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COMPUTER SCIENCE RESEARCH OUTSOURCING IN INDIA

TRENDS ANALYSIS AND DIRECTIONS

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IN recent years India has seen significant growth in Computer Science and related disciplines. Computer Science (CS) and IT research is one of the backbones to see India mature as a self-sustainable and developed nation. The Indian CS and IT workforce has professional experience, domain expertise, trust and assured capability. Exciting and important work is carried out in the Indian Information Industry. It is also known that international research talent in the form of highly qualified Computer Science workforce comes from developing nations primarily from India. There is an obvious opportunity of such research work being heavily outsourced to Indians in near future. At a higher level, outsourcing means greater productivity, coordination, more efficient goods and acceptance of proven expertise in that area. This paper tries to emphasize the possibilities of research being outsourced to India. It discusses this issue with context to Computer Science (CS) and related technologies and aims to bring out trends in CS research and development with a positive attitude for "technology generation". It summarizes the findings of the survey conducted to gather views of the IT workforce and identifies the key issues and challenges faced by the Indian research workforce. Measures such as conductive research environment, various levels of collaborations, entrepreneurship initiatives, research innovation principles and various initiatives at Government and industry levels that can direct the CS scientific community are also being discussed.

Keywords: Indian IT Industry, Research and Development, Computer Science R&D Outsourcing, CS R&D Trends, CS R&D Directions, Indian Entrepreneurship, Indian IT Industry survey

Introduction

In recent years India has seen significant growth in Computer Science and related disciplines. There have been several reports prepared by NASSCOM (id=36) (2005) emphasizing on the importance of Indian IT Industry and advantage India has in the global IT scenario. NASSCOM (id=424) (2005) predicts that at the end of 2005, the combined Indian exports including software and services are likely to witness 35 per cent growth to reach revenues of US$ 17.3 billion in FY 2004-05.

With the above statistics and trends in background, this paper aims to bring into focus and investigate Indian IT Industry's research strength and what possibilities exist that Indian IT Industry (hereafter referred as I3) can utilize and channelise its assets into becoming a world leader in developing world-class research products.

Problem and Objective

The paper's aim is not to focus on the kind of research work being carried out or the agencies doing it, or even the methodologies adopted. Leaving research to be carried out by the respected researchers,

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this paper focuses on the issue of "R&D Outsourcing", what are the industry's trends, what is the research mindset in I3 community. It analyses the opportunities, challenges existing in carrying out research-based outsourcing, the global outlook towards I3's R&D strength. Finally, based on the various studies and surveys carried out by the team, personal experiences and peer discussions, the paper attempts to find out the factors that can influence the positive trends in R&D outsourcing. It endeavors to enlist the problems that need to be addressed and the means by which positive efforts can be made to realize I3 become recognized as a major centre to outsource research.

Motivation and Outline of the paper

The authoring team is carrying out research work in C-DAC (2005) (id=424) in different domains. There are many offline discussions, readings, that one or more of the team members have been engaged into. These include topics surrounding I3's research trends, the way I3 is progressing, and the industry's visionary approaches that are being formulated and applied. The work on this paper was triggered by one of the sessions, the team members attended, from Shri. N. Ramakrishnan, Director General C-DAC, encouraging the industry to accept and recognize India's IT strength and gear up and work towards the R&D outsourcing methodologies and make it the next big thing to happen for India. The talk was a starting point for the work presented through this paper.

The above problem objectives are being discussed in the paper in various sections. It begins with "The Indian IT Industry Trends", bringing out the trends and nature of work being carried out. This is followed by a discussion on "Existing R&D status in India", wherein it focuses on Indian IT market and its R&D status. In "Outsourcing; An economic and social fact", the paper discusses need of outsourcing from an economic and social perspective. In "R&D outsourcing in India; Trends and Analysis", which forms the major part of the work, we focus on R&D outsourcing in India. This section presents the outsourcing trends from research perspective. We further discuss the results and key findings from the various surveys that were being conducted and possible steps I3 can take in order to realize the objective. We conclude by presenting a case study and our observations on the same.

The Indian IT Industry (I3) Trends

The current work carried out by I3 is classified by NASSCOM (2005) into three major categories depending upon the work being carried out. These include:

- IT Services and Products
  Related to software development either as part of software services and/or product development and/or maintenance
- ITES-BPO
  Related to IT Enabled Services (ITES), including customer support (both technical/non-technical) and outsourcing many different areas of business process; Business Process Outsourcing (BPO)
- Hardware
  Related to development of capabilities and productization of hardware equipments, peripherals and systems

Each work type involves export and domestic requirements. NASSCOM confirms that the contribution of software and services exports to India's total invisible receipts is also continuously increasing. This has a direct impact on the overall increase in foreign exchange reserves. Geographically speaking, Indian software is increasing its presence in varied markets, no longer being limited to North America and Europe regions. Various verticals have emerged in the above categories enriching the area of expertise on I3. Some of the major verticals include Healthcare, Information and Communication technology, Telecom Service providers, Retail and Government, IT consulting, System Integration,

Network Consulting and Integration, Hardware Support and Installation, Processing Services and Information Services outsourcing.

I3 has also witnessed emergence and dominance of major new generation of entrepreneurs in recent years, exemplified by the success of Infosys and Wipro as two leading Indian IT industries in India and recognized globally for the quality service being provided.

All this has made analysts and economists summarize the advantage India as an IT-triggered nation enjoys. Refer Appendix 1, provided as a reference on what are I3's advantages in the Computer Science and IT related developments.

Synergism between Government, Industry and Human Resource

This positive growth of I3 and its direct implication to Indian economy has seen a synergism between the three most important functioning bodies from IT point of view. Refer Figure 1. These are the governing, decision-making and regulatory bodies that include Government and Industry, while the human workforce forms the execution agency. The Government's vision to increase its IT workforce observing the trends and demands from the industry has seen the rise in number of educational institutions offering IT and CS specializations. The interdependence of the three entities together with a serious quality perspective at each level identified above will be a be a crucial factor in sustaining the current IT growth.

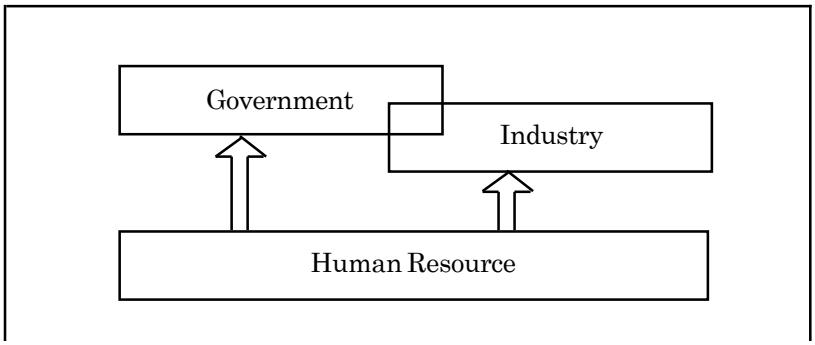

Figure 1:I3 Synergism

Existing R&D Status in India

The widespread emergence of innovative technologies in various verticals and existence of multitude of challenges that is characteristic of Computer eScience (Weiser 2005), National Science Centre (2005) has triggered research for the upcoming technologies. Research along with directed development efforts are the steering forces behind a growing economy and sustaining these efforts is always a challenge. The growth of Indian economy and its dependence on CS and IT as the thrust areas of work has placed tremendous importance for the Computer Science research to be carried out in India.

The team looks upon Computer Science research from two perspectives as depicted from Figure 2 (see below), one, which is carried out in an academic scenario, and another, which is carried out from an organization perspective. The first category comprises of universities and institutes, which have academic programs as their main focus and carry out research as an additional part of the curriculum. The second category, which comprises organizations focused towards carrying out research and development in a targeted area and/or serving as operating agencies to provide infrastructure and ambience to carry out research. These include government and non-government agencies, privately funded bodies, and/or participating organizations, which have established India as one of their R&D base.

Ramamritham (1995) lists down the organizations and institutions involved in Computer Science research. He has classified these organizations into four categories, which include

i) Educational Institutions

ii) Government-Sponsored Organizations

iii) Private Organizations

iv) Infrastructure and Operations based organizations

He points out the strengths and expertise of each organization and the motive behind setting up and functioning of the organizations.

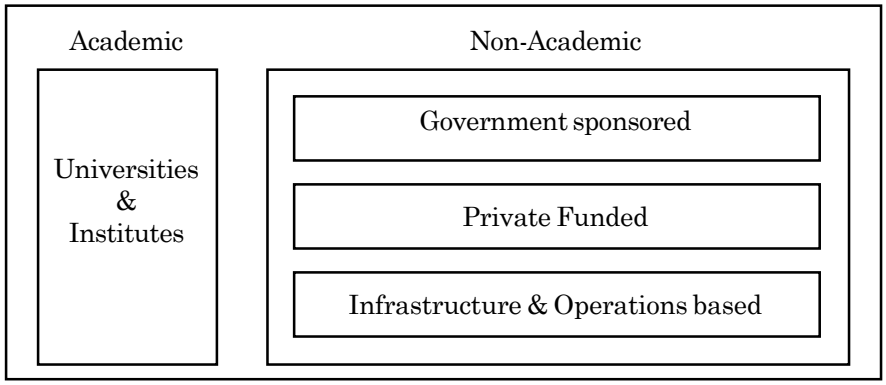

Figure 2: Research Workforce

Indian market is witnessing emergence of various multinationals and global IT players setting up their shops in Indian software space. These companies have started recognizing the I3's software capabilities and strength. They have well defined mandates and expected outcomes as outlined from their respective headquarters.

NASSCOM[2] points out the following as I3's strengths

1. Highly skilled, abundant labor pool and market-driven education system
2. Labor cost advantages
3. Process and quality focus – large number of companies have received SEI-CMM Level 5 certifications
4. Project management and complex project execution skills and experience
5. Entrepreneurial culture
6. Indian diasporas and strong customer relationships
7. Friendly government policies for IT exports

The above facts summarize the strength on which I3 can thrive on and implement stronger research base.

Outsourcing: An Economic and Social Fact

The rise in economic stability of any entity (concern, organization, state and/or country) is directly related to the amount of work being created. If the work created is being carried out by an entity on

behalf of another entity, monitored with necessary pre-defined agreements we say work is being "outsourced". This results in an environment, which is mutually beneficial to both the parties involved.

Outsourcing Concerns and Objectives

Whenever an outsourcing contract is signed, the terms of services and agreements is being clearly defined. As brought out by the following definitions,

"Outsourcing is the act of obtaining services from an external firm" Outsourcing Times (2004)

"Outsourcing and out-tasking involve transferring a significant amount of management control to the supplier. Buying products from another entity is not outsourcing or out-tasking, but merely a vendor relationship. Likewise, availing services from a provider is not necessarily outsourcing or out-tasking. Outsourcing always involves a considerable degree of two-way information exchange, co-ordination, and trust" Laborlawtalk (2005).

The important words here are "obtaining services" and "management control". This obtaining of services and a clear management control over how these services are governed form key to successful outsourcing. The mutual benefit and objectives for the party requiring services include low cost from an economic point of view and quality output from work, business point of view. While the entity providing the services generate work, develop business relations and if the outsourced entity is expert at the work, prospects of more work inflow increases, which in turn adds to the cycle of economic-social impact.

R&D Outsourcing in India: Trends and Analysis

Analyzing the outsourcing trend into Computer Science, this section discusses what are the existing trends and developments and how Computer Science research is outsourced in India.

How is Software Outsourcing different from R&D Outsourcing?

Software outsourcing involves a general relocation of software process from one entity to another. If the process involves terms and conditions wherein the implementing entity is expected to carry out research and come out results specifically expected from an R&D centre, a "Congenial Research Outsourcing environment" begins taking shape. An organization can expect research outcomes, which are different, compared to another organization. The varied outcomes include core technology based research, theoretical computer science research, product specific research, process based research. What remains same is the motive behind outsourcing the work. It is an understanding that carrying out particular research task is suitable and perhaps profitable when carried out by another entity rather than by the entity outsourcing the work. A sense of mutual trust, cohesiveness and following a process-model form the base on which research outsourcing flourishes.

Research demands significant domain knowledge, capability to carry out thorough analysis, and provide solutions that are time tested and modeled according to the entity outsourcing the work. The I3 has started getting recognition for the high quality of work being done. Already we have numerous companies, which are quality certified and have high technical workforce to produce research solutions.

I3 Research Workforce and Outsourcing Possibilities

The outsourced research based requirements can be handled at various levels. We discussed the research workforce from the purview of two categories of software research organizations, which the team has identified. (Refer Fig 2)

The *first* category consisting of universities and institutions having an academic environment, have the much needed talent pool existing at both the faculty and the student level. With the

launch of numerous CS and IT courses, the number of student enrollment in professional courses has increased. This has also been the vision and requirement from the Ministry of Human Resource to the Universities and educational institutions to increase the student intake in CS and IT related programs.

With the above research workforce increasing and Indian student community having tendency to adopt CS and IT as their professional disciplines, there exist possibilities of in-house research to get transformed into domestic research outsourcing. The following examples attempt to discuss the current research scenario, which actually contributes or could be modeled to result into a highly focused research outsourcing environment.

1. Internet and Connectivity

   Many academic and educational institutions getting connected to Internet promotes global connectivity and knowledge of the happenings around the world. If the work is focuses around research, it provides the maximum exposure to the research opportunities. The faculty and student interaction and interests to work on common related problems promotes carrying out of research activity and sharing of research work.

2. Emergence of open source software and solutions

   This has triggered possibilities of exploring and sharing software, the knowledge of the existing challenges and solutions, and provoking development of new software in similar or varied lines. Also the solutions are available at very less cost (Free Software Foundation 2005) or not charged at all (Open Source Initiative (OS) (2005). With the emergence of web and academic workforce combined with open source software, research in the form of development of new software getting developed is something, which cannot be left behind. There are numerous cases of open source software being started in an academic environment and becoming one of the most popular software in its category.

   - Linux (2001) is one such bright example, its creator being Linus Torvalds, a student in Finland.

3. Research Laboratories at various institutes

   Many academic institutions have various laboratories and test-beds set up in their premises that are funded either by Government or through private ventures. These help the students to understand the research environments and carry out research work. These labs are the ideal workplace where domestic outsourcing can happen, in the form of research assignments. Of course there is no limit to these assignments being shaped into full blown projects and products later on depending upon the outsourcing agreements, success of the research work and many other practical factors.

All the above are just some examples that discuss the in-house research work that is generally being carried out and the possibilities that exist in getting a research being outsourced to academic organizations.

The *second* category of the research workforce includes organizations carrying out focused research into verticals. The workforce here has expertise in specified areas and objectives differ with organizations. While the government sponsored organizations carry out R&D catering more towards developing indigenous capabilities and technologies. The research based private organizations both Indian and non-Indian carry out research and development focused more towards the in-house research requirements or product-specific research. They also form the leading technical research

base for advanced software technologies. The private organizations enjoy relatively better funding and management environment compared to government based research organizations, though there are exceptions too.

Outsourcing Computer Science research with industries setting up their operations in India, started as early as in mid 1980s, when Texas Instruments set up its first R&D lab. Soon, other well recognized multinational and IT giants followed and established their R&D bases in India. Significant among them are GE, Intel, Cisco, Honeywell and Motorola. Currently there exist more than 100 R&D labs carrying out software operations in diverse areas and operating from India. This has significantly boosted the economy strength of both the entities involved in this mutual assistance.

Also many global software players have announced multi-million dollar investment plans that has aimed to harness the talent pool of Indian software professionals. Media is also excited to carry out special articles on how the new investment plans of various companies, impacts on the growth and the way I3 is progressing.

Our Survey

The team conducted two surveys to ascertain the understanding of the software professionals/ academician's and students' views and thoughts on what they feel the way Indian software industry is heading towards, to ascertain the research understandings of the group and whether there is any hint of Software R&D outsourcing that is happening.

Executive Summary

1. Though majority of the survey takers admitted to having very little knowledge about research organizations and their work in India, they voiced their interest in joining an R&D outfit.
2. Brain drain is a real phenomenon due to which India is lacking people who might take on the role on innovators and entrepreneurs. Efforts are needed to retain intellectuals in India, proper funding and financial appreciation is required.
3. Software industry in India is largely service oriented and development work in India is driven by client needs located in other countries.
4. Research as a discipline should have focus right from the start rather than being an option late in career path. Education system in India has to be modeled to foster such a mindset.
5. India currently offers limited opportunities in true R&D arena.

The detailed objectives of the two surveys and the key findings are being provided respectively.

Survey I: R&D Outsourcing in India; from a Software Professional's/academician's Perspective

1. Objectives: The first survey was focused towards software professionals and academicians. There were 18 questions that ware asked in the survey, 16 of them multiple choice (both single and multiple options) while 2 of them required subjective answer/comments and viewpoints.
2. The survey was fielded on 24th October 2005. An invitation to take the survey was mailed out to approximately 250 people, and about 69 people completed the survey. This was 65.85% of the people who started and completed.
3. The following were the objectives of the survey.
   (a) To gather the profile of the person attempting the survey and personal career objectives to work in a software concern.

(b) To ascertain how many of the people attempting the survey had their professional qualification matching their current profile. This was needed to find out the interest of people in joining the software industry.

(c) To gather their views on the research capabilities and infrastructure in Indian Universities.

(d) To find out what they think is India's main reason on being chosen as the R&D destination by many global software industries and what is lacking in the same.

(e) To ascertain the awareness levels of I3's software professionals about the existing research scenario in India and to find out what the confidence the industry shows in capability of India developing world-class research products.

(f) To find out the differentiating views of software professionals working in research and non-research based organizations.

(g) To find out their views on research being outsourced and India becoming a global R&D destination.

(h) To find out their views on brain drain, how it is affecting the research growth and whether anything could be done about it.

(i) General comments.

4. Key Findings of the above survey.

(a) Majority of the people who took the survey were software engineers. While many of them would like development work, a sizeable portion of them showed interest in research and development work, which provides them a way to innovate and handle new challenges. Majority of them thought they are appropriately qualified for R&D work.

(b) Very few top profile institutions nurture conductive environment for research as leadership and visionary support is lacking.

(c) Very few of the survey takers have information on the work being done in existing research institutions in India.

(d) Brain drain is a real phenomenon.

(e) People feel working and contributing will give concrete answers as there is much that is needed to be done to make India a global R&D outsourcing destination

(f) India is a choice for R&D destination due to Indian software development strength and cost effectiveness.

(g) People are unwilling to move in research arena as India offers limited avenues for true R&D. Also current research activities are not on par with the world standards in terms of quality and effectiveness.

(h) Majority of the survey takers did not comment on the current state of research in their organizations.

(i) There is a mixed response regarding the research target being purely Indian, foreign or a collaborative effort.

(j) On R&D front, Software industry is missing out equally due to misdirected educational goals as much as due to lack of workforce with research background. But more number of survey takers say Indian software industry is missing out due to lack of entrepreneurship and innovation.

(k) India has pool of capable intellectuals to carry out research work.

(l) Industry in India mainly comprises of service based offerings.

(m) Companies investing in India take R&D as a risk. Product development is being driven by client wishes.

(n) Research work in India is not supported well financially.

(o) Motivation is lacking for carrying out cutting edge research.

(p) Software industry is looked upon as money generating machine rather than being an avenue for good research efforts.

(q) Today's education system in India churns out engineers who are namesake engineers and only good for maintenance work that is being outsourced to India. Software engineers in India work only for payday.

(r) Majority of research in India is controlled by agencies abroad. Also research in India is carried out in foreign interests and seldom in India's own interests.

(s) Lack of initiative and funding

Survey II: R&D Outsourcing in India; from a student's perspective

1. ***Objectives:*** The second survey was focused towards CS/IT student community. There were 15 questions that were asked in the survey, 13 of them multiple choice (both single and multiple options) while 2 of them required subjective answer/comments and viewpoints.
2. The Survey was fielded on 24th October 2005. An invitation to take the survey was mailed out to approximately 200 people, and about 27 people completed the survey. This was 67% of the people who started and completed.
3. The following were the objectives of the survey.

   (a) To gather the profile of the student attempting the survey including the qualifications and how many students attempting the survey had pure CS/IT background in graduation.

   (b) To find out the top most priority of expectations of the students when they join CS/IT Industry. This aimed to initially find out the number of students showing any kind of research inclination.

   (c) To find out the research awareness among student community, i.e. what they know about the kind of CS/IT research work being carried out in India.

   (d) To know the inclination of the kind of jobs the students prefer after completing their education.

   (e) To know the students' inclination to join a research based organization and particularly an Indian Government based research organization.

   (f) To understand what students' think on what level of entrepreneurship, India needs to be on the forefront of software development.

   (g) To gather their views on the research capabilities and infrastructure in Indian Universities.

   (h) To find out their views on brain drain, how it is affecting the research growth and whether anything could be done about it.

   (i) To find out their views on research being outsourced and India becoming a global R&D destination.

   j. General comments.

4. Key Findings of the above survey

   (a) Majority of the students are pursuing postgraduate degree while a sizeable number is pursuing post graduation diploma. Also majority of the students say they completed their graduation in pure CS/IT disciplines.

   (b) More number of students voted for non Indian MNC as their target company but a number of them say that given a chance they would like to work for India. Few students voted for Indian research establishments as their target companies. As a whole students voted for research and development organization as their target companies.

   (c) Students who took survey have favorable views regarding research based opportunities in software industry but students have very little information on existing research organizations and their work, in India.

   (d) Students feel Indian software industry needs more entrepreneurs as availability of conductive research environment is limited to few top profile institutions.

   (e) Students have mixed views about brain drain.

   (f) Indian industry is money oriented.

   (g) Students in India are striving towards better grades, which are leading them away from real knowledge.

   (h) Brain drain is happening, as people in R&D field are not given much attention financially.

   (i) Research should be encouraged right from the start.

   (j) Career growth is important to students. Also students have voted for good salary and challenging work environment to be expected from a software company.

   (k) Student survey takers have very little knowledge about research and research methodologies.

R&D Outsourcing in India: A Prospective Opportunity

While the survey provided mixed response regarding research and research outsourcing trends, the team tried to formulate I3's strength and the way I3's visionaries should look upon R&D outsourcing as the next big opportunity.

This section discusses India's IT strengths vis-à-vis outsourcing opportunities.

(a) *Highly skilled, abundant labor pool and market-driven education system*. The skilled research workforce is inclined to carry out research, provided there is amiable work environment, monetary benefits, as well as development of a culture that recognizes and accepts research work.

(b) *The Market driven Education System* can look research from a market perspective as I3 also enjoys labor cost advantages. This labor cost advantage and quality research will attract the research problems globally and a strong research foundation is bound to develop.

(c) *Process and quality focus* – Already we have acclaimed and proven quality based organizations. Continuing this trend in the research arena and developing and gaining expertise in processes for research outcomes will result in gaining trust and respect globally and an admiration for the quality of research being carried out.

(d) *Project management and experience* – I3 has human workforce, which is highly experienced in project management. Research imposes sufficient challenges and complex problems, which requires experience and directions at various levels and domain knowledge. I3 has already proven project management skills at various levels and the time is ripe enough to showcase research skills and undertake challenging problem domains, trusting its domain knowledge.

(e) *Entrepreneurial culture* – I3 needs to inculcate a true entrepreneurial culture to signify faith in the global software industry and to lead by example, the upcoming generation of software professionals who invariably need some direction. The Entrepreneurial Assistance Unit (EAU) managed and controlled by Ministry of Industry, welcomes and supports entrepreneurs, can be contacted for more details.

(f) *Friendly government policies for IT exports* – With the advent and practice of economic reforms and many friendly government policies for IT exports, reforms to incorporate any policy on research outsourcing and should not be a major problem and this will signify closer bonding of the two participating entities.

(g) *New Initiatives of the UGC* – The Indian government has established UGC as the only grant-giving agency to the universities (University Grant Commission 2005). One of the mandates from the UGC includes determining and maintaining standards of teaching, examination and research in universities. In its recent annual report (UGC 2004-05), UGC has come out with new initiatives including.

- Promotion of Entrepreneurship and Knowledge based Enterprises
- Protection of Intellectual Property Rights (IPRs)
- Promotion of Indian Higher Education Abroad
- Training and Development of Academic Administrators
- Comprehensive Computerisation Initiative

Though the above are in general and not specific to I3, I3 can reap immense benefits. As implementation of these initiatives will certainly lead to a higher growth of trust, responsibility and emergence of a new breed of entrepreneurs who will be the guiding force behind I3.

A very appropriate example here that can be followed and practiced is the IIT Mumbai Incubation program (ecell IT Mumbai 2005-06). This cell takes all necessary initiatives and means to carry out strong entrepreneur activities in the IIT Mumbai campus and has established strong links with the industry. The quality of students and their intellectual and technical strength, led by faculty members has ensured a neat sense of entrepreneurship among young professionals. This culture can be imbibed and practiced in other educational institutes and thus, numerous venture capitalists and research bases and cells can make a huge difference to the CS/IT growth and Indian economy.

(h) *Research; An Open Innovation* – An interesting paradigm (Babu, 1999) that is surfacing is "open innovation". This research trend emphasizes on research being carried out with an open perspective, i.e. without hiding the technology, enabling and sharing views, problems and solutions. This will be a true enabler of research that is discussed openly and prospects of extensive outsourcing are seen. Added to this, the Global Idea Exchanges (GIE), Global solution Exchanges (GSE) are the additions to this research innovation paradigm and Internet and various other communication mediums form the backbone to practice this research. India being globally connected and UGC taking efforts to connect universities and colleges and institutes together provides a direct impetus to the research possibilities. Sharing of views and ideas shall enable research problems being discussed and "technology generation" shall be the talk of the I3 visionaries.

(i) *Collaborative Work* – Research and knowledge sharing goes hand in hand. This can be in the form of publications or various IPRs. A collaborative work carried out at various levels enables sharing of views and building trust as well as working relationship between two collaborative agencies.

This enables a congenial working environment and a cyclic process of identifying problems; their solutions can thus, be formed which is truly helpful. The I3 should focus on initiating several research collaborative programs at various levels, be it Industry and Academia, or Academia and Academia or Industry and Industry. Such kind of association builds the much required trust relationship that forms the basis of an indirect research outsourcing, and hence, must be encouraged at different levels.

R&D Outsourcing in India: Issues and Challenges

Although in the above section, the various possibilities of research being outsourced has been discussed, there still exist following issues which need to be handled at various levels and which do act as deterrents to realization of a successful R&D outsourcing scenario in the I3 environment

(a) *Lack of infrastructure and funds* – Lack of required funds and at the right time is one of the most de-motivating factors especially in the first category (academic) of research workforce. Often lecturers and professors need to visit international conferences/workshops or initiate procurement of latest software packages enabling high quality research. This limited nature of funds, lack of infrastructure including library books, journals, human resource existing in many of the government research organizations has dampened the research efforts which has a serious impact on talented people staying in the organization and thus, collapsing the much sought after research environment. Sufficient measures need to be taken to direct proper funding and maintenance and availability of necessary supporting infrastructure.

(b) *Self-recognition and confidence building measures* – Krithi (1995) in his paper mentions the importance of the Indian CS community to realizing a sense of self-appreciation for its capabilities and to embark upon systematic efforts to break new ground. He encourages positive instincts among the researchers and provides examples of many established researchers that have not been let down by system constraints but have carried forward the research requirements of developments, ideas and solutions. This sense of self recognition among I3 community is what is ideally needed and confidence building measures is expected from the I3 visionaries

(c) *IPR issues, Privacy problems and Legal Hassles* – Research being a sensitive issue when it comes to disclosure of information, it needs to be handled very carefully from privacy point of view. The I3 should strive to create an active and alert environment of an understanding of the Intellectual Property Rights (IPR) of organizations, individuals and third parties. Also the research organizations interested in carrying out outsourcing or transferring research work in India should not hesitate in actually initiating the operations and this is only possible if the I3 visionaries recognize the fact of the need of R&D outsourcing and provide all facilities and ambience for the same. This will create a trustworthy environment for research to be discussed, nurtured and to flourish.

(d) *Cost and Labour Incentives* – Research is a time taking effort and immediate results cannot be expected. Though this differs from organization to organization, an effective process that takes into account compensations, incentives and benefits needs to be practiced and incorporated. This is also evident from the survey wherein many of the respondents have expressed a desire for attractive emoluments.

Case Study: A Government R&T Centre - DGF

The Development Gateway Foundation (2005), based in Washington DC, is an independent not-for-profit organization. Its mission is to help improve people's lives in developing nations by building partnerships and information systems that provide access to knowledge for development. Towards this end, the Development Gateway Foundation is mobilizing membership from countries that are interested and have relevant potential into a Research and Training Network. This network draws on the strength

of Research and Training Centers in various countries and regions, set up with local commitment to provide expertise and resources to:

- Conduct applied research in Information and Communication Technologies (ICT); and
- Provide ICT policy and technology training.

The Government of India is a member of the foundation. Accordingly, a ICT Research and Training (R&T) Center (2005) of the Foundation has been set up in Bangalore, India. Center for Development of Advanced Computing (C-DAC) has been chosen as the Project Implementing Agency and the Indian Institute of Technology (IIT), Bombay as the first collaborating institution.

Objectives: ICT Research and Training (R&T) center, India has undertaken several ICT applied research projects. These various ICT projects aim to provide solutions that enable people in India to communicate, store and retrieve data, and communicate in their local language. Also the aim of these projects is to provide a network backbone that enables efficient transfer of information.

Here this symbiotic arrangement is benefiting both the entities. DGF as the fund provider and coordinator of world-wide activities is fulfilling its commitments towards eradication of illiteracy, poverty through the setup of such R&T centers where local expertise is available and can be made good use of. The host country where the R&T center has been set up benefits from this as the general population of the country will be provided cost-effective and self-sustaining applications that will make their day-to-day life easy.

Conclusion

The I3 has made a significant mark on the global software front. Research paradigm, though not new is not actually being currently harnessed by the I3 visionaries, though there are currently lot of initiatives to encourage collaborations and engage in various research work. The I3 visionaries, government and software industries representatives actually accept the fact of research pool existing in India.

The I3 workforce has a positive inclination to carry out research work. The intellectuals accept that they are interested in carrying out research and given the proper ambience and emoluments many will actually work in a research organization based in India and thus, contribute to stopping brain drain.

That I3 software expertise is being recognized not only for its software strength but also of the high quality standards maintained at a low cost and many I3 professionals have in-depth domain knowledge of various research areas.

Supported by our survey results, a thrust emergence of research outsourcing is possible and I3 is ready and quite capable to accept the challenge. What is required is to focus on the existing issues and problems and I3 visionaries along with the various government agencies, to work more towards creating environment more favorable to carry out research and collaborative work. With more or less no legal hassles and providing IPR and security, a sense of trust between the outsourced and the outsourcing entities can be built.

The I3 is being targeted by many countries to outsource research work. These countries not only include US and Europe regions but also Asia Pacific and surrounding regions. This implies a greater responsibility on behalf of I3 representatives at all level and an alert research workforce ready to innovate and accept challenges.

As Dr. Mashelkar's maintains: "India's future is in IT. But do not read IT as "information technology". Read "Indian talent", it is this Indian talent that needs to be harnessed, to make India emerge as a global R&D hub and a major economy for outsourcing CS research work, Rodrigues (2005).

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