked at the challenge of screening vast numbers of job applicant resumes to develop automatic resume mining and search plus match technology to speed up the identification of the best candidates for particular jobs.

Emerging market solutions focused on a unique characteristic of the Indian market: enormous numbers of transactions that had to be processed at very low costs. Indian telecom companies handled five billion call data records (CDRs) per day and had to do so at very low revenues per call. This resulted in massive electronic transaction loads. One India Lab project sought to address this with a consolidated data hub that reduced processing loads and increased performance. Another project sought to use acoustic sensing and statistical modeling to sense traffic on the chaotic streets of places like India or Viet Nam. A third project was developing semi-automated techniques to collect, cleanse, and standardize often conflicting customer data from disparate sources and make it useful for analytics.

By 2011 the India lab had approximately 200 researchers on staff, most of whom were Indian. Although the majority held advanced degrees from Western universities such as Cambridge University, Carnegie Mellon, Cornell, Georgia Tech., Institut national de recherche en informatique et en automatique (INRIA), Stanford, the University of California at Berkeley, the Indian Institute of Technology system and the Indian Institute of Science were also represented. Within its ranks IBM Research India counted two IEEE fellows, four ACM Distinguished Scientists, and one IBM Distinguished Engineer, along with 12 best paper awards for its researchers at international conferences in 2009-2011.

The mix of researchers had changed significantly since the lab opened in 1998. L. Venkat Subramanian, a Research Staff member and one of the early hires into the Delhi lab, described the changing mix:

We started out with a larger proportion of Ph.D.'s. Initially out of the 30-40 people, three-fourths were Ph.D.'s and rest Masters and others. But if you look at the lab today, out of the 200, a large proportion are Bachelor's degree holders - potentially a reflection of the fact that there are not enough Ph.D.'s in India right now.

In addition to the lack of PhDs emerging from India's university system, the shift was driven by the change in funding model. The additional business skills needed to run the lab with external funding were underdeveloped. Even if an employee with a Ph.D. was interested in such work, their advanced degree made them an expensive resource to use in building a business case for a research project. Furthermore, some PhDs felt business driven research was less appealing.

The Spoken Web Project

The Spoken Web project started as an exploratory research project and has been around for five years, which is rare because projects usually don't last that long. People still have faith in the potential of the vision.

— Amit Nanavati, Senior Research, IBM Research, India

There were over 800 million mobile phone numbers in India, and approximately 15 million were added every month, yet there was barely 7% Internet and PC penetration. Thus applications like e-mail and online services were not available to large numbers of the poor or illiterate. The pattern was pervasive globally: in 2010 only 22% of the world's population had access to the Internet.³ The Spoken Web project attempted to create a network of information that would endow this market segment with the benefits others enjoyed from the World Wide Web: information dissemination, market transparency and connection, self-promotion and expression, organization of people around common interests, et cetera.

Spoken Web was envisioned as a complementary network to the existing Web, one that was entirely navigable using a voice-based interface and an ordinary telephone. Instead of a website, users would be able to host and browse “VoiceSites,” traverse “VoiceLinks,” and even conduct business transactions, all by talking over the existing telephone network. The goal was to enable access for local communities, enabling people to surf a web of local information using only a phone. The design point was different from conventional interactive voice response systems; VoiceSites needed to be creatable by subscribers and hosted on a mobile network. A VoiceSite would be associated with a phone number. If it were an individual’s VoiceSite it would be tied to his or her phone number. As everything was designed to be accessible via audio interfaces, even non- IT savvy users would be able to use them. Nanavati described his vision:

What I want to see next is to take Spoken Web to at least someplace where all people can start using it easily and conveniently. Just like people started building their websites, it would be lovely to see people building their own voice sites by themselves and deploy them. That would be my wish for Spoken Web.

Using telephony as a platform created a range of technical challenges. As all information was to be conveyed audibly, the researchers had to develop an efficient way for those users to interact with the system in a sequential way, i.e., each hyperlink option had to be read one at a time. Initial testing also showed that if the user did not consider the content useful, the system seemed too slow. If the content was useful, the system seemed too fast. **Exhibit 4** shows scenes from a pilot test. It was also important that the system be easily understood by a population without the same technical savvy and experience as a PC user in 2012.

The interesting nature of the problem and the wealth of technical challenges held promise for publications. But there remained the question whether there was a business justification. Nanavati explained:

Right now, we are really looking for customers and for scaling and deploying this and having a business model ... Wherever we do pilots, we offer this as a toll free service and everybody loves it. But the moment you say that ok, now who is going to really pay for this - that’s where we get into all sorts of trouble. That is the problem we haven’t solved yet.

Basic science versus business impact

To Manish Gupta, the Spoken Web project was an excellent example of use-inspired research. It was directed at solving a practical problem that was highly relevant to India, and there were significant technical challenges because of the target user demographic. But it also framed the challenge of producing research that would be viewed as business-driven. “We got an award from the President of India for the Spoken Web technology as a technology for the disabled, and physically challenged population,” he pointed out, but the challenge was that they had not figured out a business model that would sustain it. Long term, it might be an important component of services delivery as well, but that was on the distant horizon.

To some researchers who were familiar with the academic environment for basic scientific research, The IBM Research India environment represented a trade-off. Jayram Thathachar, a Research staff member who had worked at the Almaden Research Center in California described the tension that India Research staff faced:

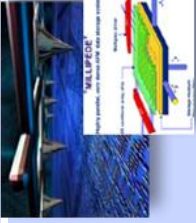
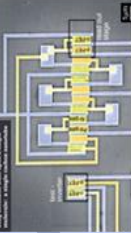
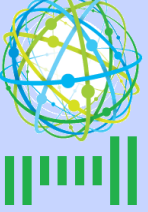
Science can emerge out of the projects that people are involved in. That is the tension - we would like to do projects that have a very long-term view. But the tension that IBM India faces, because it's so services driven and because of the funding model this lab is under, is that research is often short-term ... The services lines that this lab focuses on don't have much of an academic standing. It is a mixture of so many things that it is hard to even ask who are the top students in the field.

Yet there were some who argued that the reason some of the other great industrial research labs like Xerox PARC had fallen by the wayside was because their efforts had been conducted without direct knowledge of customer needs or the competitive environment.⁴ Gupta felt it was essential to strike the right mix and balance between pure exploratory work and work grounded in business needs. ShivKumar Kalyanaraman, Senior Manager, described it as he and Gupta talked:

IBM has made a choice, more broadly, at the highest levels that we are going to be a balanced laboratory...balanced in terms of applied versus exploratory research, balanced in terms of depth of scientific probing versus making sure that there is an impact. Research is a very small organization. In the grand scheme of things, we are 3000 of IBM's 425,000 people. We need to find a way to balance between being embedded as an innovation component for our key customers and grow with them and being able to focus on the hard problems. Let's not forget our role and become essentially an extended division of sales or an extension of a product division for that matter.

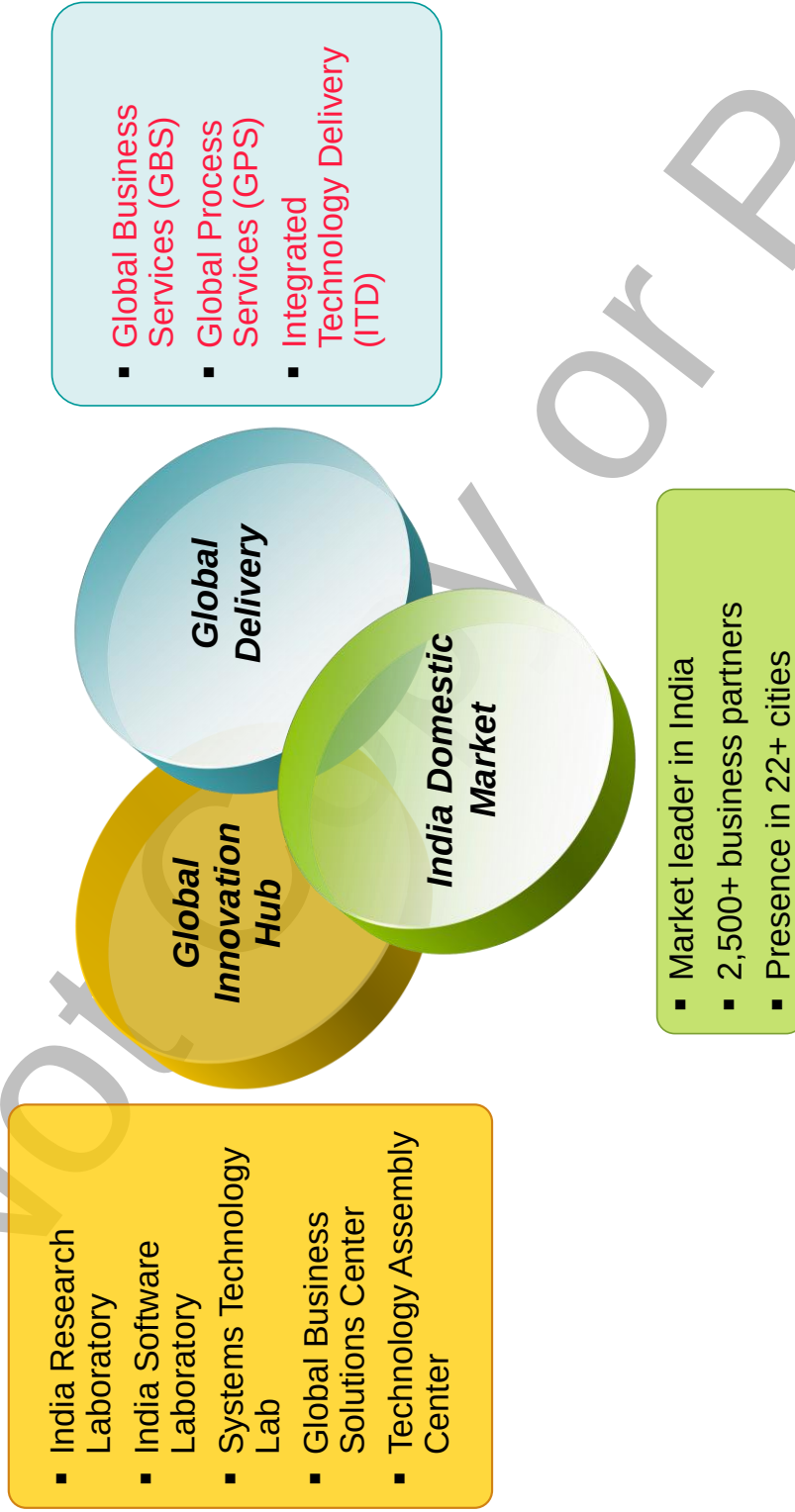
Now if they could only figure out how to make Spoken Web self-sustaining.

Exhibit 1 IBM Research significant contributions

	1944: Mark 1		1948: SSEC		1956: RAMAC		1957: FORTRAN		1964: System/360		1966: One-Device Memory Cell		1967: Fractals		1970: Relational Database		1971: Speech Recognition		
	1973: Winchester Disk		1979: Thin Film Recording Heads		1980: RISC		1986: Scanning Tunneling Microscope		1987: High Temperature Superconductivity		1990: Chemically Amplified Photoresists		1994: SIGe		1993: RS/6000 SP 1996,97: Deep Blue				
	1997: Copper Interconnect Wiring		1998: Silicon-on-Insulator		1998: Microdrive		2002: Millipede		2004: Blue Gene The fastest supercomputer in the world		2006: 5-stage Carbon Nanotube Ring Oscillator		2008: World's First Petaflop Supercomputer						
													2011 : Watson Competed in Jeopardy						

Source: Company presentation.

IBM India: Growth driven by Services



Source: Company presentation.

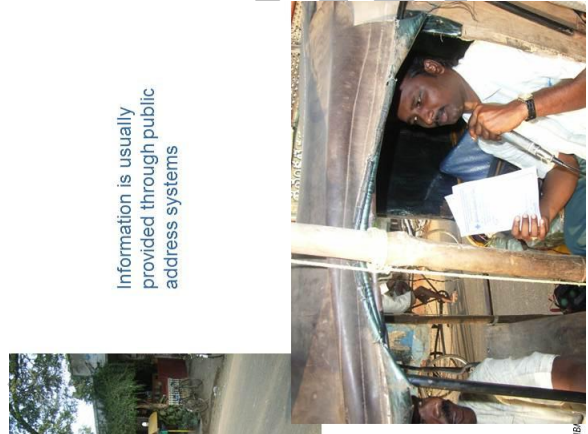
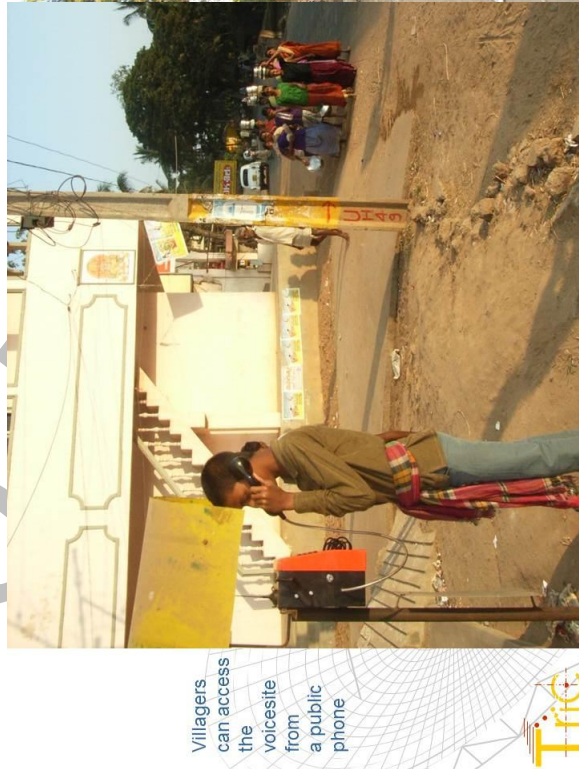
Exhibit 3 IBM Research Site Map



IBM Research Lab

Source: Company presentation.

Exhibit 4 Spoken Web Pilot Tests.



Source: Company presentation.

Endnotes

¹ "Quintessential Quotes," <http://www-03.ibm.com/ibm/history/documents/pdf/quotes.pdf> accessed February 25, 2012

² Dinesh C. Sharma, "Rise, fall, and rise of IBM in India," *Business Today*, June 17, 2011, <http://businesstoday.intoday.in/story/ibm-india-george-fernandes-history-in-india/1/16367.html> accessed February 25, 2012.

³ Arun Kumar, Sheetal Agarwal, and Priyanka Manwani, "The Spoken Web Application Framework - User Generated Content and Service Creation through low-end mobiles," presented at W4A2010-Technical, April 26-27, 2010, Raleigh, NC U.S.A.

⁴ Robert C. Alexander and Douglas K. Smith, *Fumbling the Future: How Xerox Invented, Then Ignored, the First Personal Computer*, (New York: William Morrow and Company) 1988.