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NERD

YES to NA-NO

COVER STORY

Beyond **Electronics** with nanotech

Micro and Nano-structuring Silicon for non-electronic applications.

demystifying nanotech

Conversation with Dr. Ashutosh Sharma, Coordinator, DST's Nanosciences Unit, IIT Kanpur

students for sustainability

Thoughts on a nationwide campus based student network for a sustainable future

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The editorial could have been titled "Small is the new big!" but statistically speaking this epitome of a cliché has been used over a googol times. So we thought we would better serve soup. It suits too. The cover story of this issue of NERD is nanotechnology. We will let the issue talk for itself but just to set the buzz here are some stats to get you started on nanotechnology. The field is progressing like an epidemic. Or maybe epidemic's a lesser word. The nanostatistics are not nano at all. They are astronomical!

For example: the estimated annual R&D investment in nanotechnology by 2010 alone (USD 4 billion) is projected to be 31% of the total investment made so far in the field in the history of mankind. With over 5340 patents in the US, 2559 in the EU and 1220 in Asia till 2004 (Ernst and Young 2007), nanotechnology is all set to become the most researched area in recent history.

GoPubMed®, the knowledge-based search engine for biomedical texts, states that in 2009 alone 2369 nanotechnology based publications have appeared opposed to 29 publications in 1999. That's an increment of over 8000% in just 10 years. Add to that the facts that 2009 isn't even over yet and that all these number are in the context of biomedicine alone.

Already over 600 products (most of them in health and fitness) are using nanotechnology in one way or the other. The Global Market for products incorporating Nanotechnology in 2009 will be 400 Billion USD (Plunkett Research) and will quadruple to USD 1.6 Trillion in the next four years! The Global Research Market itself stands at around 14.5 Billion USD in 2009 (RNCOS) and is estimated to double in the next 4 years. Ten years from now Nanotechnology based industries will directly employ 2,000,000 people globally.

Nanotechnology has garnered special interest in India. Type in the term nanotechnology in the search box of Google's Insight for Search service and hit enter and you will find that India leads in the regional interests for nanotechnology searches followed by Srilanka and Iran. Indian market for nanotechnology was USD 100 million in 2008 (ReportLinker). Indian research scene in Nanotechnology got a boost when DST set up the Nanoscience and Technology initiative in 2001. A whooping USD 200 million has been earmarked for R&D expenditure between 2006 and 2011. The Central Government has already spent USD 50 million in the last five years. Compare that, however, with the investment Intel has made in India for nanotechnology research: USD 250 million. Clearly, Industry supported research will grow in the years to come if more players like Intel join. That also seems to be the right approach because Nanotechnology can be a highly application based area revolutionizing everything from electronics, energy and defense to medicine and environment. This is also an indication of opportunities that are present in the field. There are issues too like the rate of technology transfer from lab to market, health hazards et cetera but only with more research can these issues be resolved. Research will grow as the first ever Nanoscience and Technology Institute comes up in Mohali followed by Kolkata and Bangalore. DST has already established its Nanosciences unit at Indian Institute of Technology Kanpur. Several research projects are already going on in various institutes all over India.

It is in the backdrop of these facts that we bring this issue of NERD to you. Apart from nanotechnology the issue covers spirituality in science, the ongoing series of green articles, interviews and various other interesting feature articles. Oh and by the way, we welcome thee to the **Official version of NERD**! NERD is now a publication registered with the Registrar of Newspapers in India. The guys in the back room suggested that the editorial should start with this news but it has been science over vanity till now and it will be that way for as long as we are here. Enjoy!

Demystifying Nanotechnology

Interview with Dr. Ashutosh Sharma, Coordinator, DST Nanosciences Unit, IIT Kanpur

Dr. Ashutosh Sharma is a well known name in the field of chemical engineering. His research on thin films and nano-systems is world renowned. Currently he is the Coordinator of the DST Nanosciences Unit at IIT Kanpur. Bhuvnesh Goyal and Akash Rastogi of NERD team caught up with him to understand his research.

NERD: Nowadays terms like are floating around: nanosciences and nanotechnology. Please elaborate on the differences between these terms.

Dr. Ashutosh Sharma: Nanosciences is the understanding of physical, chemical and materialistic behavior and properties of devices on small scale, in particular on some few hundred nanometers. These could be optical, magnetic, electronic, electrical or mechanical properties such as bending, strength etc, which are the basic ingredients of any science. The relation between nanoscience and nanotechnology is just like the relation between science and technology in general. Nanotechnology would be the use and exploitation of the properties understood from nanoscience performed for technological purpose. If you make a transistor which measures 20nm across, then it is nanotechnology. People are already down with 50nm transistor by the way. Nanotechnology is not a single discipline unlike chemical, mechanical, civil, and other things because it is not in that sense centered on some classical subject. It is an interdisciplinary field. In fact, each of the disciplines mentioned before has some relation to nano. For example in civil, you are looking at construction material, we can make nano cement because if I reduce the particle size or alignment, which is currently around microns, and bind disposal, then it turns out that the smaller particles would be more reactive and have more strength. Or in electrical engineering if you are making some electrical device, for example a chip with nano scale components. If you are in chemical engineering you might be using nanotechnology for better catalysts to boost reaction rates or say in material science you are making some nano composite material, in that context some particles or some fibers may be dispersed in a matrix and those particles and fibers are small, and they give you much better toughness, this becomes the material

Dr. Ashutosh Sharma

science perspective. Today nanotechnology has an impact on cosmetics, fabrics, materials, chemicals (catalysts for example) and a lot of other things implying that this is a very spread out technology which touches about every aspect of our life.

NERD: What are the various areas of study of nanoscience?

Dr. Ashutosh Sharma: There is no human activity which is not attached with nano. The reason is simple: you can modify the property of any material that you are using today. For example, take a filter. Filters are used in air conditioners, cars, in industry, in medicine, or even in chemical/biological warfare. Now these filters can be made more efficient by applying nano-technology, thus making smaller fibers that have larger surface area and are far more active in terms of removing contaminants. If you want to do purification of air or water, you can use the new filters.

Now if you look around yourself, you may use glass in window panes. With the help of nanotechnology, they can be made less rough, less brittle, tougher, or can be made more 'smart'. Smartness means they can cut down the UV, other radiation or the light coming in depending upon the lighting condition inside. Thus in winters you can allow more light but in summers cut down light. Many of these things have already been done. Also you can take these glasses and add metallic nano particles to change the property.

If you take our skin and the cosmetics that are being used, a lot of them are already using nanotechnology. Many cosmetics that we use have an active ingredient that must penetrate through the pores of our skins which could be very useful. Hence this particle could be a nano particle which could be the delivery vehicle in cases where a big particle cannot penetrate through the pores. In terms of delivery as posts of drugs, cosmetics or anything else like a beneficial therapy invasion, a lot of work can be related to nano technology. If you want to think of something that should go in and that should protect the skin from UV etc, they can again be made much better from nano particles rather than micro particles.

Nowadays plastic is also being nano tailored. All kind of polymers are getting affected. Metals are getting affected. So every day products, areas or any technology that exists

today can be upgraded using nanoscience. Everything that we look around can be changed by nano.

NERD: Apart from the DST's Nano Science and Technology Initiative (NSTI), are there some other groups within IITK or outside which are working in similar or related fields?

Dr. Ashutosh Sharma: Inside IIT Kanpur there is a group under Dr. Y.N. Mahopatra. The group works in the field of optoelectronics i.e. optical electronic devices. Outside IIT Kanpur, if you at the webpage of any department in a given institute or university, there is a fair chance that you will find people related to this field. It is truly global. I would say that in the past few years roughly 40% of total research funding has gone to some aspect of nano technology. The nano diversity of the world in terms of people and applications is emerging. But the question is about the research or technological saturation. One can't get extreme results by doing the same thing again and again unless they bring in a new idea to get completely new results. For example if I want to increase the strength and toughness of a table by utilizing the old conventional techniques, you may be able to increase the efficiency by say 2-3%. If you want to increase it five-fold or say by 20%, you have no idea. All that we learn in 4, 5 or 10 years is restricted only to a certain area of that domain. It can only sustain till the level civilization has extended. It now needs continuity. If you want to go further you need new ideas and better technology and also proper resources and money management, just as nanotechnology got when it was brought in.

NERD: Are there any environmental applications of the research that is going on in nanosciences?

Dr. Ashutosh Sharma: We are trying to work on remediation, like we just discussed about filters, that is, purifying air, water, industrial waste, locking up all kinds of impurities. People are also studying the effect of nano materials on environment and health. It is not now that car exhausts have started generating nano particles; it was that we were not able to see them until now. People are now worried about how these nano particles spread, how they affect human body, where and for how long they remain etc. They are searching the man made, industrial and the natural sources of these nano particles and their influence. This is all part of nano science. Nano technology is now related to locking up these particles and preventing their spread by making new and efficient materials. These preventive materials are like shields for situations of extreme environment.

NERD: Please elaborate on nanolithography?

Dr. Ashutosh Sharma: Lithography is a microfabrication technique. 'Litho' means stone and 'graphy' means to write on it. It is basically for producing structures

"There is no human activity which is not attached with nano."

and patterns on small scale. A derivative technique is photo lithography. If you want to make a structure or device on a small scale, you can make it by utilizing this tool. Photo lithography enables us to go to a scale of about a micron or a half of a micron. To go beyond this scale one needs other kinds of lithography which is not based on light but on X rays or electronic beams since they have smaller wavelength. The technology implementation is complex and expensive. Among the major changes that nanotechnology has brought is not in underlying principles or concepts but in the ways of implementation of these concepts.

NERD: Tell us something about Carbon MEMS.

Dr. Ashutosh Sharma: Carbon MEMS are Micro Electrical Mechanical Systems made from carbon. Carbon is used because it is bio compatible. One can use Carbon MEMS as micro batteries by using an array of micro electrodes made of carbon. These batteries are light weight and can supply power for a longer time.

NERD: Sir, please explain your research related to the dry eye syndrome.

Dr. Ashutosh Sharma: A lot of people have dry eyes. People who suffer from dryness in eyes find it very painful. It is very difficult to manage this condition. Our eyes have a tissue called the cornea. Cornea is a very fragile tissue and directly interfaces with the outside world. Cornea is transparent and it is covered by a very thin film of water about 50 micrometers, which is called tear film. This film protects Cornea which is very vulnerable because bacteria are coming in all the time, invading it. If we didn't have this water layer, then things would be coming in directly and hitting the cornea. Skin cells are hydrophobic, i.e., they repel water whereas the corneal epithelial cells are hydrophilic, which means they like water. Without water they can't survive, they get damaged or eroded leaving a hole in the cornea. In some people, this film is deficient in function and formation due to which cornea is exposed. So if eyes are not producing enough tears or even if they are producing enough tears but the film is not stable (like water on plastic surface comes out as a drop and doesn't remain spread out) then we have a case of dry eye. It's a very serious condition affecting large number of people and there is no therapy addressing the underlining causes which, by the way, are not known for sure. Dry eye solutions are available but are expensive. Depending upon the severity of the problem one may have to use the solution 4-5 times daily. There is only management for the disease; there is no cure for it. Ours was the first chemical group that looked at this problem, to see if we could understand it in a different way. The question we asked was: Are there

some physiochemical aspects of the problem? Like the example I gave you about the water on a plastic surface, we thought that the hydrophobicity or the hydrophilicity of the cornea in different people in different conditions might have some relation to dry eye. Earlier I gave you an example why interdisciplinary and multidisciplinary research is needed. In this context, one must understand that a biologist or a doctor will never take up the dry eye problem as a chemical engineering problem as both their conditioning and their training is quite different. If a person with a different background looks at the same thing, he may find a different meaning in it. There is no problem that classifies itself as a problem of chemical or mechanical engineering or biology, chemistry or physics. Every object or thing reveals a different aspect when looked at using a different perspective. What I mean to say is that different people depending upon their conditioning and training will look at the problem differently. At some time when I was doing surgery, we had to learn different setup skills and operate different tools. The methodology for tackling a problem is different in different areas, nomenclature included. To work in an interdisciplinary manner one needs to understand the entire nomenclature, otherwise specialist conversations are hampered. In order to convey the problem to others you need to know it well. These are essential aspects of doing interdisciplinary research: one needs to appreciate and understand different tools of the trade and nomenclature.

NERD: What was the scenario of research before at your time and what changes have you noticed in the opportunities for pursuing research?

Dr. Ashutosh Sharma: Research is far more inter disciplinary today than it ever has ever been. Moreover we know far more of everything than 50 years ago when many laws were being discovered. Today, everything is pretty much clear, implying that innovation and creativity today is more about linking up unrelated areas. So it's like bridging knowledge of two unrelated domains to solve a particular problem which doesn't belong exclusively to either of the two domains. This is why the actual meaning of creativity has become

> "Research is far more inter disciplinary today than it ever has ever been."

different; it is now more of seeing these connections and networking rather looking at isolated problems. Another implication is that how often one ends up collaborating with others. A person working alone to solve some substantial problem is a very rare thing now. Today it's far easier for people to come together from across the world than it was 30 years ago. When I was a student, to submit a paper or to talk to somebody, one had to write a letter which used to take 20 days to reach destination, then they had to wait another month before any reply came. Thus the communication across distance and across discipline was not as readily forthcoming. Today we can very quickly find out, through web, the people working in a particular area and related logistics. The bottom line is that the way you do research today is very different then it was 30 years ago.

NERD: What do you think is your most important contribution to the scientific community?

Dr. Ashutosh Sharma: Throughout my life I had been working on Soft Materials on a small scale. Most of my work is related to understanding behavior of small scale systems, dealing with their instabilities and finding means how to control them. I have also tried to understand self assembly of materials and how can we spontaneously assemble them to create desired material. My most important contribution has been to try and understand self assembly or self organization of soft materials on small scales and using those skills to fabricate things. Suppose we take a very thin sheet of some polymer. Now the question is: Can I produce a certain pattern from that sheet without doing any mechanical work? The answer to that is self assembly or self organization.

NERD: How can students make better career choices?

Dr. Ashutosh Sharma: We need a system where students are informed, encouraged to ponder on different aspects and think independently. We need to ensure that students opt for choices not because some relative or a friend forayed into it. This is so because everyone has his or her own strengths and weaknesses and the filed one person goes into might not be suitable for someone else. Hence it is important that students make choices based on their own interests and knowledge. When you gain

> "I am very optimistic about NERD. It is a very valuable service to the community and the students."

knowledge about a particular field, it becomes your own territory and now you can decide which career suits you better. This means that one must gain sufficient information to make a sound judgment. Not only this, we have to spread out the information to people across, as long as they themselves can judge to make informed choice. Currently many students follow a blind system based on rat race. An enlightened system is one where people know their effective strength. If you do stumble upon your calling, then you might do well but you will be an unhappy person: another name in the long list of people in the same category.

NERD: NERD is a platform where people working on various research areas can write for the general audience. What are your views regarding the magazine? What plans would you suggest to sustain it?

Dr. Ashutosh Sharma: I am very optimistic about NERD. It is a very valuable service to the community and the students. Through this, they are now much more aware of stories like this and will certainly inspire some of them to come up with their own ideas. Unless we have this sort of information freely available, people won't have much understanding about these topics. Another advantage is that it is a smart and informed choice to rely upon, especially for those who panic in trying a new thing just because they don't know enough of that stuff. I think it informs people about what is Research and Development,

> "Just follow the path that your heart shows you."

appropriate career options in it and eventually keeps them aware of other related aspects too. I would suggest that this should be a part of any academic campus. Education would not be complete if we don't have such activities. Sustenance of NERD can be brought up by linking more people with it, by monitoring that the enthusiasm doesn't die so that the students who are involved today may not quit tomorrow.

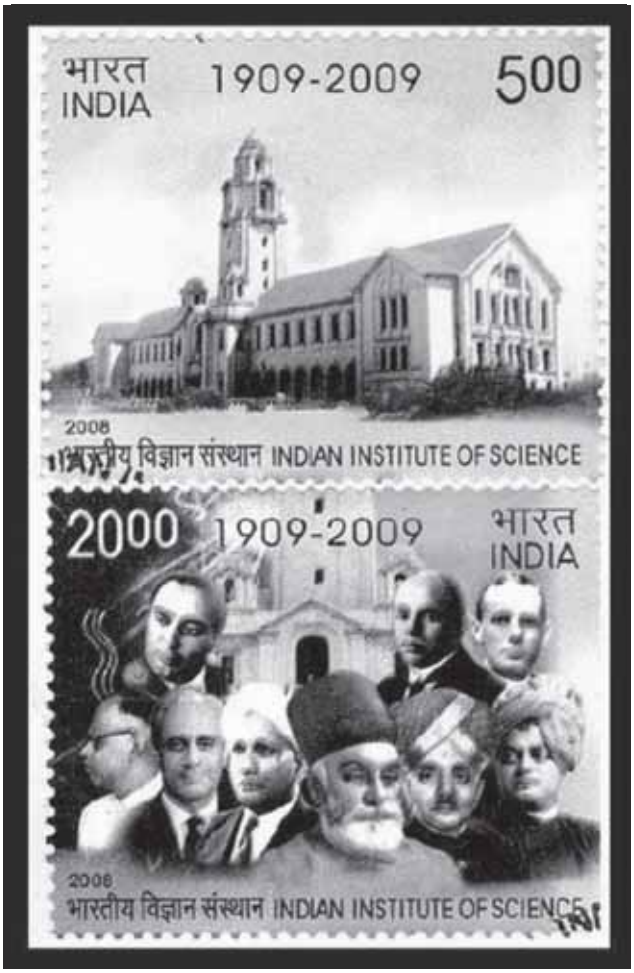
NERD: What is your final message for the students/readers?

Dr. Ashutosh Sharma: Just follow the path that your heart shows you.

IISc introduces Undergraduate Programme

Introduction of U.G. Program in IIScOn it's 100th anniversary, IISc gives good news to the undergraduates by introducing U.G. programs for the first time in its 100-year history.It would be an exceptional four-year, research based programme, to lure and retain some of the best minds of India into hard-core science and engineering. Professors think that there would be initial setbacks, but the programme will survive.

The move has been taken on the eve of the institute's 100th anniversary,created as a result of J.R.D. Tata's vision in 1909.IIsc has been blamed in the past for its gap between undergraduate studies and postgraduate and research on the other. This move would surely serve to fill that gap.The institute hopes to introduce an ideal undergraduate programme, which could later emerge as a model for other institutions too. It will be titled a BS (bachelors in science) programme in accordance to the student's choice.Students will have to face humanities as a compulsory subject. To give the course an inter-disciplinary touch, students would have to study a certain minimum number of courses of other fields, While majoring in their chosen stream.The final year of the course would be devoted to a research project, compulsory for each student.



Ashokwise

Smart Grids and the concept of Distributed generation

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Distributed Energy generation typically refers to a multitude of small generators instead of having one huge generator that takes care of the entire load.

A smart grid is defined as one which integrates advanced sensing technologies, control methods and integrated communications into the current electricity grid.

So what's so different about these modern grids as compared to older grids? - The major difference is the fact that it is designed to deal with both ways power, rather than the traditional design where the grid just gives out power. Comparing only the power delivering part, at the transmission level today's grid is efficient, smart, intelligent. Its at the distribution level that there is a difference. At the distribution level and at the customer level, there are opportunities for automation, intelligent appliances, advanced data collection networks. This in part is because there was no need previously as there was little demand matching done. The Smart Grid makes it possible to integrate large scale intermittent generation through demand response. The typical components of a smart grid are :

1) SCADA (Supervisory Control and Data Acquisition), PMUs (Power Management Units), FACTs (Flexible AC transmission systems), Advanced Conductor: At the generation, transmission, substation levels. These things help in maintaining the power quality, reliability and efficiency .

2) Substation Automation: Helps in resource utilization and demand matching.

3)Distribution Automation, MicroGrid: Enables synchronization of distributed generators.

4) Advanced metering, Demand response, and distributed resources - at the customer end: Helps in demand matching at the consumer level. Ensures correct pricing as there is power both in and out of a building.(As the building also has a generator, when it is producing more than it needs, it sells power to the grid and when in deficit, it buys from the grid.)

So what does it achieve?

1) Reduce peak demand by actively managing consumer demand: The ratio of available appliances and equipment that can respond to both consumer and grid operator priorities continues to grow. Because these grids can manage power both out and in the grid, it will reduce the need for power, especially during high-use periods. like hot summer afternoons when the cost of producing and delivering power is extremely high.

2) Balance consumer reliability and power quality needs: Although some uses of electricity require near perfect reliability and quality, others are almost insensitive to these needs. For example: A device working on a resistor heating up or a motor rotating, does not really care a lot about the quality. But a device using electronics, needs to care more about the quality of power in. It cant afford to have a lot of frequency changes or voltage sags or swells. Similarly, there can be some critical loads that need a very reliable power like a server or some central controller type thing cant afford to go off. Smart grid will be able to distinguish the difference and adjust power reliability/quality accordingly at appropriate cost.

3) Mine energy efficiency opportunities proactively: A smart grid will furnish consumers and utilities with accurate, timely, and detailed information about energy use. Armed with this information, one can identify ways to reduce energy consumption with no impact on our safety, comfort, and security. This would mean that just be managing our demand and supply better, we can reduce the total amount of energy required. This will help us gain some understanding and insight into how our energy use affects our environment, and economy.

4) Improve overall operational efficiency: A smart grid is automated, and smart sensors and controls are integral to its design and operation. This will help the grid operators to easily identify, diagnose, and correct problems, and will even have the capabilities to anticipate problems before they happen.

5) Seamlessly integrate all clean energy technologies: Clean energy is so central to the idea of sustainable development that it cant be left behind, especially by a modern technology. Roof-top/side-wall solar systems, wind farms, small community hydro-plants and storage devices will become a fundamental part of the grid. These clean energy technologies will generate not only energy and power, but perhaps more importantly save on the fuel consumption.

About the Author

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142857

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Can you think of a 6-digit random number? Let me suggest you one-142857- sounds perfectly random, doesn't it? Even I used to think so.
Let me tell you a little story about it (a fully original and true one!!). One fine day, during my high school days, I was solving a simple mathematical puzzle. It was the kind of problem that most of the High school students love to do- "Find a 6 digit number 'abcdef' which when multiplied by 5 yields its own cyclic permutation such that the last digit shifts to the first place i.e. 'fabcde'." Working out this problem for some time, using trivial arguments, I got the answer- a perfectly 'normal' (??) number '142857'.

But somehow I had a feeling that I had seen this number before. Pondering over it for some more time, I found that I had mugged up this number (the same way as we mug up sqrt (2) = 1.414..) earlier and our perfectly 'normal' number happened to be the recurring part of 1/7 which is 0.142857142857…!! And the cynically permuted number that we obtained by multiplying by 5 is nothing but the recurring part of 5/7. Now a thought occurred to me which was that what crime did 2/7,3/7,4/7 etc. commit, that only 5/7 was blessed to be cyclic permutation of 1/7. So I checked out for their values too. Have a look.

1/7 = 0.142857….

2/7 = 0.285714….

3/7 = 0.428571….

4/7 = 0.571428….

5/7 = 0.714285….

6/ = 0.8577142….

Aha!! All of them happen to be cyclic permutations of 1/7!! This was pretty interesting an observation, so interesting that for days together, I searched for more such numbers having properties similar to those of this so considered 'normal' number which now did not appear to be as 'normal' since I could not find any other such number at that time (and I remember having a naïve thought whether 142857 would be named after me- (!!) like Ramanujam's number (1729) if it turns out to be the only one of this kind). So I decided to look in for more properties of this number and indeed this number contained many more magical properties. I'll mention some of them which I haven't forgotten.

```
        14
*2     28
*2      56
*2       112
*2        224
*2         448
*2          896
*2           1784
*2            ..........
-------------------------
+      142857142857142
```

- (142857)^2 = 20408 122449
  20408 + 122449 = 142857!!!
- 143 * 999 = 142857
- 142857*8 = 1142856
  1+142856 = 142857!!
- 142857 * 9 = 1285713
  1+285713 = 285714!!
  (Cyclic permutation of 142857)
  & keep multiplying this way

There are numerous other interesting properties, that can be observed but I shall restrict myself here (if you want to try out sit with a calculator and try out some yourself, and I can bet that you'll find something about this number that I have not written here!!)

So, those were high school days, then came JEE time, and fortunately (??) I landed up in IIT, during this process, our dear old 142857….subsided to some dark corner of the mind and would have stayed there. But, somehow, while participating in the On-the-spot-programming contest in Techkriti'04, we had a question where we needed to check whether a number 'a1a2a3…..an', when multiplied by any number from 1 to n gives its own permutation. And peeping out of the sample data was the magical number 142857… and more interestingly, there was another number in the sample data which had the same property!!

.0588235294117647….

(Observe: 142+ 857 =999 and 05882352 + 94117647 = 99999999!!)

And I wondered whether this number too would be a recurring part of the decimal representation of some '1/n' like 142857… was of 1/7, and was more than glad to find out that this number having 16 digits was 1/17. The next step to find out more such numbers was to see whether more numbers of the format 1/n were showing same properties. And indeed, I came out with a result (a conjecture) that I could not prove-

"**Only All those numbers 'n+1' having "exactly" 'n' digits in the recurring part of the decimal representation of 1/(n+1) were showing this property of giving their own cyclic permutations**

(n+1)	1/(n+1)	Recurring Part	No. of digits in Recurring Part	Exactly n digits in Recurring Part
3	1/3=0.3333….	.3	1!= 3-1	No
7	1/7=0.142857…	.142857	6!= 7-1	Yes
11	1/11=0.90909…	.09	2!= 11-1	No
17	1/17=0.0588235294117647	Same	16 = 17-1	Yes

on being multiplied by numbers from 1 to n."

Now let me clarify what is meant by "**Exactly n digits**" in the above conjecture:

Here, '!=' means "**not equal to**"

Now, after the programming contest got over, I shared this little revelation with my friend **Divesh Aggarwal (3rd, M.Sc. Maths),** who has given a partial proof to the proposition I made. He could prove that the numbers of the suggested format show this property but he could not prove that these are only ones to show this property.

Here is the proof of the first part:

When we divide 1 by n+1, during our division we get some remainder, which obviously lies in the range of 1 to n, then we add an extra 0 to the right and divide the resulting number by n+1 again to get another remainder (again in the same range 1 to n) and then we keep repeating the process to get the decimal part of the number 1 (n+1).

```
_____
7) 10   ( 0.142857....
   7
   30   Added 0 to the right (remainder 3 here 3<7)
        (First Division)
  28
  ---
   20   Added 0 to the right (remainder 2 here 2<7)
        (Second Division)
```

Now suppose that the decimal part is recurring after k positions where k is the 'minimum' such number i.e. we have 'exactly' k digits in the recurring part. According to the required condition of the proposition, k=n.

Now, if k=n, then I claim that we'll get all the numbers from 1 to n as remainders during the process of finding first k decimal places of 1/(n+1). I prove it like this- suppose that the claim is not true. Then during

the first k (k=n) divisions we get at least two remainders that are equal, if not, then we'll have k (k=n) different remainders and since all remainders lie from 1 to n; which is what we claimed (this could have been said more precisely as- by the Pigeon Hole Principle). So, we must have two remainders say Ri and Rj (both I and j <= n implying |i-j|<n) that are equal. This implies that Ri+1 = Rj+1 and Ri+2 = Rj+2 and so on, thus the number of digits in the recurring part will then be |j-i| which is less than n; contradicting our basic condition of exactly n digits being there in the recurring part of 1/(n+1).

Hence, we prove our claim that all numbers from 1 to n are obtained as remainders during the process of finding first k decimal places.

So now, lets consider the number obtained by multiplying '**a1a2a3…..an**' **by** m (let it be 'b1b2b3…..bn'). here, m<n+1, otherwise m/(n+1) >= 1. So, when we divide 'b1b2b3…..bn' by n+1 we get some remainder say say 'R' (1<= R <=n obviously), now let R* be the remainder obtained at next division.

Since 1<= R <=n and we have proved earlier that all numbers from 1 to n are obtained as remainders when we divide a1a2a3…..an by n+1. So R will also be obtained as remainder at some (say ith) step in this process, so remainder obtained at (i+1)th step will be R*, obviously.

This inductively implies that the 3rd remainder for b1b2b3…..bn will be the same as the (i+2)th remainder for a1a2a3…..an and so on. This implies that the same sequence of digits will be there in the decimal representations of both a1a2a3…..an and b1b2b3…..bn with the only difference in the digits that the decimal part begins with. Thus the recurring part of b1b2b3…..bn is a cyclic permutation of recurring part of a1a2a3…..an.

Haaaa…(sigh of relief !!). Hence proved that the numbers of suggested format show this property.

But the complete proof of the conjecture that I have observed is still not obtained by us as we have not been able to prove that these are the 'only' ones to show such a property. May be, it is awaiting you to try it out.

By now you must be convinced that 142857… is not a 'normal' number. But now, I believe that 142857 is as normal as any other number, because even if it has some special properties, then I would say that there is nothing special in having special properties since all numbers have special properties, we just need to keenly observe them.

About the Author

Gaurav Chaparwal is an alumnus of the Class of 2006 of IIT Kanpur. He graduated from the Department of Aerospace Engineering. This article was written by him and is first in a two part series that appeared in 'Meander', IIT Kanpur's student magazine.

Applications of Nanoparticles in Biology

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The use of nanomaterials in biotechnology merges the fields of material science and biology. Nanoparticles provide a particularly useful platform, demonstrating unique properties with potentially wide-ranging therapeutic applications. The unique properties and utility of nanoparticles arise from a variety of attributes, including the similar size of nanoparitcles and biomolecules such as proteins and polynucleic acids. Additionally, nanoparticles can be fashioned with a wide range of metal and semi conductor core materials that impart useful properties such as fluorescence and magnetic behavior. Biomacromolecule surface recognition by nanoparticles as artificial receptors provides a potential tool for controlling cellular and extracellular processes for numerous biological applications such as transcription regulation, enzymatic inhibition, delivery and sensing. The size of nanoparticle cores can be tuned from 1.5nm to more than 10nm depending on the core material, providing a suitable platform for the interaction of nanoparticles with proteins and other biomolecules.

Nanoparticle-Biomolecule Interactions

The conjugation of nanoparticles with biomolecules such as proteins and DNA can be done by using two different approaches, direct covalent linkage and non-covalent interactions between the particle and biomolecules. The most direct approach to the creation of integrated biomolecule-nanoparticle conjugates is through covalent attachment. This conjugation can be achieved either through chemisorption of the biomolecule to the particle surface or through the use of heterobifunctional linkers. Chemisorption of proteins onto the surface of nanoparticles (usually containing a core of Au, ZnS, CdS, and CdSe/ZnS) can be done through cysteine residues that are present in the protein surface (e.g., oligopeptide, serum albumin), or chemically using 2-iminothiolane (Traut's reagent). Bifunctional linkers provide a versatile means of bioconjugation. Biomolecules are often covalently linked to ligands on the nanoparticle surface via traditional coupling strategies such as carbodiimide-mediated amidation and esterification. For biological applications oligoethylene glycol (OEG) or polyethylene glycol (PEG) is used in the linker to enhance the stability of the attached biomolecules and minimize non-specific adsorption of other materials. Non-covalent assembly provides a highly modular approach to the biofunctionalization of nanoparticles. DNA-NP binding can be affected through electrostatic interactions, groove binding, intercalation, and complementary single-strand DNA binding. Nanoparticles provide an attractive receptor for nucleic acids, providing a direct analogy to protein-DNA interactions. One approach to particle-DNA assembly uses complementary electrostatic interactions to promote high affinity of nanoparticle-DNA binding. The use of cationic ligands on the nanoparticle surface provides a complementary surface for binding the negatively charged backbone of DNA. Intercalation provides another mechanism for DNA binding, a third approach to DNA conjugation exploits the high affinity and specificity of DNA-DNA interactions

Nanoparticle-protein interactions can regulate multiple biological processes such as protein-protein interactions, protein-nucleic acid interactions, and enzyme activity. As with DNA, electrostatic assembly provides a direct means of conjugation. One system that has been explored is the binding of a-chymotrypsin (ChT), exploiting the ring of cationic residues around active site of ChT (Fig. 2). Time-dependent inhibition of ChT activity was observed upon incubation with negatively charged NP 2. A two-step binding process with a fast reversible association followed by a slower irreversible denaturation was established. This interaction could be reversed using cationic surfactants (Fig. 2b), restoring ChT activity. Based on the dynamic light scattering (DLS) data two distinct mechanisms were postulated: alkyl surfactants 3 and 4 form a bilayer structure, whereas cationic thiol 5 and alcohol 6 directly modify the monolayer to liberate the bound proteins.

The use of simple alkyl-based monolayers generally results in protein denaturation; an unfavorable outcome for a number of applications in delivery and biotechnology. Relying on the resistance of OEG to nonspecific interactions with biomolecules, tetra (ethylene glycol) spacers were introduced at the nanoparticle-protein interface. Specific biomacromolecular interactions such as streptavidin/ biotin complementarity (Ka~1014 M-1) have been used to provide specific protein-NP binding. Biotin functionalized quantum

dots (QDs) can also be used for specific protein binding in a time-resolved fluoroimmunoassay. Another way to specifically bind proteins is through the use of transition metal complexes that can bind with surface-exposed histidines of proteins. FePt magnetic

nanoparitcles were fabricated (NP 7), with nickel terminated nitrilotriacetic acid (NTA). These NPs show high affinity and specificity towards histidine-tagged proteins (proteins with six consecutive histidine residues) (Fig. 2e). In comparison to commercial magnetic microbeads, these NPs have a great protein binding capacity owing to their high surface-to-volume ratio. This concept can be employed to manipulate the histidine-tagged recombinant proteins and bind other biological substrates at low concentrations.

Nanoparticles in Biosensing

The sensing of biological agents, diseases, and toxic materials is an important goal for biomedical diagnosis, forensic analysis, and environmental monitoring. A sensor generally consists of two components: a recognition element for target binding and a transduction element for signaling the binding event. The unique physicochemical properties of NPs coupled with the inherent increase in signal-to-noise ratio provided by miniaturization make these systems promising candidates for sensing applications. As an example, gold nanoparticles exhibits unique optical and electronic properties based on size and shape. Gold nanoparticles show an intense absorption peak from 500 to 550 nm arising from surface plasmon resonance (SPR). SPR occurs from the collective oscillation of the conductive electrons owing to the resonant excitation by the incident photons, although the fundamental physical principles of SPR are very complex. The SPR band is sensitive to the surrounding environment, signaling changes in solvent and binding. A particularly useful output is the red-shift (to ca. 650 nm) and broadening of the plasmon band due to the interparticle plasmon coupling. This phenomenon leads to the popular and widely applicable colorimetric sensing. Metallic nanoparticles also possess superb quenching ability and photoluminescence under certain conditions.

Here, a colour shift from red to blue is occurring due to aggregate formation, as colour reflected by the particle depends on its size which is proportional to the "band gap" of the particle, i.e. colour of the particle is the colour it reflects from the visible spectrum of the light incident on it. Higher the band gap higher the energy it will require to jump the electron from its valence band to conduction band, hence complementary lower energy wavelength is emitted back when the electron falls back to valence band and vice versa.

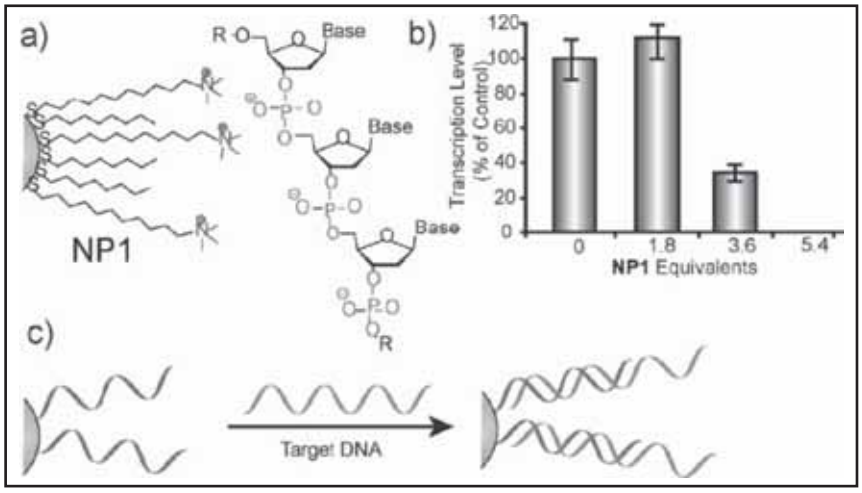

Fig. 1 *The DNA-nanoparticle interactions. a) Structure of NP1 scaffold and the DNA backbone. b) Transcription level as a function of DNA-NP1 stoichiometry. c) Binding of DNA through complementary oligonucleotide hybridization.*

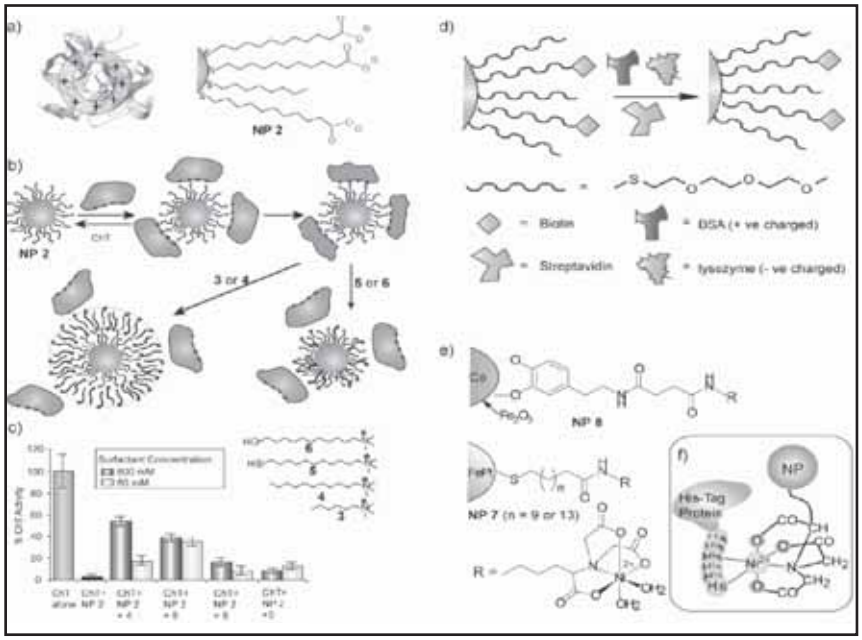

Fig. 2 *Protein-nanoparticle conjugation and its applications. a) Electrostatic targeting of ChT by anionic* ***NP 3*** *b) Complexation of ChT with anionic nanoparticles and its release mechanisms by addition of various surfactants. Addition of cationic alkyl surfactant (3 and 4) forms a bilayer structure, whereas addition of cationic thiol and alcohol (5 and 6) amends the monolayer. c) Different degree of restoration of enzymatic activity of nanoparticle bound ChT by addition of various positively charged surfactants. d) Specific interaction of biotin-functionalized nanoparticles with streptavidin. e) Structure of NTA-modified magnetic nanoparticles. f) The NTA-Ni 2+ functionalized magnetic nanoparticles selectively bind to histidine-tagged proteins.*

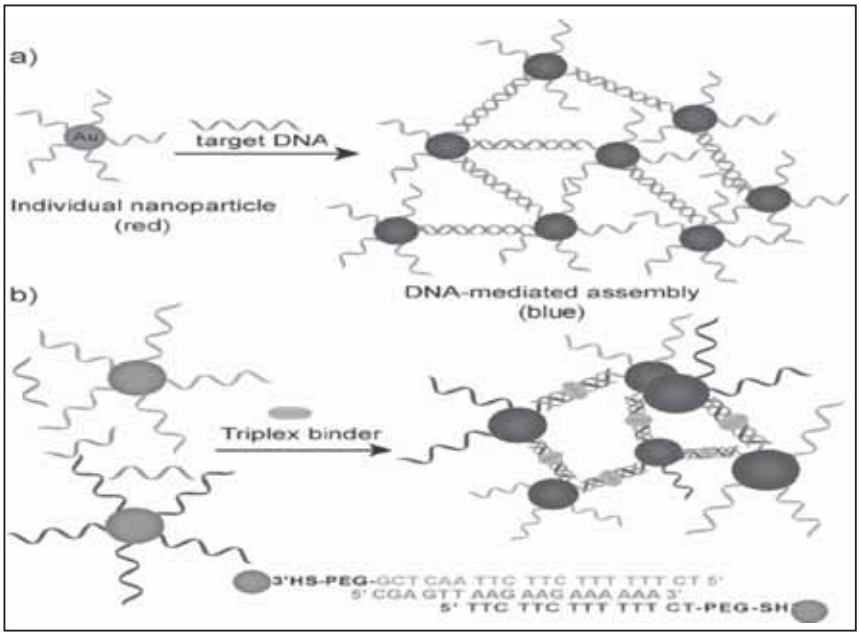

Fig. 3 *Schematic illustration of colourimetric sensing a) DNA-induced nanoparticle aggregation, and b) sensing of DNA triplex binder using DNA-directed Au NP assembly.*

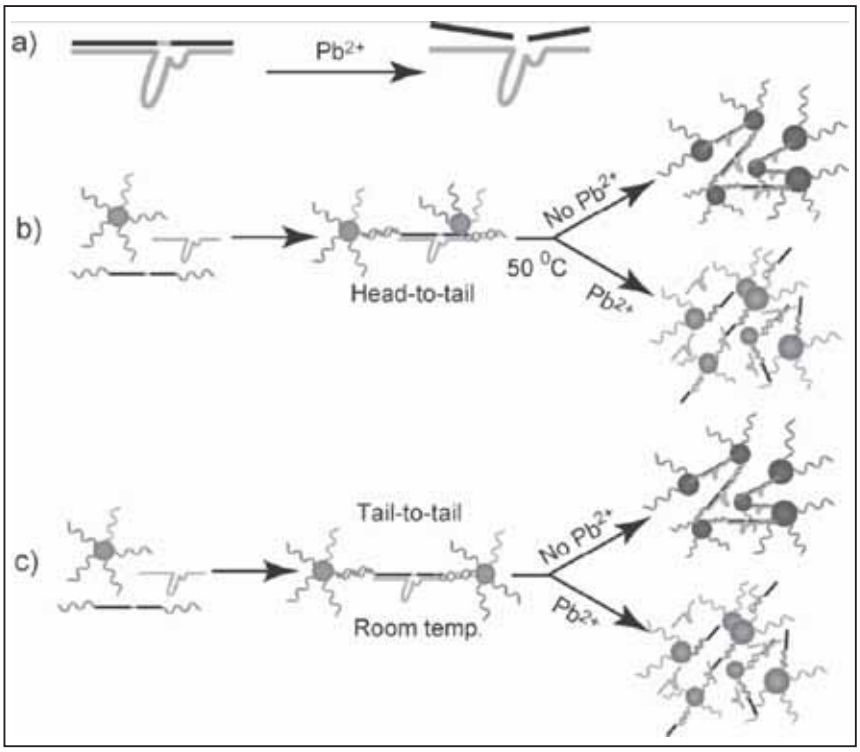

Fig. 4 *Fluorescence Sensing a) Cleavage of the substrate strand of DNAzyme in the presence of Pb2+ DNAzyme mediated assembly of gold nanoparticles in b) a head-to-tail or c) a tail-to-tail manner.*

Because of their exceptional quenching abilities, metallic nanoparitcles can be used as excellent materials for Forster resonance energy transfer (FRET)-based biosensors, for example, for the fabrication of molecular beacons for sensing DNA. In this approach, the dye molecule is close to the nanoparticle surface in the absence of the target DNA strand due to hairpin structure of the attached DNA, resulting in fluorescence quenching (Fig. 4a). Hybridization of the target DNA opens up the hairpin structure, resulting in a significant increase in fluorescence. A range of single-strand DNA and DNA cleavage processes have been monitored using this molecular beacon approach.

There are some other sensing methods which are still in the process of development e.g. electrochemical sensing, Surface Enhanced Raman Scattering (SRES), etc.

Nanoparticles as Drug Delivery Systems

Nanoparticles can provide effective carriers for biomolecules such as DNA, RNA, or proteins, protecting these materials from degradation and transporting them across the cell-membrane barrier. "Safe" delivery of these biomolecules provides access to gene therapy as well as protein-based therapeutic approaches. For successful delivery, carriers must:

(i)form condensed complexes with biomolecules,

(ii)facilitate penetration of the cell membrane after complexation, and

(iii)unload their payloads inside of cells

A key goal of delivery systems is to discharge their payloads specifically at the diseased tissue. Two approaches to serve this purpose are "passive" and "active" targeting. Passive targeting relies on the homing of the carriers to infected tissues. In tumor tissues, the blood vessels are frequently leaky, facilitating accumulation of nanosized carriers. On the other hand, active targeting relies on specific recognition of the ligands that are displayed on delivery vehicles by cell surface receptors. The ligand used for active targeting can be a small molecule, or a peptide or a protein. Protein delivery is complementary to nucleic acid therapies in the field of biomedicine. Nanoparticles can efficiently bind protein, and hence be used as protein delivery systems.

RNA technology has emerged as a potential tool for curing disease at an

early stage. A small interfering RNA (siRNA), generally consisting of 19-21 base pairs, can efficiently slice the gene of interest. For in vitro delivery, siRNA has been conjugated by a thiol linker with variety of nanoparticles, such as gold, quantum dots, or iron oxide. Scientists are designing the multifunctional superparamagnetic nanoparticle that can:

(i)carry the siRNA,

(ii)deliver it in a site-specific manner, and

(iii)probe the delivery by magnetic resonance imaging as well as optical imaging.

(iv) The multifunctional nanoparticles were effective for in vitro and in vivo gene silencing via a specific pathway.

For example, nanoparticle-based drug delivery systems have considerable potential for treatment of tuberculosis (TB). The important technological advantages of nanoparticles used as drug carriers are high stability, high carrier capacity, feasibility of incorporation of both hydrophilic and hydrophobic substances, and feasibility of variable routes of administration, including oral application and inhalation. Nanoparticles can also be designed to allow controlled (sustained) drug release from the matrix. These properties of nanoparticles enable improvement of drug bioavailability and reduction of the dosing frequency, and may resolve the problem of non-adherence to prescribed therapy.

Nanoparticles for Bioimaging

A number of molecular imaging techniques, such as optical imaging (OI), magnetic resonance imaging (MRI), ultrasound imaging (USI), positron emission tomography (PET), and others have been reported for imaging of in vitro and in vivo biological specimens. The current development of luminescent and magnetic nanoparticles advances bioimaging technologies. Two different types of nanoparticles

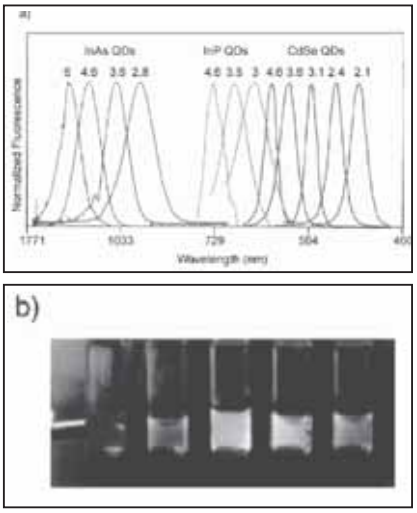

Fig. 5 *a) Size- and material-dependent emission spectra of several surfactant-coated QDs b) A true-color image of a series of silica-coated core/shell CdSe/ZnS or CdS QDs*

have been widely used for imaging: luminescent nanoprobes for OI and magnetic nanoparticles for MRI. There are also dual-mode nanoparticles for simultaneous imaging by OI and MRI.

Optical Imaging

Most nanoparticle-based optical imaging agents can be subdivided into two categories:

i. quantum dots (QDs) and

ii. Dye-doped nanoparticle QDs.

Compared to conventional fluorophores, QDs are photochemically stable, brighter, have a narrow, tunable and symmetric emission spectrum (Fig. 5a and b), and are metabolically stable There are, however, issues of toxicity, photo-oxidation, and water solubility associated with these materials. The problem of acute toxicity and photo-oxidation can be overcome by capping with a protective shell of insulating material or semiconductor, for example, ZnS-coated CdSe core/shell QDs. As water solubility is key to their applications in imaging, there are a range of methods reported to make the QDs water soluble and biocompatible for biological imaging, such as fabricating the surface with suitable thiolated ligand, over-coating with silica, and encapsulating with amine-modified polymer. Likewise, there are a number of strategies for their functionalization.

Magnetic Resonance Imaging

MRI is another important non-invasive imaging technique. The MRI technique is based on the nuclear magnetic resonance of the various interacting nuclei, with most imaging applications focusing on proton resonance. The factors influencing MRI signal strengths are T1 (spin-lattice/longitudinal relaxation time), T2 (transverse relaxation time), and r (spin energy). Exogenous contrast agents are generally introduced to enhance the tissue contrast, including complexes of GdIII and magnetic nanoparticles. Complexes of GdIII in liposomes or micelles are widely used as a MRI contrast agents. In a recent study, antibody-conjugated magnetic Poly- (D,L-lactide-co-glycolide) (PLGA) nanoparticles with doxorubicin (DOX) were synthesized for the simultaneous targeted detection and treatment of breast cancer.

Taking advantage of both OI and MRI, multimodal imaging agents such as magneto-fluorescent nanoparticles have been developed.

Conclusion

Nanoparticles present a highly attractive platform for a diverse array of biological applications. The surface and core properties of these systems can be engineered for individual and multimodal applications, including biomolecular recognition, therapeutic delivery, biosensing, and bioimaging. Nanoparticles have already been used for a wide range of applications both in vitro and in vivo. Full realization of their potential, however, requires addressing a number of open issues, including acute and long-term health effects of nanomaterials as well as scalable, reproducible manufacturing methods and reliable metrics for characterization of these materials.

Beyond Electronics with Nanotechnology

Micro and Nano-structuring silicon for non-electronic applications

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When someone hears the term "silicon microtechnology" one immediately connects it to computers and other electronic applications. This mental impression is certainly correct, but very limited. Has anyone heard about utilizing silicon micro- and nanotechnologies in drug analysis or in droplet microfluidics? Miniaturization offers almost infinite number of possibilities not only in electronics but also in micromechanics and microfluidics. The fabrication technologies already exist, now people have to be bold and innovative and utilize these technologies in the way that no one has ever done before. Transistors and integrated circuits revolutionized the world of electronics and our everyday life. I believe that miniaturization is a key to revolutionize also the other fields of engineering.

Introduction

The first transistor was fabricated in 1947 by Bardeen, Brattain and Shockley and in 1959 Jack Kilby patented the first integrated circuit (IC). Integrated circuits soon revolutionized the world of electronics and nowadays all consumer electronics rely on integrated circuits. The scientific community also realized the value of work that Bardeen, Brattain, Shockley and Kilby had done and they all were awarded by the Noble Prize in Physics.

Silicon is the second most common element in the Earth's crust and by far the most common material used in micro and nanofabrication. Especially in the field of electronics silicon dominates the markets. There are several reasons that have led to the dominance of silicon. Its good availability, the possibility to fabricate single crystalline silicon wafers and tailor the resistivity of the material made its use feasible in electronic applications. Still, the single most important factor that made silicon the transcendent material for electronic applications was possibility of growing a silicon dioxide layer on top of the wafer in a controllable manner. The silicon dioxide layer can be utilized in several different manners during the fabrication process. Since the demonstration of the first integrated circuits, the electronics manufacturers have developed extremely sophisticated fabrication methods for silicon. Today, structures that are only 45 nm wide are routinely produced on silicon wafers that have diameters up to 300 mm using optical lithography and etching. To give some perspective, the diameter of a human hair is ca. 100 μm. This means that over 1000 lines and spaces that both are 45 nm wide could be fabricated side by side on a cross-section of a single hair.

Gradually microfabriaction and miniaturization have gained popularity also in new fields, such as micromechanics, microfluidics and micro-optics. Although, all fields have their own specific demands concerning material properties and structures to be fabricated, still silicon was the most natural material of choice because of the already existing fabrication techniques. Silicon is also mechanically very strong, which makes its use in mechanical applications feasible. Microelectromechanical systems (MEMS) is already a big market. For example pressure sensors and accelerometers have found their way to applications, such as cars, mobile phones and wrist watches. Also some microfluidic devices, such as ink jet nozzles, have already been successfully commercialized. So far, electronics have benefited most from miniaturization but certainly there are also many non-electronic applications that take advantage of silicon microtechnology. The emphasis of this article is on novel fabrication methods and applications, which were developed during my Ph.D. studies [1], but some basic fabrication techniques are covered as well. The purpose of this article is to encourage scientists to apply silicon micro- and nanotechnologies completely new applications.

Basics of silicon microfabrication

Silicon microfabrication is a huge field of science and only a few basic things are covered here. If one wants to get more comprehensive understanding about the field, and the available techniques the author recommends a textbook found in ref [2].

The transfer of micro and nanopatterns into a silicon wafer typically requires two processes: a lithography step for masking, followed by an etching step that copies the mask pattern into the underlying silicon (Figure 1). Some direct etching methods, such as focused ion beam etching, are capable of producing accurate patterns without the masking step, but their use is mainly limited to niche processes and research purposes due to their slow speed.

The most common masking method, which is also used by the electronics industry, is optical lithography. A thin (ca. 1 μm), aqueous photoresist layer, which is sensitive to selected UV-wavelengths, is applied on the silicon substrate, typically by spin coating, after which the photoresist is baked to solidify it. Subsequently, the photoresist layer is UV-exposed through a partly opaque photomask. This photomask is typically made of quartz, and opaque patterns are made of chromium. After exposure, the photoresist is developed.

Depending on the chemistry of the used photoresist, the exposed or unexposed photoresist areas are dissolved during the development and the opaque pattern on the photomask or its negative is copied to the photoresist layer.

Next, the silicon wafer that has a patterned photoresist layer is etched and the pattern of the protective photoresist layer is copied into the silicon wafer. Etching can be divided to two main categories: wet etching and dry etching. In wet etching, the partially protected silicon wafer is immersed in an aqueous solution such as potassium hydroxide, which etches silicon from unprotected areas. In dry etching gaseous etchants such as fluorine radicals or bombarding ions etch the silicon substrate. The most common dry etching method is reactive ion etching (RIE) or its extension deep RIE (DRIE), which both utilize combination of chemically active radicals (e.g. fluorine) and ion bombardment to etch the silicon.

Depending on the etching method and chemistry, the sidewall angles of the etched trenches can vary drastically. The most typical sidewall profiles are presented in Figure 2.

Isotropically etched trench. Etching proceeds with a constant etch rate to all directions. Can be attained e.g. in a solution which is a mixture of nitric acid (HNO3) and hydrofluoric acid (HF) or in pure fluorine plasma.

Anisotropically wet etched trench. In anistropic wet etching the (100) atomic planes are the fast etching planes while the (111) planes etch substantially slower. Therefore, the sidewall angel of anisotropically wet etched trenches is 54.7°, which is the angle between the (100) and (111) atomic planes.

c) Anistropically plasma etched trench. RIE and DRIE produce trenches that have vertical sidewalls if the etching conditions are chosen properly.

Still, creating nanostructures accurately is not always an easy task. Processes have many non-idealities and an optical lithography system, capable of creating photoresist patterns as small as 50 nm cost tens of millions of US dollars. Basically only the major electronics manufacturers can afford this kind of equipment and therefore novel, cost-effective nanofabrication methods are developed constantly. The typical and more affordable lithography equipments are not capable of producing patterns much smaller than 1 μm.

Fabrication of silicon nanopillars

A silicon surface, which is filled with pillars that have diameters in the range of 100 nm, is an interesting material (see Figure 3). Such surface has an enormous surface area compared to smooth one, which is important in fluidic applications where strong fluid-surface interaction is required. Nanostructured surfaces also absorb light extremely efficiently and therefore they appear as a black surface to the naked eye. Efficient light absorption makes possible to bring energy to the surface using e.g. a UV-laser. If the surface chemistry of a nanostructured silicon surface is modified, water droplets behave in unexpected manner.

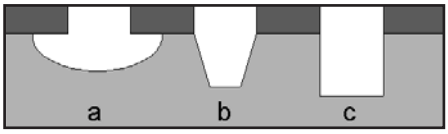

Fig. 2 *Different sidewall profiles of trenches etched into a silicon wafer.*

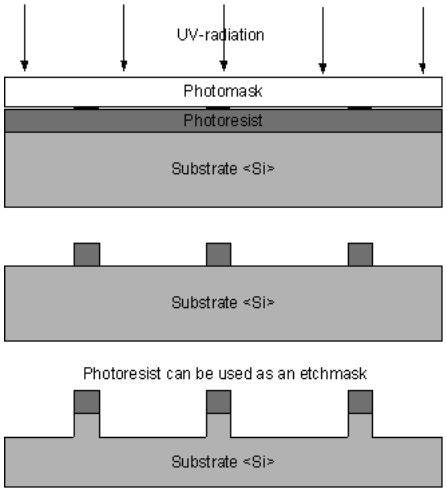

Fig. 1 *Schematic illustration of creation of micro- and nanostructures on silicon a silicon wafer using lithography and etching.*

a) The photoresist layer is exposed to UV-light through the partly opaque photomask.

b) In the case of positive photoresist chemistry, the exposed areas are developed away in aqueous developer solution.

c) The remaining photoresist layer serves as an etch mask during the subsequent etching process and the photoresist pattern is copied into the silicon wafer.

Masking of the nanopillars is not trivial. In principle it can be done using optical lithography, if one has a multimillion dollar system. Otherwise one has to use some non-standard method. For example a layer of nanoparticles, that does not cover the whole surface of a silicon wafer, can be used to define the nanopillars. If material of the nanoparticles is etched at lower etch rate than silicon in subsequent etching step, the nanopillars form. The question is how to produce the nanoparticles and introduce them on the surface of the silicon wafer. This can be conveniently done by using liquid flame spray technique, where a liquid precursor is sprayed into a turbulent flame where nanoparticles are formed. Silica nanoparticles can be formed by spraying tetra–ethyl–ortho–silicate (TEOS) in a 2-propanol solution, into a turbulent H2/O2 flame. The formed particles are collected on a silicon wafer by moving the silicon substrate through the turbulent flame. After the nanoparticle deposition, the silicon is etched using highly anisotropic deep reactive ion etching step to from the nanopillars. The whole procedure is described in a more detailed manner in ref. [3]. The described fabrication procedure is rapid, inexpensive and suitable for large scale fabrication, but the pillar arrays are random. Using optical lithography instead of nanoparticle maksing, the placing of the pillars could be accurately defined.

Second and more straightforward method for fabrication of random arrays of silicon nanopillars is so called black silicon method. In black silicon method the silicon wafer is etched using either RIE or DRIE in plasma conditions that also result in formation of polymeric passivation layer. On the other hand, the passivation layer is etched

simultaneously by the free radicals and ions. If the formation and etching processes of the passivation layer have an adequate ratio, the passviation layer will be only partially removed in it will create small nanomasks that initiate the formation of silicon nanopillars. The nanopillar structure is often called as black silicon due to its color for a naked eye [3, 4].

Fig. 3 *Nanostructured silicon surfaces fabricated using*
a) silica nanoparticle mask combined with DRIE
b) black silicon method.

Droplet manipulation on nanopillar structured silicon surface

A liquid droplet placed on a solid surface forms an angle of contact which is independent of the size of the droplet. This angle is known as the contact angle and it is defined by the surface energies of the solid-vapor, solid-liquid and liquid-vapor interfaces when vapor and liquid phases are in thermodynamic equilibrium. If the contact angle of a water droplet is less than 90°, the surface is termed hydrophilic, whereas surfaces that exhibit contact angles greater than 90° are said to be hydrophobic. Surfaces that have angles close to zero are called completely wetting. Over this type of surface the water droplets spread forming a thin water film. Conversely, surfaces with contact angles close to 180° and small sliding angles are referred as ultrahydrophobic. Sliding angle is the term used for the tilting angle of the surface required for a droplet to slide on a surface as a result of gravity.

The contact angle between a water droplet and the solid surface can be tuned by changing the chemical and physical composition of the surface. A smooth, clean silicon surface has a contact angle of around 65°. Oxidation of the silicon wafer lowers the contact angle and makes the surface more hydrophilic. Conversely, more hydrophobic surface properties can be attained by depositing a Teflon-like fluoropolymer film on top of the silicon surface. Physical micro- or nanoroughness changes the wetting behavior by enhancing the intrinsic properties of the smooth surface. A nanostructured hydrophilic surface, such as oxidized black silicon, is even more hydrophilic than a flat oxidized silicon surface. The water droplet fills the cavities between the pillars and wets the entire surface. On the other hand, if a nanopillars structured surface is intrinsically hydrophobic, the water droplet is pinned on the nanostructures. The air trapped between the droplet and the nanostructures acts as 180° contact angle material, making the surface more hydrophobic. This kind of method is repeatedly exploited in the fabrication of ultrahydrophobic surfaces. Oxidized black silicon is completely wetting, whereas fluoropolymer coated black silicon has a contact angle of around 170° and is ultrahydrophobic.

The fabrication of ultrahydrophobic surfaces has attracted a considerable amount of attention lately especially because of their applications in self-cleaning surfaces [5]. Ultrahydrophobic surfaces have also been utilized e.g. in analytical devices and fluidics. Still, formation of completely wetting and ultrahydrophobic areas on the same surface is a fairly novel idea. The fabrication of such a surface with lithographic accuracy, using only standard clean room processes is described in detail in ref. [6]. Briefly, DRIE is used to create black silicon, which is subsequently plasma coated with Teflon-like polymer to make it ultrahydrophobic. Using lithography and oxygen plasma, the Teflon-like film is removed from the desired areas. Oxygen plasma etches the Teflon-like film and oxidizes the black silicon surface, making it completely wetting. After removal of the photoresist, the surface has Teflon-like polymer coated black silicon and oxidized silicon side by side. The polymer coated black silicon is ultrahydrophobic whereas the oxidized black silicon completely wetting. The fabricated surface is shown in Figure 4.

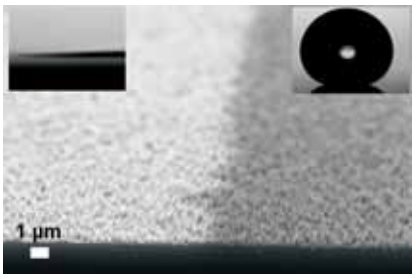

Fig. 4 *Chemically modified black silicon surface. On the left side of the boundary: oxidized black silicon surface, which is hydrophilic. On the right side of the boundary: Teflon-like fluoropolymer coated black silicon surface, which is ultrahydrophobic. The small images at the top of the figure show the cross-sectional images of droplets on the surface.*

The behavior of water droplets on these kinds of surfaces where completely wetting and ultrahydrophobic areas side by side is interesting. A high wettability gradient allows droplet shapes to be tailored practically freely. When a droplet is applied onto a completely wetting domain, which is surrounded by an ultrahydrophobic surface, the droplet copies the shape of the completely wetting area accurately as demonstrated in Figure 5.

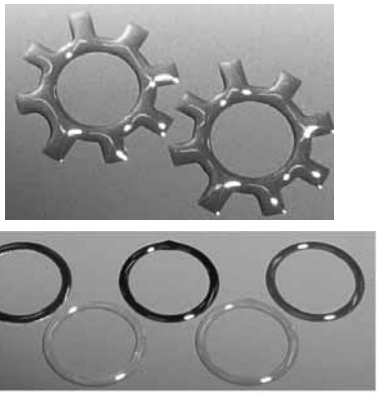

Fig. 5 *Water droplets on completely wetting domains, which are surrounded by ultrahydrophobic area. The diameters of droplets are ca. 2 mm.*

High wettability gradient also allows droplets to be passively split. A typical droplet splitter has a round completely wetting source which is surrounded by a very narrow ultrahydrophobic barrier and a completely wetting fairly large target surrounds the barrier. The first droplet is applied on the source. The

size of the droplet is increased until it must also occupy the barrier's space. The droplet splits if its size is increased further until its edge touches the target. Finally, one droplet sits on the source and the other one on the target. The splitter design with two separately applied dyed water droplets is shown in Figure 6.

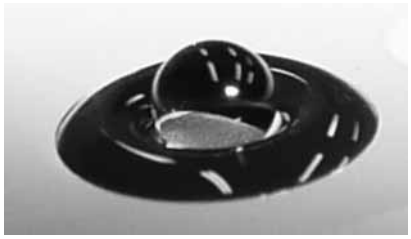

Fig. 6 *A droplet splitter. The green water droplet sits on source and the red torus-shaped droplet on the target. These two droplets are separated by the ultrahydrophobic barrier. Nanostructured silicon surfaces for analytical applications*

Laser desorption ionization (LDI) mass spectrometry (MS) is one of the most used chemical analysis methods. In LDI methods, the sample, e.g. a drug sample in solvent, is applied to the surface of a sample plate. The sample is desorbed from the surface and ionized by shooting it with a UV or IR-laser pulse for a few nanoseconds. The desorbed and ionized sample molecules are subsequently analyzed using an MS. The principle of the technique is schematically illustrated in Figure 7. Because the nanostructured silicon surface absorbs light extremely efficiently, especially at UV-range, it can be used as a sample plate material in chemical analysis [2].

In order to increase the sensitivity of the mass spectrometry measurement the wettability of the nanostructured silicon surface can be manipulated as discussed earlier. The nanostructured silicon can be coated by some hydrophobic material, such as Teflon-like polymer coating. The hydrophobic coating is removed only from small areas. When the sample is applied on such surface, the sample concentrates on the areas that do not have the hydrophobic coating and the measurement give higher signal intensities [6].

Conclusions

The existing silicon micro- and nanofabrication technologies enable fabrication of wide variety of different kind of micro- and nanostructures. At the moment the most successful applications are in the field of electronics, but many other application areas such as fluidics benefits a lot form miniaturization. In this article only a few applications were presented, but practically if one is familiar with miniaturization technologies, everything can be miniaturized. We just have to indentify applications that can benefit the most from it.

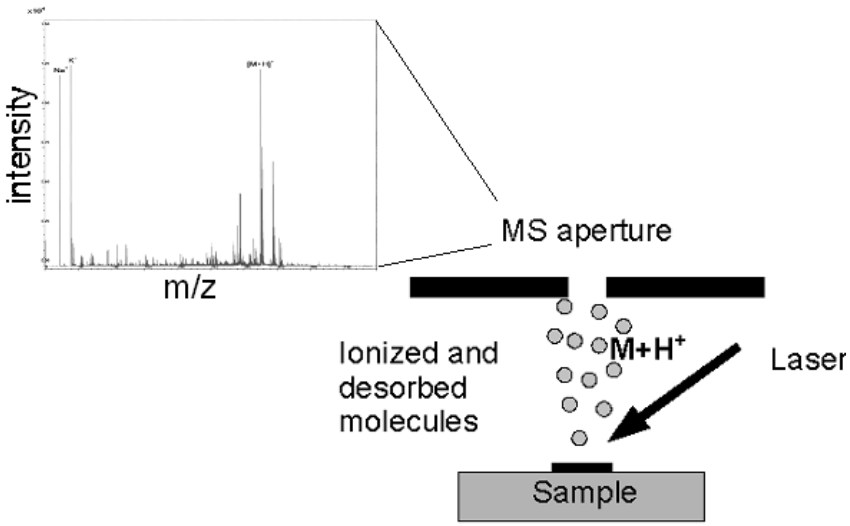

Fig. 7 *Schematic illustration of LDI-MS technology. Nanostructured silicon surface can be used as a sample plate material due to its good light absorbance.*

References

[1] L. Sainiemi, Cryogenic Deep Reactive Ion Etching of Silicon Micro and Nanostructures, TKK Dissertations 163, Helsinki Univeristy of Technology, 2009, ISBN 978-951-22-9866-2 (Available http://lib.tkk.fi/Diss/2009/isbn 9789512298679/)

[2] S. Franssila, Introduction to Micro Fabrication, Wiley (2004)

[3] L. Sainiemi, H. Keskinen, M. Aromaa, L. Luosujärvi, K. Grigoras, T. Kotiaho, J. M. Mäkelä, S. Franssila, Rapid fabrication of high aspect ratio silicon nanopillars for chemical analysis, Nanotechnology, 18, 505303, 2007

[4] H. Jansen, M. de Boer, R. Legtenberg, M. Elwenspoek, The black silicon method: a universal method for determining the parameter setting of a fluorine-based reactive ion etcher in deep silicon trench etching with profile control, J. Micromech. Microeng., 5, 115-120, 1995

[5] R. Blossey, Self-cleaning surfaces – virtual realities, Nat. Mater. 2 (2003) 301-306

[6] V. Jokinen, L. Sainiemi, S. Franssila, Complex droplets on chemically modified silicon nanograss, Adv. Mater., 20, 3453-3456, 2008

[7]N. Suni, M. Haapala, A. Mäkinen, L. Sainiemi, S .Franssila, E. Färm, E. Puukilainen, M. Ritala, R. Kostiainen, Rapid and simple method for selective surface patterning with electric discharge, Angewandte Chemie International Edition, 47, 7442-7445, 2008

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The current article is a derivative of his doctoral dissertation.

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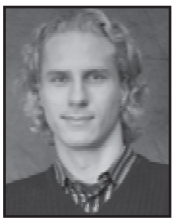

Energy and Carbon Productivity Solutions

NERD series on Tech Startups

Gaurav Parashar

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With the growing awareness about climate change and global warming, as a part of the social responsibility more and more firms are going green and environment friendly. For any firm measuring and keeping a track of the energy usage and the carbon emissions is an important but tedious task. ECPS steps in for this purpose.

Introduction

ECPS or Energy and Carbon Productivity Suite is a hardware cum software solution to measure, analyze and improve corporate and individual energy and carbon productivity. Presently, measurement of energy usage and carbon emissions is done by third party consultants or independent auditors. Current market offerings estimate the carbon emissions, based on standard protocols and offer a strategic solution to reduce and offset these emissions. ECPS works on a highly client friendly and market friendly approach. It brings unique and powerful offering to the end customers by empowering them with component of the carbon emissions by component analysis and allowing them to simulate changes in strategies and business modules to understand how they can reduce carbon emissions economically.

In short, ECPS India is a firm for integrated software and hardware SAS solution to measure, monitor, manage and monetize energy and carbon emissions of an organization/ individual. It is started with a goal to improve energy efficiency, productivity and fight climate change, inside India and across the globe.

Features

The suite allows energy and carbon management, simulation and projection, and carbon footprint estimation which can be summarized as:

1. The user is provided with hardware options of:

a) Portable hardware device, 'A'

b) Installing software on his cell phone, which simulates the functioning of device 'A'

c) A multi functional hardware device, one of whose uses is similar to 'A'

2. The user carries this device with him and records all his daily business/personal activities in this device. e.g., user clicks on "office to home" and the device records this travel event. The user has the option of adding various modules like "office to home" + "car1" or "office to home" + "route 1" etc. This device is a "click" based device and requires not more than 3 seconds for the user to record his activity (based on study conducted at IIT Bombay and IIM Bangalore).

3. A software application, installed by the user on his/her computer, allows the user to make simple modules by filling up a form. e.g., module "office to home" will ask user details on car mileage, distance from home to office etc. The user can on a periodic basis, weekly/monthly, plug the hardware device into a computer and the software will download the data, and use an algorithm based on energy/carbon accounting protocols like GHG protocol and ISO 14064 and others to convert the data into kWh/Kilo Joules and CO2 ton-equivalents.

4. The activity wise 'Energy consumption and GHG emissions' (called as E&C) is then available to the user, and the software allows him to do data and statistical analysis. The software can be installed on a number of computers connected by a Local Area Network with editing and/or analysis permissions restricted to a few key users. The user with requisite permissions can import data from all other users and can use the software to congregate the data to conduct a macro level analysis.

Example

A trucking company wishes to monitor its overall E&C. The company gives the drivers, a hardware device 'A', and they go on the road (starting New York). They use the device to record their activities, and when they reach California and hand over the device to an office manager who plugs it into his computer. The software application imports the data. Also, data from office electricity usage etc. is recorded into the device by employees in charge and imported into the computer.

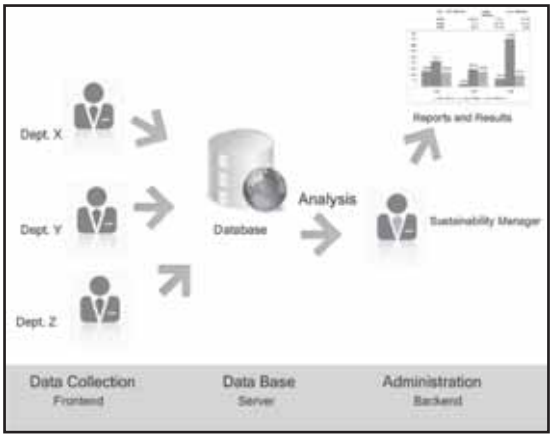
At the end of every month, the "carbon manager" and the "energy manager", in charge of the company's energy needs and carbon strategy, in London UK imports data from all offices worldwide and conduct analysis using the suite. This analysis is useful for decision making; which office is following 'best practices', and which have poor energy and carbon productivity. The manager can compare its E&C with the data to the regulatory requirements/company targets and constantly monitor the risks/opportunities faced by the company.

This is just an example, not the only situation in which the software finds its use.

Various Software features

- Estimation Mode: Allows the customer to estimate the E&C of the whole of business (employees, equipments, travel, accommodation, etc)
- Simulation: Allows the customers to simulate changes in his workspace environment (e.g. "set up an new remote branch", etc) and analyze its impact on the carbon emissions
- Projection mode: Allows the customer to project future emissions given a particular activity set
- Sharing over the network: aids decision making, permits expert analysis and best practice exchange

Workflow



Software Requirement System Details

Context Diagrams for Energy and Carbon Productivity Suite Release 1.0

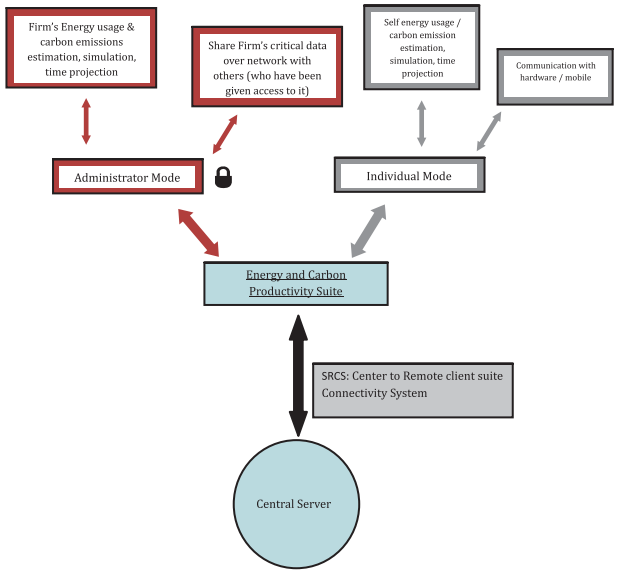


Fig. 1 *Logical diagram for Software usage and modes*

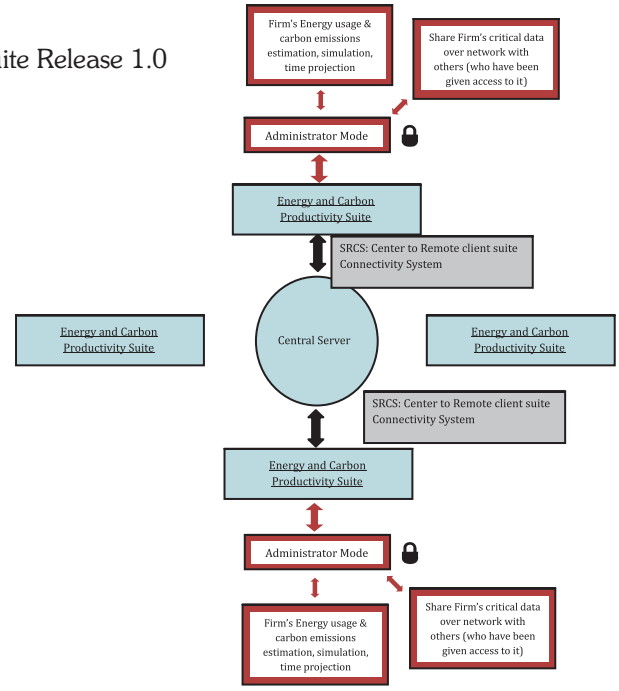


Fig. 2 *Logical diagram showing communication of two suites through the central server*

ECPS Team

ECPS consists of a team of students from IIT Bombay and IIM Bangalore which has been actively involved in Climate Change Mitigation, Carbon Market and Software development. The four promoters (cumulatively) have vast experience in firms like Schlumberger, Microsoft Research, Amazon, ICF Consulting and around 6 start-ups in key positions. They collectively share more than 10 publications in the field of Climate Change and Green Markets. The promoters of ECPS India are also actively involved in India's first campus sustainability program Delta Climate - www.deltaclimate.com which has been active in Climate Change Mitigation and sustainability programs across the 7 Major IIT's. Delta Climate was a mascot at IIT Kanpur's Antaragni and IIT Bombay's Mood Indigo and various other festivals. ECPS consists of four members - Gaurav Parashar (Computer Science Dept, IIT Bombay); Abhijit Parashar (IIM Bangalore and IIT Roorkee); Abhishek Mittal (Electrical Dept, IIT Bombay) and Sunny Goyal (Computer Science Dept, IIT Bombay)

Milestones

ECPS India is a proud winner of Eureka! 2008 - Asia's largest business plan competition. ECPS is also one of the finalists of the global business plan competition McGinnis Venture Competition held at Tepper School of Business, Carnegie Mellon University. ECPS has also been invited as a direct finalist to participate in Champions of Champions league at the India Innovation Pioneers Challenge 2009 organized by Indo-US Science and Technology Forum in partnership with INTEL and University of California, Berkeley.

About the Author

Gaurav Parashar is a final year undergraduate from Department of Computer Science and Engineering at IIT Bombay. He is the founder of Energy and Carbon Productivity Solutions India. He has been very active in environment related initiatives. He is Mumbai Coordinator of Indian Youth Climate Network (http://iycn.in) and is the founding member of Delta Climate (www.deltaclimate.com), India's first campus based sustainability program . He can be reached at: gauravp@iitb.ac.in.

Wired

Letters from Readers

Shikhar Mishra, a 4th year undergraduate student of Department of Mechanical Engineering at Motilal Nehru National Institute of Technology says: It is not just a magazine; it is an honest collection of genuine technical thoughts for having a link between all brilliant minds. In short it is an effort from heart.

Anugrah Jain, a second year undergraduate student of Department of Electrical Engineering at IIT Kanpur says: This time NERD was really different .Several topics caught my eyes. There war lot of interesting stuff in it. Especially the articles based on real research which I feel after reading these articles many students would have been forced to think a little bit along that direction.

Ashish Sharma an undergraduate from IIIT Allahabad says: Well, last issue was highly impressive. I found most of the articles very interesting. A wide variety of articles is included which are very interesting to read. Hopefully this magazine will continue to give best articles, ideas and views in the future.

Abhinav Gupta, a 4th year undergraduate student of Department of Civil Engineering at IIT Kanpur says: Firstly I would like to congratulate you and your entire team for bringing in such a wonderful, informative and research oriented publication helping young minds to flaunt their work. I just hope you people continue your good work and hope to see more articles from other NIT's and engineering colleges making NERD face of face of student research in the country.

Shish Basu Palit, a second year undergraduate student of the Department of Mathematics at IIT Kanpur remarked on 'Decisions: More than just a game', the Game Theory article published in Vol. 1 No. 4: In the section The Prisoner's Dilemma in the article on Game Theory, the terminology used is very odd. While it's perhaps not a mistake strictly speaking, it is confusing and may raise the ire of the more conservative types because the standard terminology has been inverted. Also, consider the statement: "*Thus, game theory can be used to design laws and mechanisms to get socially desirable outcomes.*" While the authors are of course free to express their opinions, this sentence strikes as particularly controversial. Which outcomes are socially desirable, whether human beings are rational in the game theoretic sense or whether they are super rational, all these are highly debated points, and particularly the question of using game theory to create legislation is a highly charged issue in political ethics.

Dr. Mainak Chaudhuri, Professor, Department of Computer Science and Engineering, IIT Kanpur observed: After going through NERD magazine issues over one year, I must say that I'm impressed. This is a fantastic idea. I hope this magazine will be able to generate enough interest to do research among the students. The idea of extending the authorship to students outside IIT Kanpur is an excellent idea. I would also like to see more articles on women in science and engineering in future (I enjoyed reading the article on Sophie Germain prepared by Parul Agarwal) and an increased number of articles from the female students of IIT Kanpur. While the conversation with Leslie Valiant (Vol. 1, No. 4) spent a little time on undergraduate research, I would like to see more elaborate articles from the student community about their perception of the same.

How to make a Nuclear Giant ?

Interview with Dr. R.B. Grover, Director Knowledge Management Group, BARC

Dr. Grover is well-known as a proponent of nuclear energy in India. An editor of the international journal of nuclear knowledge management and a member of the World Nuclear University, he was one of the eminent nuclear scientists who made the Indo-US nuclear deal possible.

Dr. Grover was on campus for a panel discussion on 'Energy 2020' in Techkriti'09, the annual science and technology festival of IIT Kanpur. NERD team got a chance to interview him. Some parts of the interview are presented below. The interview was taken by Mohit Kumar Jolly and Rishabh Chauhan.

NERD: Sir, you have been instrumental for the success of Indo-US Nuclear Deal which led to 123 Agreement. Please explain the significance of this deal in terms of technical and economic growth of the country.

Dr. Grover: We have about 6% of the world's coal reserves, a reasonable potential for trapping hydro energy and many renewable resources, but these available resources are clearly not sufficient and they can only meet a fraction of the present demand in our country, which constitutes 16% of the world's population. Also the population density in India is too high. We are around 330 persons per square kilometer, but in countries like Brazil and Argentina, only 15 persons reside per sq. kilometer, and hence they have been able to adopt alternate methods to get energy such as diverting a signification fraction of land for growing cane, converting it into alcohol and using that cane waste fuel for their automobiles. Such options do not seem to be viable in India.

Nuclear technology is a field which is capable of minimizing the gap between demand and supply of energy and we should exploit this potential to its fullest. We have developed technologies for setting up nuclear reactors like Pressurized Heavy Water Reactors (PHWR) and fast reactor and currently one prototype fast breeder reactor is under construction. Having done this, our difficulty is that we do not have uranium. Hence it became necessary for the government to take the initiative of having the 123 agreement such that we are able to tap the world's uranium resource and setup Pressurized Heavy Water Reactors ourselves and use imported uranium or import both light water reactors as well as uranium and setup reactors in collaboration with other interested countries. This particular initiative will enable use of imported uranium in indigenous pressurized

Dr. Ravi B. Grover

heavy water reactors as well as setting up of light water reactors with other countries.

NERD: You are the founding director of Homi Bhabha National Institute. Please tell us about the mission and vision with which it was established in 2005.

Dr. Grover: In the Department of Atomic Energy (DAE), we do basic research and applied research, and move on to technology development and deployment. In order to accelerate the pace of research leading to deployable technologies it is necessary to work on subjects lying at the interface of basic research and technology development. One of the main aims of setting HBNI up was to ensure this and accelerate the pace of technology development. The existing university system is also an option only if it will not differentiate between students on the basis of their field. There are issues of this kind in most of the universities except for the elite institutions in the country, which will be resolved at a glacial speed. So we felt that in-house universities will provide more flexibility with regard to these procedural hurdles and hence tried to set up our own university. We already have around 600 students pursuing PhD level research and we hope to be able to change the scene with regard to the quality of research in the country.

NERD: Will HBNI take only Masters Students or there is a vision to commence some UG program as well in future?

Dr. Grover: No, we are not planning for UG programs but only concentrating on programs at M.Tech and PhD level. In the DAE we have setup a National Institute of Science Education and Research (NISER) and NISER also is one of the constitutive institutes of the university i.e. Homi Bhabha National Institute and there UG programs in Physics, Chemistry, Life sciences and environmental sciences are being taught.

NERD: You hold a Bachelor's degree in Mechanical Engineering, and you pursued your PhD in the same. What motivated you to choose nuclear knowledge management as your field of interest?

Dr. Grover: When I graduated in 1970, jobs were hard to come by.

This was really the first good offer I got and I went there. Once I went there, I liked it and so went on with it.

NERD: You authored an article 'Nuclear Energy and India' in the journal 'Atoms for Peace". Please tell us about the Indian Nuclear Energy Programme and its three stages.

Dr. Grover: First stage consists of setting up Pressurized Heavy Water Reactor (PHWR) where we use natural uranium as fuel and heavy water as moderator. This was chosen because of several reasons including the fact that it was not possible at that stage of development to manufacture equipment which were necessary for Light Water Reactors. So we started with the PHWRs which also had maximum plutonium yield, the plutonium produced per kg of mined uranium.

Second stage Fast Breeder Reactors were based on the plutonium recovered from the spent fuel of the first stage. These reactors basically recycle and irradiate Thorium and once irradiated in a reactor Thorium gets converted to Uranium 233. Then U233 can be used as a fuel in the appropriately designed reactor in the third stage. And to get industrial scale experience in the use of Thorium one Advanced Heavy Water Reactor has already been designed which will use it in such a way that 2/3 of the power will be derived from Thorium only. This

"With regard to fast breeder reactor technology we are definitely ahead of others."

reactor design has been completed and is currently undergoing regulatory review.

NERD: You are the Director of Strategic Planning Group at DAE (Department of Atomic Energy), India. DAE has been pursuing extensive research to exploit nuclear energy, but we do not see much effort to explore other energy technologies. What would suggest for the same?

Dr. Grover: Mandate of DAE is nuclear science field. With regard to other technologies there are some institutions in the country where some work is being done like Central Power Research Institute under ministry of Power and some other institutes under ministry of Natural Gas and Petroleum. In those areas whatever efforts are being made, they are not as visible as in the area of atomic energy.

"Ethics, responsibility, hard work this is what will carry the country forward."

NERD: Dr. Anil Kakodakar, Chairman of Indian Atomic Energy Comission (AEC) outlined his vision for India becoming a world leader in nuclear technology due to its expertise in fast reactor and thorium fuel cycle. What are your views on the same?

Dr. Grover: With regard to fast breeder reactor technology-"we are definitely ahead of others". We are constructing a large fast reactor and when this reactor is ready by 2011, it will give us a head start over all the other countries in Fast reactor technology. And a lot is being done on thorium; Dr. Kakodkar and his team are working on an advanced heavy water reactor. And once this reactor has been constructed it will give us a valuable experience in thorium technologies. And we'll definitely be world leader in growth of fast reactor technology and thorium technology.

NERD: You are a member World Nuclear University. Are there no safeguards to prevent misuse of nuclear power knowledge as we recently saw in Pakistan?

Dr. Grover: There are regulations in this area but there will be people always who try to violate those regulations but we have to ensure from our part that our behavior always remains responsible and that is what DAE does.

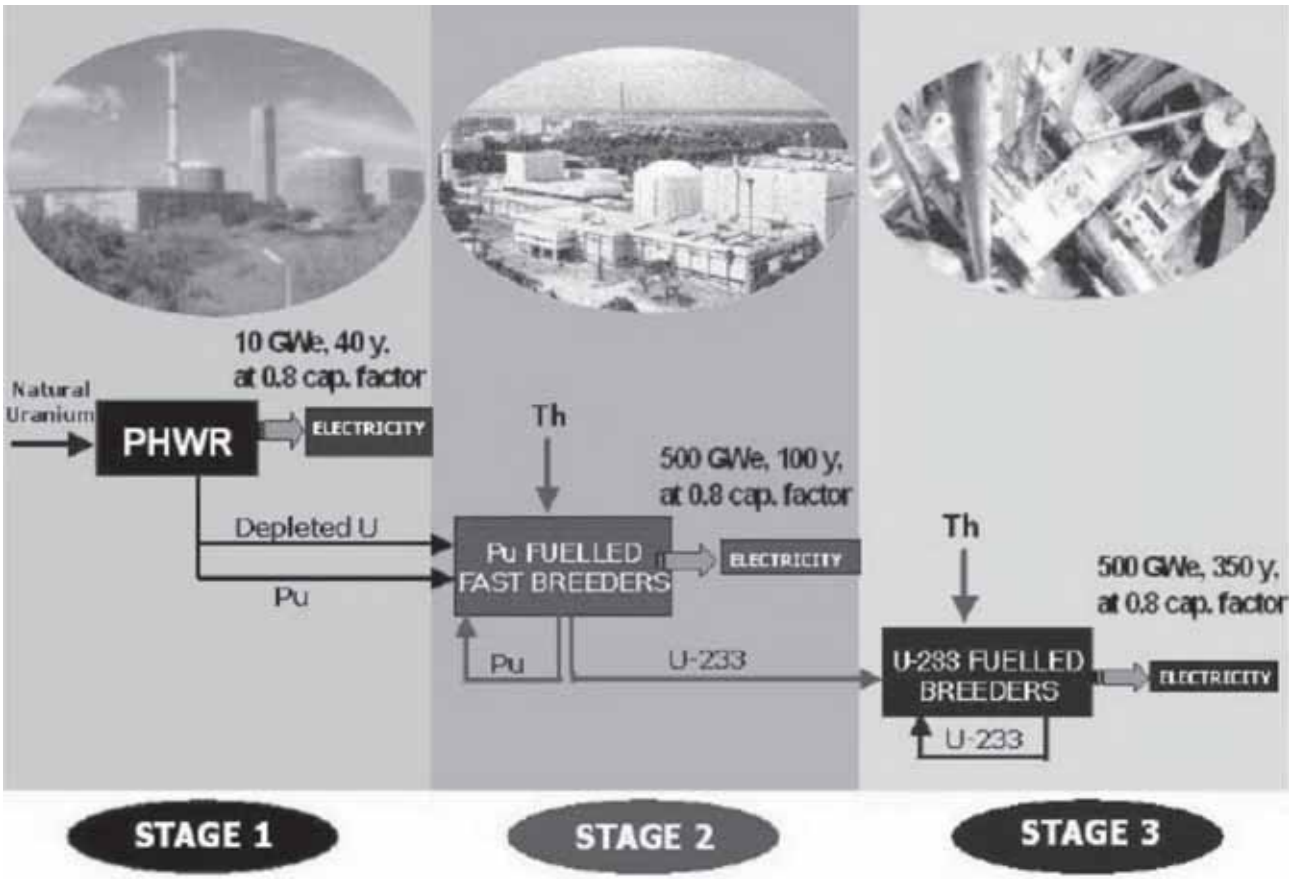
NERD: Safety of Nuclear Materials as well as people is an important issue. Have appropriate steps been taken to prevent smuggling of nuclear materials and cases like that seen in the news?

Dr. Grover: Basically these radioactive material are also used for radiography and cancer therapy in the hospitals e.g. Cobalt 60. Sometimes that material when it has completed its number of curies (i.e. a major portion of its life); the radioactivity level becomes very low. We have full data on these kinds of resources and there could be a case where these resources come in public like one particular instance when a radiography source was immersed in a river several years ago in Chennai but we immediately deployed our staff and that source was recovered. But we keep track of these things and do not allow it to happen. Otherwise some news items which have come in recent past regarding something in U.P. or Meghalaya were investigated and found to be untrue.

NERD: What expectations do you hold in Nuclear Energy developments from our Thirteenth Five Year plan, keeping the current progress and political scenario in mind?

Dr. Grover: It will depend on how much uranium becomes available to us both via the domestic channel i.e. exploration and mining in the country and via imports. Depending upon availability of uranium we will calibrate our program and setup reactors accordingly. But the first thing which has to be ascertained is uranium. As we did this exercise earlier, we will read our previous plan for the 12th five year plan to make a similar plan for next time.

NERD: The knowledge related to energy efficiency, management and conservation has not yet percolated down well to the level of collages as well as schools. Our friends are unaware that they can make a career in energy and they do not know much of it. So what reforms do you suggest to overcome the shortage of young minds in this direction?



Dr. Grover: Energy being a multidisciplinary field is inappropriate to be studied at UG level. At that level students must focus on classical disciplines like Electrical, mechanical etc. and then at M. Tech. level move on to specialized disciplines. At UG level, students will only be analyzing situations and not working very deeply in the field of energy, so I don't think research at that level is a good option.

NERD: With the relaxation of NSG norms India can now easily import foreign technology. Will the indigenous capacity be retained or replaced by the foreign technology.

Dr. Grover: No, our indigenous program will continue as such. Whatever upgradation is needed is being done on the basis of domestic R&D (Research and Development). The opening up civil nuclear trade is not supposed to replace the indigenous program but just provide additionality to it.

NERD: Will it be a good idea for the DRDO and other national wide institutes for recruiting students directly from campus keeping in mind your concern on sustainability of efforts taken by responsible behavior to develop India?

"We have about 6% of the world's coal reserves, a reasonable potential for trapping hydro energy and many renewable resources, but 16% of the world's population."

Dr. Grover: We used to come to IITs earlier for campus recruitment and recruited a few people for a couple of years. But most of them tended to resign after a very short period. So we stopped it. But we are open to start it once again if there is a possibility that people would not use it only for a few months and we are fully open to recruit directly from IITs. Students can join us via GATE or we have our own written test conducted in April or May. Once they score high enough marks they can join our department. People are welcome to apply against the tide and join.

After recruitment we give one year of course work and projects completing which the student gets the degree and becomes an employee. We give two calendar years for one year academic work of the project. Just now the first four students have completed their M. Tech. and this program is moving ahead.

NERD: What final message would like to convey to the youth of the country?

Dr. Grover: Work hard since there is no substitute for hard work and work in a responsible way, which is very important for the image of the country. Ethics, responsibility, hard work this is what will carry the country forward.

Science & Spirituality: The case for India

India should focus on a balanced growth of Scientific Temper and Spiritual Wisdom

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In this article the basic philosophy underlying the proposition made in the subtitle of this article has been examined and the terms and concepts associated with the proposition are clarified. By establishing the relation between the development of science and the development of spirituality, and analyzing this relation for the particular case of India, the requirements for balanced growth and the methods by which the same can be achieved has been outlined.

Keywords: *Objective fact, subjective fact, dichotomy, spiritual paths, rationality*

Introduction

It has been the subject of countless debates over the decades regarding the mutual antagonism of science and spirituality, as has been the issue of how to balance them. A number of inherent assumptions underlie most of these arguments, and one must examine the assumptions inherent in the question itself in order to even attempt a satisfactory answer to it. This fact is not unknown, as it is often said that it is more important to ask the right question, than it is to get the right answer. Socrates, for one, knew this better than most, and utilized his Socratic method to highlight that. In order to clarify the subject of this essay, it is hence of primary importance to address the following questions:

1. Are scientific temper and spiritual wisdom two different things?
2. If so, what is meant by "balance" between them? If not, what is our aim?
3. How much of this is specific to India, and hence needs to be seen in that light?

As it often happens, once the basics of the subject are clarified, the question will get answered with almost no effort, and in addition, clues are obtained regarding the methods of dealing with other relevant subjects as well. This deductive method of analysis is followed here, to avoid the various pitfalls which occur while using terms that have varied meanings (such as "spirituality" and "science"). It also helps for accurate evaluation and criticism of the arguments.

Discussion and Analysis

a) Objective and Subjective Facts

What is the origin of the dichotomy between what we call "science" and what we call "spirituality"? A probable origin is via the definition of fact. It is well accepted that science derives its meaning due to objectivity, wherein facts are those which can be reproduced and verified under controlled conditions. The underlying theme here is one of collective realism, where a fact can be verified by more than one person. This collective verification is what qualifies an observation of a physical fact.

However, the moment one diverges from collective fact, science reacts. Let us take the simple example of psychology. Science has never been able to completely integrate psychology into its structure, such that one can predict scientifically the reason for every emotion and feeling. This is primarily because the moment one ventures into the realm of "individual fact" one is automatically outside the realm of science. If a person exclaims that he saw his friend in a dream, there is no way science attributes a reality to his statement just as it attributes the reality to a person's claim that he has discovered a new fundamental particle. In other words, a scientist would claim that individual facts are of no value to science unless they correspond to a collectively accepted standard, which would in turn make the fact a collective one.

Spirituality, on the other hand, does not impose a restriction on individual fact, and accepts it as a valid perception. Attempts have been made to resolve the problem of collective and individual facts, and in each case the pendulum has swung to either one extreme or the other. In other words, one school of thought attributes every perception (hence, a valid fact) as being an individual perception, while the other attributes every perception as being an objective and a collective one. All feelings, emotions, visions, revelations, and experiences are said to be different patterns of brain-neuron activity, according to Mr. Objective. They correspond to actual events, and hence a reality, for Mr. Subjective. But if Mr. Objective is faced with the fact that the surrounding world which is filled with objective facts can also be the result of a brain-neuron activity, bringing it to the same level as feelings or emotions, he is in trouble [1]. Similarly, if one asks Mr. Subjective why certain experiences are common to everyone, while some are not, he is equally stumped.

Here we find the origin of the dichotomy, and therefore the origin of the idea of balance. But although it is clear that the two topics science and spirituality are different, we have not yet established their relative merit. Is science, because of its restriction to objective fact, better or worse than spirituality, which does not restrict itself in that fashion?

b) Establishing the Perspective

A loosely defined idea of spirituality will get us into trouble later on, so here that aspect will be made clear. There are two kinds of spirituality that are generally recognized as defining spirituality reasonably well. The first route (not according to merit or chronology, merely as a listing order) is to establish an understanding of ourselves, and to determine the nature of the individual and his consciousness. The second route is to see and understand the workings of a higher organizing principle (referred to as "God" or "Nature" as the case may be depending on the culture). The culmination of these paths, or at least substantial progress therein, is established once the two paths are realized to be the same; as one of the Indian Mahāvākyas puts it so aptly - "Tat tvam asi" (Thou art that).

Mind and Matter

Hence, the individual's actions are seen to be vital in the process of spirituality. Care must be taken that the idea of spirituality is not reduced to a list of "shoulds" and "should-nots" as often happens simply due to the inertia of a large population following a particular path. The sacred texts are treated as a replacement for one of the above paths, instead of the guidelines that they are meant to give for both the paths. For example, an individual who has decided to skip the first route (of understanding oneself) focuses on the scriptures to justify his behavior on the basis of their authority. Similarly, a person who has decided to skip the second one (understanding the working of the world) lays forth a list of "shoulds" and "should-nots" that people around him must necessarily follow. In other words, an attempt is made to conform the outside world to the authority of the scriptures. It may be mentioned here that this particular aspect particularly infuriates the scientist!

The scriptures and Sacred texts serve as highly useful instruction manuals for the Spiritual Seeker, and through many constant disclaimers affirm to the student the importance of traversing both the paths by himself. After all, one needs the instruction manual only as far as experience is lacking, as in the case of the computer geek who has no need of a manual for everyday computer activities, but will need a textbook to start the study of spoken language.

So here we have the necessary details required to give us a perspective about the subject. The first path mentioned in the above paragraphs is seen to correspond with what we identified as the subjective viewpoint, while the second path can be identified as the objective viewpoint. Hence, "science" is merely one of the ways in which a spiritual path can be pursued, up to a point. Granted, what we currently call science may not account for all the objective facts in the world (as every scientist admits that he or she has unraveled only a small part of the mysteries of the world) but nevertheless it forms a good approximation of the second route for our purposes.

The first path has its roots in the subjects which have primarily dealt with inner states of an individual, but due to their inherently subjective nature have been dismissed by the scientific community as being unscientific or even sheer trash. Psychology, the arts, ethics and morality, and even culture, which belong to the realm of feelings and value judgments, both of which are entirely subjective experiences, have hence been misunderstood by scientists due to their different foundation.

Since the center of gravity of the present society is to attribute a "scientific reality" to all perceptions, attempts are made to analyze the interior individual growth (Subjective path) on par with scientific requirements, and this has created a lot of confusion in the understanding of these issues. A lot of the subjective states tend to get explained away as chance occurrences, as chance is the only realm of science not governed by objective principles (origins of chance cannot be proved, only verified to a finite extent) [2]. Even if they are explained using graphs, equations and calculations, it would not be as convincing as a scientific paper due to the inherent subjectivity. Understanding that the Teachers of the past who have traversed an inner journey have done so based on a different set of assumptions about reality than the scientist will help us to figure out how to resolve the conflict between the two. One only has to establish the validity of both the viewpoints, utilizing spirituality, which gives equal value to both.

c) The Case for India

We are now in a position to tie up all the loose ends which formed the assumptions underlying the question. The surprising result is that there is no requirement of needing to "balance" science and spirituality, as there is no fundamental difference between the two. Instead, scientific thought is a natural result of applying rational

ideas to the foundations of objective facts, and is a subset of spirituality. The other aspect of spirituality, wherein subjective facts come into play, is the area which is most commonly ignored by scientists, and for any progress to be lasting, one has to understand how the subjective and objective form the two sides of the same coin. Hence, this is the most pressing need as of today: to utilize a rational thought process to examine and understand subjective experiences, and to show how overall progress of individuals and society is dependant on appreciating this fact. In view of the recent development of nuclear weapons all over the world, including India, this aspect is evidently vital.

In India's case, particularly over the past few centuries, the emphasis given to the interior stages of development (Self Realization) in spirituality has been far more than that given to exterior stages of development (scientific thought). But due to the impact of the extensive scientific objectivity of the Western world, the country as a whole is facing the question of proper placement of science within its original spiritual framework. Even a cursory examination of Ancient Indian history reveals the level of scientific and technological advancement achieved by the civilizations of the time (a recent example is the development of Vedic Mathematics [3]); hence it is obvious that somewhere along the way, the average Indian spiritual Seeker lost sight of the other side of the coin. This resulted in a lack of appreciation for science and rational thought by the subsequent generations, and a lot of internal growth was left to religious authority. This degeneration has been the cause of a tremendous amount of confusion regarding even the preliminary meanings of spiritual life, science and values.

To address this situation, a wholesale adoption of advanced technology would not generate a lasting scientific advancement, unless every individual involved is able to place his values and his thoughts in sync. Hence, in addition to scientific exploration, education in values and exposing its relation to science would go a long way in tipping the balance, as intended by the current topic. At the national level, this would mean an inclusion of value education in a far different manner than the one currently in vogue, and its inclusion at every level of the society, from schools to professional guidelines. If a thorough subjective evaluation forms an integral part of individual merit as does a person's academic achievements, it would serve not only direct the right people into the path best suited for them, but would also make sure that the right tools are in the right hands.

Conclusions

In this essay we have explored the assumptions underlying the topic of discussion, by clarifying the terms "spiritual wisdom/spirituality" and "scientific temper" using the difference between perception of objective and subjective facts. Further analysis showed how spirituality had two aspects to it, one of which can roughly be categorized as science and one of which falls in the realm of feelings and ethics. The balance was seen to be desirable between these two realms, by recognizing their common origin in spirituality. As a result, in the case of India, the relevant importance given to these two aspects was examined and some measures were suggested to establish spirituality without conflicting with science.

Acknowledgements

I would like to acknowledge the guidance given by a personal friend, Dr. Bruce Peret, in grasping some of these concepts.

References

[1] Ken Wilber; A Theory of Everything, Gateway publications, Dublin, 2000, pp. 59-82.

[2] Jeffrey, R.C.; Probability and the Art of Judgment, Cambridge University Press, 1992, pp. 54-55

[3] Jagadguru Swami Sri Bharati Krishna Tirthaji Maharaja; Vedic Mathematics, Motilal Banarsidass (1965).

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Editor's Note

This article was an entry in the essay competition organized under the aegis of All India Students' Conference on Science and Spiritual Quest (AISSQ) in 2008. The entry won third prize.

AISSQ is organized by the Bhaktivedanta Institute (http://www.binstitute.org) for the holistic development of personality of students. AISSQ aims at bringing together a number of leading experts from all over the world on a common platform to present and outline their vision for the benefit of the humanity in search for deeper questions of the life and cosmos.

Till now four AISSQs have been organized. The last conference in the series (AISSQ-2008) was held at NIT Tiruchirapalli, India in which about 500 students and faculty members from premier technological institutions like IITs, NITs, IISc, IIMs and AIIMS from India and some from academic and R&D institutions of countries like the USA and UK participated in the 3-day conference. The 5th AISSQ will be held at MNNIT Allahabad, India in January 2010. It aims at bringing together a number of leading experts from all over the world on a common platform to present and outline their vision for the benefit of the humanity in search for deeper questions of the life and cosmos.

Categorical Syllogisms and their Validity with the help of Diagrams

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Some valid Categorical Syllogisms in traditional interpretation befall invalid in the modern point of view. Euler Circles and its variants evaluate the validity as per the traditional interpretation whereas Venn Diagrams and its modifications examine the modern point of view. Hence, we fail to find any standard diagrammatic technique, which incorporates both the points of view together. The present article explores the possibility of developing an alternative diagrammatic technique to test the validity of Categorical Syllogisms. The proposed technique also attempts to test the validity in both the formats.

Keywords: *Euler Circles, Venn Diagrams, Method of Minimal Representation*

Editor's Note

The present paper is an adaptation for NERD, IIT Kanpur that was previously published with Springer. See,

Sharma, S.S.: Method of Minimal Representation: An Alternative Diagrammatic Technique to Test the Validity of Categorical Syllogisms. LNAI 5223, 412-414. Springer, Heidelberg (2008)

Introduction

This article is divided into two parts. In the first part, we will attempt to understand what is meant by Categorical Syllogisms and how to assess its validity with the help of existing diagrammatic techniques. In the concluding section, we will attempt to develop an alternative diagrammatic technique to test the validity in both the traditional and modern frameworks.

Categorical Syllogism

Here, we will deal with four kinds of propositions. They are: Universal Affirmative Proposition (A) - (All S is P) Universal Negative Proposition (E) - (No S is P) Particular Affirmative Proposition (I) - (Some S is P) Particular Negative Proposition (O) - (Some S is not P). Suppose we have an argument, which has exactly two premises and one conclusion. For example: All snakes are reptiles. All cobras are snakes. Therefore, all cobras are reptiles.

It contains exactly three terms (snakes, reptiles and cobras), each of which occurs twice. This type of argument in deductive logic is called a categorical proposition. There are several methods to test the validity of categorical syllogisms. It can be divided under the following heads:

a) Formal Rules.

b) Diagrammatic Rules.

a) Formal Rules

The first rule explicate that a syllogism must consist of exactly three terms each of which is used in the same sense throughout the argument. The second rule expounds that the middle term must be distributed at least once in the premises. The third rule states that no term can be distributed in the conclusion unless it is distributed in the premise. The fourth rule illustrates that from two negative premises no conclusion can be drawn. The fifth rule demonstrates that if one premise is negative, the conclusion must be negative and vice versa. The last and final rule, which is a later addition, concerns existential import. It states that no valid syllogism with particular conclusion can have two universal premises.

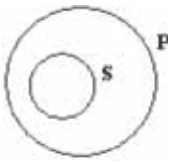
It can be seen that the above stated rules are technical, and thus we refrain from discussing them here.

b) Diagrammatic Rules

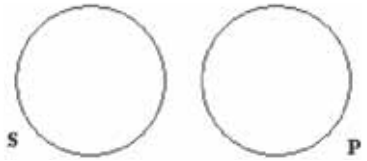
Diagrammatic methods are also used to test the validity of Categorical Syllogisms. They have been employed in pursuit of reasoning, as a heuristic tool to explore the proof of any given problem. Now, it has proved that the status of diagrams is not that of a second grade citizen but rather an effective tool for proof systems. A complete discussion on the status of diagrams is found in Shin, S.J.: The Logical Status of Diagrams. Cambridge University Press, New York (1994). In this article, we will concentrate chiefly on Euler Circles and Venn Diagrams.

Euler Circles

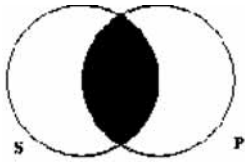
Euler proposed circles or closed curves to illustrate relation between classes. The representation for A, E, I, and O type of propositions are given below:



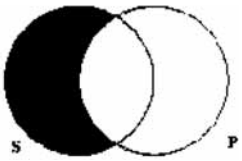
A: All S is P



E: No S is P



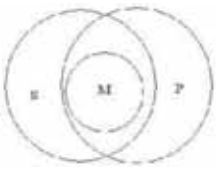
I: Some S is P



O: Some S is not P

The above scheme of diagrams speaks for itself. In A type, S is drawn inside P, in E, S and P are disjoint whereas in I and O two intersecting circles are drawn and the relevant part is shaded.

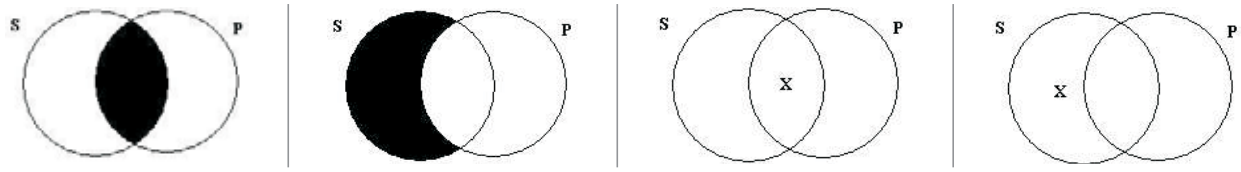
Let us take this example, and see how it works: All M is P All M is S Some S is P The Euler Circles for the above categorical syllogism is given below:



The conclusion asserts that some S is P. If we examine the diagram above, we find that some part of S and P is common between them. Therefore, the above categorical syllogism is valid according to Euler Circles.

Venn Diagrams

Venn diagrams' representation scheme is different from that of Euler circles. The diagrams are as follows:



No S is P | All S is P | Some S is P | Some S is not P

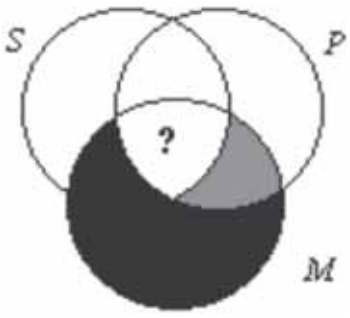
In Venn diagrams, shading means that the part is empty whereas "X" mark means that it has at least one member in the designated area. Once this is clear, the diagrams are self-revealing. In All S is P the part of S, which is not there in P, is shaded out, which means that there is nothing which is S but not P. Similarly, in No S is P, the common part of S and P is shaded out. In, Some S is P, the common part is indicated with " X" which means that there is an element in the common part of S and P whereas in Some S is not P, the element is represented in the part of S which is not P.

Now let us draw a syllogism with these understanding. We will take the same example as above in order to maintain uniformity.

All M is P

All M is S

∴ Some S is P



In the above diagrams, the part of M, which is not there in P, is shaded out. Similarly, the part of M, which is not there in S, is also shaded out. The conclusion says that Some S is P, which means that there shall be an "X" mark in the common part of S and P. We are unable to find the desired conclusion and therefore, we put a "?" mark there. Thus, the above categorical syllogism is invalid according to the Venn Diagrams.

There is a fundamental difference between Euler Circles and Venn Diagrams. Euler Circles and its variants validate the traditional perspective pioneered by Aristotle. Venn Diagrams and its adaptations on the other hand, corroborate the modern viewpoint as championed by Boole and other logicians. Therefore, we fail to find any standard diagrammatic technique, which incorporates both the points of view together.

In the next part, we will attempt to devise an alternative diagrammatic technique, which can substantiate both the frameworks together.

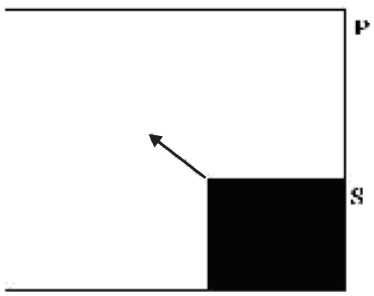
Part-II

In the first section, we have understood what is meant by Categorical Syllogisms and how to test its validity with the help of Euler Circles and Venn Diagrams. In this part, we will attempt to develop an alternative diagrammatic technique to test its validity.

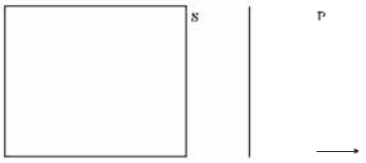
Method of Minimal Representation

The proposed representation method is based on the following findings. Traditional understanding seeks to find representation in the objected area, i.e. whether the diagram draws the area claimed by the conclusion. However, in case of modern viewpoint we look for specific demonstration. Therefore, in the proposed method, diagrams remain the same but the evidence we look for changes in both the perspectives. We use rectangles for universal propositions and right-angled triangles for particular propositions. When we are corroborating the traditional perspective, we seek for the representation of the conclusion in the diagrammed figure. However, when we deal with the modern interpretation, the shape of the geometric figure becomes important and necessary differences (if any) are made. The diagrams are explained below:

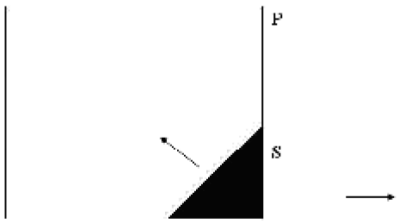
1. Universal Affirmative Proposition (A)-All S is P. Here, a rectangle is drawn from the right bottom edge containing it and it is shaded. The arrow shows that the orientation or probability of finding S is inside P only.



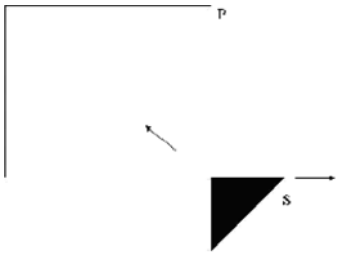
2. Universal Negative Proposition (E)-No S is P. Here, two disjoint rectangles are drawn and the arrow shows that the orientation or probability of finding S is outside P only.



3. Particular Affirmative Proposition (I)-Some S is P. Here, a right-angled triangle is drawn from the right bottom edge containing it and is shaded. The arrows suggest that the orientation or probability of finding S is both inside as well as outside P.



4. Particular Negative Proposition (O)-Some S is not P. Here, a right-angled triangle is drawn from the right bottom edge outside it and is shaded. The arrows suggest that the orientation or probability of finding S is both inside as well as outside P.



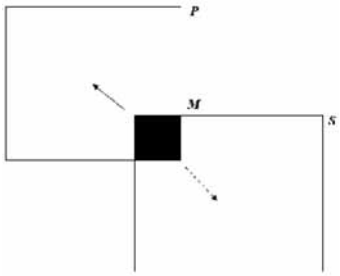
Working of the Diagrams

Let us take the following categorical syllogism for understanding the working of this proposed technique.

All M is P

All M is S

∴Some S is P



It is diagrammed as below:

In the above diagram, we draw M inside P as given in the first proposition. Similarly, we draw M inside S as given in the second proposition. The traditional understanding requires that there shall be a common part between S and P. In the above diagram, it can be seen that at least M shall be the common part. Therefore, the above categorical syllogism is valid according to the traditional understanding. In the modern interpretation, a perfect geometric shape is required which means in order to corroborate Some S is P, we need a right angled triangle. Inability to find this shape makes the above argument invalid according to the modern understanding.

Conclusion

We have tested 256 categorical syllogisms with the proposed diagrammatic technique. The results were found confirming both the points of view. The scope of the paper is limited to check the efficacy of the illustrated diagramming technique to categorical syllogisms only. This paper attempts to unify the existing stalemate over representing valid syllogistic reasoning with a single diagrammatic technique in both the elucidations.

Glossary

Syllogism:

A syllogism, also called as a logical appeal, is an important kind of logical argument in which one proposition (the conclusion) is inferred from two or more premises of a certain form.

Categorical Syllogism:

A logical argument consisting of exactly three categorical propositions, two premises and the conclusion, with a total of exactly three categorical terms, each used in only two of the propositions.

Euler's circles:

A diagram in which the terms of categorical statements are represented by circles. This technique is less sophisticated than Venn diagrams.

For more details visit:

http://www.philosophypages.com /

http://www.mathresources.com/

References

[1] Kneale, W., Kneale, M.: The Development of Logic. Oxford Clarendon Press, London (1962)

[2] Shin, S. J.: The Logical Status of Diagrams. Cambridge University Press, New York (1994)

[3] Sharma, S.S.: Method of Minimal Representation: An Alternative Diagrammatic Technique to Test the Validity of Categorical Syllogisms. LNAI 5223, 412--414. Springer, Heidelberg (2008)

Celebrating students' research

About the Author

Sumanta Sarathi Sharma has submitted his doctoral dissertation "Syllogistic Reasoning: A Philosophical Study of Diagrammatic Approaches" on October, 30, 2009 in the Department of Humanities and Social Sciences at IIT Kanpur. He is currently teaching in the School of Philosophy and Culture at Shri Mata Vaishno Devi University, Katra, Jammu & Kashmir. His broad area of research is Philosophical Logic. He is also interested in Philosophy of Science, Human Rights and Greek Philosophy. He can be reached at sumantas@gmail.com.

Students for Sustainability

Thoughts on a nationwide student network for a sustainable future

The world is undergoing a sea change. The global financial meltdown and the increasing awareness of the adverse impact of climate change have brought the concept of Sustainability to the forefront. Sustainability has emerged as a global movement – a movement that will manifest itself into all walks of life. The Sustainability Network is an initiative that engages the leaders of tomorrow – students and prepares them to face the realities of this emerging scenario. By enabling students to lead Sustainability Movements to bring real on-the-ground change on campuses of educational institutes, the Sustainability Network will help the future leaders of the country to develop a well-rounded awareness of the multi-dimensional nature of Sustainability issues.

Campuses as Life-Size Laboratories

Educational institutions are microcosms of our society. College campuses are effectively life-size laboratories for testing cutting-edge technical, social and behavioral solutions to Sustainability problems. If students can lead successful sustainability initiatives on campus, they will be well on their way to developing a sustainability consciousness which they will carry with them into their professional lives. A new born child adopts the traits and characteristics of the family he/she is raised into. Similarly, a campus community which embraces sustainable practices infuses a spirit of sustainable living, as a way of life among citizens of tomorrow.

Students today, have a strong level of awareness about sustainability issues. In fact, as we started reaching out to different campuses across the country, we realised that students had already formed a number of groups and were putting considerable amount of effort into pursuing various sustainability issues. Yet in the entire eco-system of a campus, the efforts of these groups were not focused on delivering positive outcomes in terms of making campuses sustainable. While these initiatives which focused on organising events to create a general awareness were commendable, the real understanding of the practical social, economic and technical difficulties of making a transformation into a "green" campus would have remained poorly understood through this approach.

Some of the key factors which hinder the development of a comprehensive green campus initiative are:

a) Lack of Administrative Support and Involvement

Any initiative, unless acknowledged and supported by top administration of the institution never gets institutionalized. We observed that a key reason for poor administrative support was the lack of confidence in the commitment and seriousness of the students. In fact most of the college administrations want to create a green campus, but are hesitant to allow the leadership of this to rest with the students.

b) Reinventing the Wheel Syndrome

There were lot of synergies possible between different groups. For example, few students had done a campus audit on one campus and it served as a good starting point for groups elsewhere. But due to lack of collaborative culture, these synergies were not being explored and leveraged.

c) No Alumni Involvement

There were issues beyond technical where student groups needed mentoring from alumni and faculty. The involvement of alumni with experience in the relevant area vastly improves the effectiveness of any result oriented initiative.

The Sustainability Network Concept

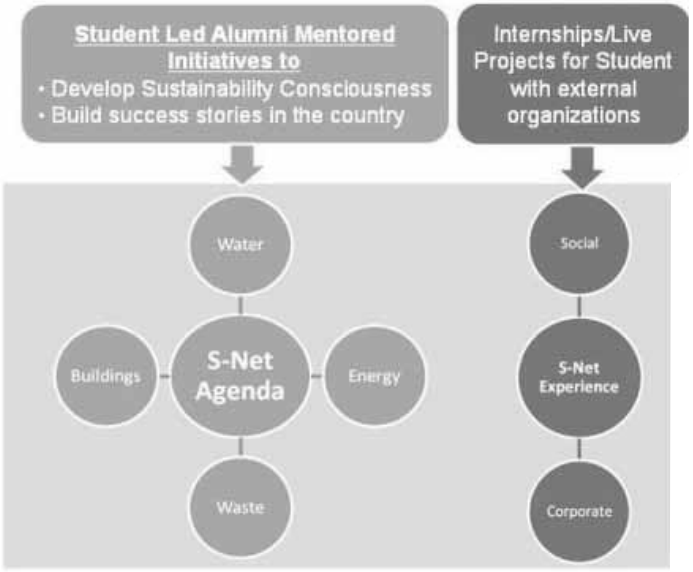
In the process of conceptualizing The Sustainability Network, all these limitations were considered and a model driven by students, mentored by alumni and supported by the administration has been developed. In this model, a student team, with the help of Alumni Mentors are involved in the conceptualisation and actual implementation of the solutions to sustainability problems on campus. This not only gives a well-rounded awareness to the students on all aspects of sustainability issues, but also helps build green campuses that act as examples for corporates to emulate. The Alumni Mentor, trained by the Sustainability Network plays the key role of linking students with the administration and arrives at the ideal model for the green campus initiative specific to each campus. The Sustainability Network portal helps the groups from different educational institutes collaborate and share experiences..

The Vision is to create campuses that operate on near zero dependence on external energy sources, recycle and re-use their waste within campus community, develop a mechanism for self perpetual replenishment of its water sources, build intelligent infrastructure with minimum environmental impact and maximum natural synergy and above all, create citizens of tomorrow that are committed to sustainability.

The Sustainability Network is in the process of preparing the Sustainability Agenda – a policy cum strategy document to be developed jointly by students, faculty and professionals coming together from diverse educational, professional and geographical backgrounds. The agenda is a baseline document which sets out the blue print for the creation of a vibrant student-led sustainability movement encompassing all aspects of the sustainability of campus community - Energy, Water, Waste and Buildings. Students and alumni are encouraged to form a **Sustainability Chapter** in their campus for adopting the Agenda as part of campus development plans. The students can then get involved in the actual implementation, monitoring and maintenance once the resources for the same are allocated. Through this model, Sustainability Network ensures that the initiatives go beyond the stage of propaganda and into actual implementation. A key aspect here is that it also creates a channel for alumni to get involved both in mentoring and funding specific initiatives on campus.

The Progress

In the summer of 2009, the Sustainability Network initiated the pilot project of the Energy Conservation and Energy Efficiency (ECEE) initiative at the IIT-Madras campus in April 2009. With the support of the Dean of Students, the Maintenance Department and an enthusiastic student-team of volunteers, the foundation for building a successful campus energy saving initiative was built. IIT-Madras Alumni from the class of 2005 is mentoring the students and providing them with industry experience to ensure that the initiative remains result-oriented and does not veer towards a theoretical study. The ECEE initiative will be launched as a campus-wide initiative during the upcoming academic year, including a campus energy conservation award.



Sustainability Network: Working Scheme

Another key role of the Sustainability Network is to facilitate students from the various Sustainability Network chapters to undertake internships with both non-profit institutions and corporates. We call this The Sustainability Network Experience. Students are encouraged to work with non-profit institutions that work on sustainability solutions at the grass root level. In order to better prepare them for their future careers, the students are also given opportunities to work on sustainability initiatives in professional set ups.

As a pilot initiative in the summer of 2009, Sustainability Network facilitated student participation in Lighting a Billion Lives initiative of TERI. Students and alumni from IIT Kanpur travelled to villages and tribal regions of Jharkhand and Orissa and upon their return took up projects to strengthen the campaign. A team of students also interned under the Griha Green Building group at TERI.

Lead the change on your Campus

We believe that the time is right for educational institutes in India to rise to the occasion and play their part in securing a sustainable future for the country. We also strongly believe that this movement will necessarily have to comprise of student-led and hands-on initiatives to bring about a transformation of their campuses. By tapping the intellectual horsepower of educational institutions, we can emerge as a country which can play a leadership role in the fight against climate change. We hope that leaders from every college will step forward to begin Sustainability Network Chapters and contribute to this transformation. It is time for students to take up the gauntlet and bring about a green transformation in every single educational institute in the country. This is, in essence, the vision and belief of the Sustainability Network.

Visit the network at

www.sustainabilitynetwork.in

Editor's Note

The idea of Sustainability Network was floated by Ankush Garg (Electrical Engineering) and Sarath Srinivasan (Mechanical Engineering), graduates of the Class of 2001 from IIT Kanpur and IIT Madras respectively. The network already has a chapter in IIT Madras while the environment group at IIT Kanpur, The Group for Environment and Energy Engineering (GE3), is coordinating with the network to implement the model at IIT Kanpur. This article was complied by Ankush Garg for publication as an Orange Paper in the NERD magazine. He can be reached at ankush.garg@cleantech2market.com.

NERD Project Logs

Electronic Voting Machine

NERD Project Logs is a new series chronicling the various projects done by students across the various technical education institutes in India. The aim is to present the basic concept and the problems the students faced while trying to implement the idea. The first article in this series is about an Electronic Voting Machine attempted by two IIT Kanpur students in Summer 2009.This project was undertaken by Rajdeep Chauhan and Rohit Kumar. They can be reached at rajdeep@iitk.ac.in and rohitpd@iitk.ac.in respectively.

Election Commission of India is using Electronic Voting Machines (EVM) for conducting polling throughout the country. We wanted to make a similar kind machine for conducting student government elections in IIT Kanpur. The idea was to save the enormous amount of paper wasted every year during the elections for the purpose of polling. This motivated us to take this topic as our summer project.

As this EVM was mainly made to serve the purpose of elections for IIT Kanpur community, we programmed the Micro Controller Unit (MCU) such that voting for more than one post can be done at a time. Considering the storage limitation of the MCU, presently it is programmed to conduct voting maximum of 3 posts and each posts can have maximum of 5 candidates. To make it self-sufficient, a keypad is also provided with a keypad. Just before start of election, one can feed the data related to Name of the post and the candidates contesting for that post. There is no need to program the MCU every time we conduct an election. There is also an option for not to vote any one. Results are displayed as soon as you go for it. Names of the candidates with the number of votes they received for a particular post are displayed in the decreasing order of their votes.

Major difficulty we faced was related to the 20x4LCD screen and the implementation of touch switch with the help of Infra red LEDs and TSOPs (Thin Small Outline Package, a surface mount memory packaging).

We were not able to get the exact datasheet of the LCD we were using. So we were not able to find the correct connection for LCD. The data sheet we used had a different DDRAM convention. Due to this we had a lot of trouble in programming and we were not able to find out whether it was a hardware problem or a programming problem. At last we tried for the conventional DDRAM address as in the case of 16x2 LCD and it worked.

TSOP was not able to sense the intensity of IR LED for the distance we wanted it to work. Increasing the range of the IR LED was a great challenge for us. We knew that to increase the intensity of IR LED we have to provide more current to it. We tried for a different combination of transistor but none of them worked. At last the problem was solved by providing additional power supply to the IR LED.

A common problem was Soldering. During soldering, due to extensive heating, some of the components stopped working. Also, the soldering heat was carried by the wire to be soldered which caused melting of the soldering at the other end thereby causing short circuit. Due to this our touch switch stopped working at the last moment. While replacing one of the IR LEDs, timer got short circuited with output of one of the TSOPs.

Video of this project can be seen at http:/www.youtube.com/watch?v= pUJQI5pyDg

Call for Articles!

NERD is the scientific and technical research and development magazine run by the students. We publish news on scientific breakthroughs happening in various technical education institutes, research labs et cetera across India and the world with an emphasis on the work done by students. So NERD is a magazine of the students, by the students, for everyone. The NERD magazine is first of its kind and we need everyone who is interested in science and technology to be on our team. Join the NERD Herd! Yes, you can be the one writing for the magazine.

There are a variety of things you can do:

1. Write about the work that you have done or will be doing at your institute as hobby project (write about those robots, will you?), semester projects, internships, B.Tech projects, theses or work presented elsewhere as papers.
2. We even publish articles on failed projects, abandoned research so that people know what led to failure.
3. I've done work but it's incomplete." No worries! We publish work in any stage of completion—even ideas if they are well supported scientifically.
4. I am interested in a field but haven't done any work in it." So what! Since you are interested in the field, why not tell about it to others? Who knows, you might get ideas while doing that.
5. Write book reviews for popular science and technology books.
6. Interview professors and eminent scientists doing research.
7. Collect ideas for geeky cartoon strips and send them to us. You can also send illustrations and cartoons.
8. Perform table-top science experiments and pen them down. You could maintain a field diary of your work and publish it with us.
9. Decide the content of the magazine: send us ideas for articles. Tell us what you want to read.
10. Inspire more people to do these activities.

Note that although articles related to science and technology are published, these articles are NOT papers but accurate versions written by students that are more easily understandable to non expert audience.

Visit http://www.nerdmag.org/faq for more answers.

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Interested people can send in entries for publication on or before December 25, 2009 to editor@nerdmag.org. Contact us for query resolution or if you have already written something or contact us just for the sake of it. We will be happy to chat with you.

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Attributions

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Reminiscences

Sir Norman Ernest Borlaug
1914-2009

Dr. Norman Borlaug, who won the Nobel Peace Prize for his work increasing grain yields, died at the age of 95. Dr. Borlaug was a true visionary. Born in the northeast Iowa town of Cresco, he obtained his PhD in plant pathology from the University of Minnesota. He passed away on 12 Sep 2009.

While working in Mexico at the Rockefeller Foundation, he developed "miracle wheat" that tripled production and helped save Mexico from famine. He then took his high-yielding, disease-resistant wheat to India and Pakistan, averting an anticipated mass famine thereby sowing the seeds of what was immediately dubbed as the Green Revolution.

In 1970, Borlaug won the Nobel Peace Prize, the only time the award has been given to someone working in agriculture. He instituted the World Food Prize (headquartered in Des Moines) to recognize notable achievements that help feed people around the world.

Most recently, Prof Borlaug was involved in setting up the Global Rust Initiative to combat the devastating new strain of wheat stem rust Ug99. His death is a great loss to science and developmental aid work.

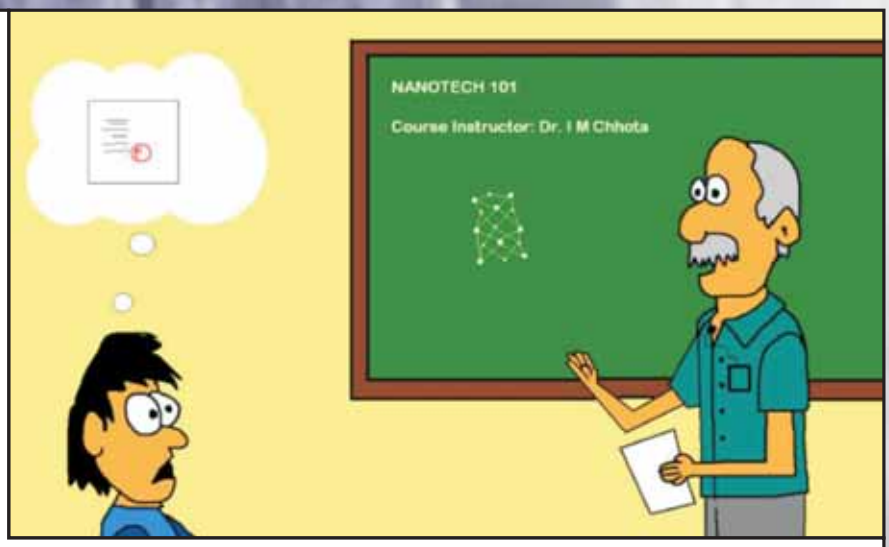
His innovative spirit led to new discoveries in agriculture that would help reduce hunger for countless individuals. More than 1 billion people are alive today because of his work. NERD team salutes him for his phenomenal contribution to the human cause.

"We believe that nanotech is the next great technology wave, the nexus of scientific innovation that revolutionizes most industries and indirectly affects the fabric of society. Historians will look back on the upcoming epoch with no less portent than the Industrial Revolution."

Steve Jurvetson, Partner, Draper Fisher Jurvetson

SCIENTOON

Until the late 1990s the outputs of nano papers from East Asia, Europe and the US were similar, but East Asia is now clearly in the lead, with the US in second place. There has also been a rapid increase in the number of universities offering courses on nanotechnology. Initially most of these courses were for postgraduates, but the first undergraduate courses are now being introduced. The University of Worzburg in Germany and Chulalongkorn University in Thalland are among the institutions that offer first degrees in nanotechnology and more are sure to follow.



"My assignments and exams will be like Carbon Nano Tubes. They'll be small but a 100 times harder than any known material."

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