In Phase

IIT Guwahati-Cepstrum Magazine

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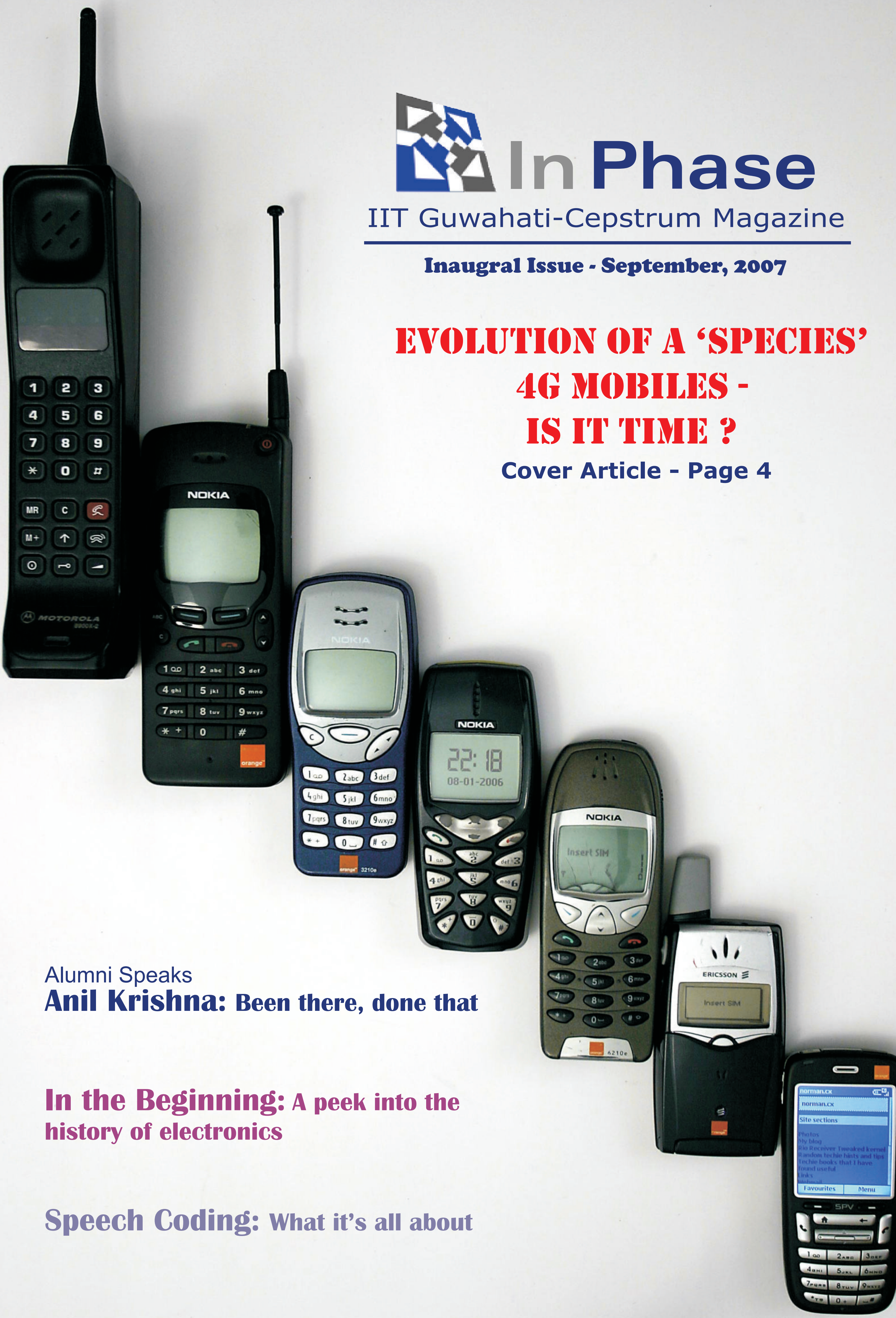
EVOLUTION OF A 'SPECIES' 4G MOBILES - IS IT TIME ?

Cover Article - Page 4



Alumni Speaks

Anil Krishna: Been there, done that

In the Beginning: A peek into the history of electronics

Speech Coding: What it's all about

From the editor

"The world is changing very fast.", says *Rupert Murdoch*, "Big will not beat small anymore. It will be the fast beating the slow." And surely it will be the more informed beating the lesser one, the most knowledge bearing person getting ahead of the rest. Certainly then, for innovating and thus for succeeding, being informed and being '*in-phase'* with the developments around are as important as having the drive to succeed. This magazine is but a small step to aid this process of "being informed".

'In Phase' is an endeavor to connect all the students, research scholars and our faculty and to bring them in-phase with what's going on in the department, in the industry and in the electronics and communications field in general. It will also be a medium to gain valuable insights from the experiences of our alumni and from prominent people in the industry as well as academia. Our vision for In Phase is to gradually build up as a valuable source for knowledge and information and become a respected monthly for all who are connected to electronics and communications.

On behalf of the editorial team, I would like to thanks all the faculty members for their valuable insights for the magazine. Special thanks to Cepstrum faculty advisor, Dr. A.K.Mishra for his constant involvement and to Dr. R. Sinha for his invaluable contributions.

Hope you will like the magazine. We are really looking forward to your feedback to improve it in the further issues.

Akash Baid
editor-in-chief

Foreword from the HOD

The year 2007 marks the two hundred years of the Fourier Analysis. Jean Baptiste Joseph Fourier (1768-1830), a French mathematician, presented his memoir on the Propagation of Heat in Solid Bodies to the Paris Institute in this year. While solving the partial differential equation for heat diffusion, Fourier represented the periodic function as an infinite series of sine and cosine functions. This genesis of the Fourier series sparked controversy, Laplace and Lagrange did not approve this analysis because of 'wanting in rigors' and Lagrange particularly was opposed to publishing it.

The Fourier analysis has seen vast developments over last two hundred years in terms of the Fourier series, the Fourier transform, the generalized Fourier transform, the discrete Fourier transforms and their fast implementations. We all understand its importance in diverse and apparently unrelated fields of science and engineering. Particularly, many of the developments in signal processing and communication are directly related with spectral analysis, estimation and detection.

The Cepstrum, which is the Fourier transform of the log-magnitude spectrum, is itself a remarkable development in Fourier analysis. The ECE student society of IIT Guwahati is appropriately named after this important concept and its publication 'In Phase' is a reminder of the Fourier phase spectrum. This is a glorious coincidence that the first issue of In Phase is coming out in this momentous year!

I wish that In Phase will be an important forum for the intellectual pursuit of the ECE community.

P.K. Bora

From our faculty advisor

Many may claim that this is the age of electronics. Information is accessible and costs hardly a dime. People tend to forget tomorrow, the jubilant discoveries of today. How do we at the universities keep ourselves informed, in such a dreadful time? Certainly by e-media and handing over a chunk of the duty to students. As Prof. Srivatsan would say, today institutes are tending towards *sishyakulas* instead of *gurukulas*. Why should they not? After all we in India take pride in a rich history of education system; an education system, where the *sishya* (student) was exactly at par in importance to the *guru* (master). *Tejaswino-badhitamastu*. Together we (teacher and student) scintillate.

I am really excited on this occasion of the release of the first issue of the student magazine "In Phase" of the electronics and communication engineering students. This in reality is a transfer of some of the duties from the teacher to the student. Now the students too will share the responsibility of educating the inmates of the institute. This is a landmark and I am confident that our students will be extremely successful in fulfilling their new duty. One day, I am quite certain to find this baby magazine in a mature stage and state, where it will make me feel meanly proud!!

Cheers:
Amit

Anil Krishna: Been there, done that

He was among the first batch of students at ECE IITG and has made it big in the industry today. Having done his MS from Purdue University and after a 4 year stint at IBM, he`s presently pursuing his PhD from the North Carolina State University. Alumnus ***Anil Krishna*** talks to editor ***Sourabh Sriom*** about his experiences in and after IITG.

“ My only preconceived notions about IITG were that it would be a young institute looking to build itself ”

Q. Being a student of the 1st batch of our IIT, tell us about your apprehensions and pre-conceived notions, if any, about IITG.

A. From what I recollect about my state of mind then, I believe I was more excited than apprehensive. The opportunity to study at an institution where the quality of education, faculty, students and facilities was reputed to be at par with the best in the country excited me. My inclination was towards ECE as a subject area and I was only grateful that I could pursue that subject at IITG when I probably could not elsewhere, given my rank in the JEE. My only preconceived notions about IITG were that it would be a young institute looking to build itself, both in literal terms and in its beliefs and character. I knew it would be an institute that would not have much to show for itself in the first few years in brick and mortar terms. I also knew that when you put smart, motivated and courageous people - people who were smart enough to get into IITG, motivated enough to prioritize their area of academic interest over the place of study, and courageous enough to choose an hitherto unexplored destination – the chances are good that you will end up with an institution you can be proud of.

“ The emotional support, comic relief, opinionated exchanges and lifelong friendships are experiences we students shared with each other and the faculty.”

Q. Talk us through the experiences of the rest of your B. Tech, the faculty, other students, and, the placements.

A. We were lucky to have some highly motivated faculty members whose knowledge of their subject was thorough, and, enthusiasm for their craft, contagious. It was a pleasure to actively learn from them in the classroom and beyond. With 63 other students to begin with and with more joining in the future years, it was a non-stop learning experience in social behavior. The emotional support, comic relief, opinionated exchanges and lifelong friendships are experiences we students shared with each other and the faculty. The combination of our being in our late teens, the 4 years we were together for and the shared adventure that was IITG, might be the reason why the friendships made in those days are still so strong. The placements and higher studies are but a blur in my mind. I remember that even then we were able to attract some of the best companies and were offered good jobs with competitive pay.

Q. What prompted you to go for higher studies abroad?

A. My main motivation for higher studies was that I felt I had only begun to skim the surface of my field and there was a lot more for me to learn. The other school of thought was that what you really need to learn you can learn while doing a job. Though that was true to the extent of doing your job well, I wanted to learn more for its own end. That is, I wanted to learn what great minds of the past had thought up or discovered, for no other reason than that I wanted to know. I had no plans for how I was going to use that knowledge. Why abroad? I wanted to explore the kind of academics and research that is practiced in other reputed institutions of the world. It was, in some sense, IITG all over again - the yearning to put yourself in a new situation, to, hopefully, gain a new perspective.

Q. What were the major differences you felt graduating from a premier institute in India to doing your PG from a reputed university in the US?

A. I went to Purdue University in West Lafayette, Indiana, USA for my Master's in Electrical and Computer Engineering. It was a gigantic University compared to IITG and certainly a bit overwhelming. The size, the history and the bureaucracy were the first things I noticed. It worked like a giant machine with things happening like clockwork running on old but well-oiled and well-cared-for parts. However, I was able to find myself an apartment, make new friends, get a decent understanding of the geography of the large campus, get my head around the official rules and requirements, participate in a different culture, continue good performance in academics, and participate in

" The main difference between academia and industry is that industry tries to channel research into an end product that is tangible, useful and therefore, sellable."

" Being in touch with academia allows you to see patterns that would be harder to see from within the industry."

" Be connected to reality by being aware of your thoughts, your motivations, your limitations, your duties and your actions."

sports and other extra-curricular activities. So all in all, I think IITG prepared me well to take up the new challenges in the new environment.

Q. How did you land up in IBM? Tell us something about your stint there

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A. Similar to placement interviews at the end of a B.Tech at IITG, there was a job fest organized at Purdue University's ECE Department. I interviewed with several companies and decided to get some exposure to the industry. I joined IBM, primarily, because of the company's reputation, the breadth of knowledge the company seemed to possess and because the team that interviewed me seemed to be doing very interesting work. The main difference between academia and industry is that industry tries to channel research into an end product that is tangible, useful and therefore, sellable. IBM has a Research division too; however, the team I joined is part of Development. I work as a Future System Performance Engineer. My work deals with helping hardware designers and system architects optimize the design of a future computer system such that it performs the best it can, given various requirements, such as expected workloads, throughput and latency requirements, and constraints, such as the area and power budget, architectural or microarchitectural extensions allowed etc. I learn a lot of new things on the job and work with some very sharp people.

Q. At what point during your job did you make up your mind to go for a PhD?

A. I noticed that high importance is given to innovative thinking at IBM. I realized that with better knowledge of the Computer Architecture field, I could not just solve the current design problems better, but more importantly, I could foresee future problems and try to incorporate that vision into the current solutions. I also noticed that in the region where I live and work, there were several good Universities and IBM management was always supportive and encouraging in allowing me to go back to school for either an MBA or a PhD. So after working for about 4 years at IBM, I applied to and joined North Carolina State University in Raleigh as a part-time PhD student. By then I had gotten a reasonable understanding of the types of design and technology constraints computer architects and hardware designers face in their work and the kind of solutions that make a product competitive in the market. I thought the time was right to look at the directions academia was taking in this field. Academia and Research are typically a few years ahead of the Industry and Development. Therefore, being in touch with academia allows you to see patterns that would be harder to see from within the industry.

Q. How was research in ECE different from a job in the area?

A. Though I have not yet started serious research as part of my PhD, and am currently taking classes and only recently formed my Advisory Committee, I can give you my current view on this topic. Since I joined my PhD after some exposure to the industry, I can research a topic that is a new and interesting problem both in academia and industry. Such overlap is usually not perfect, but if research in an academic setting is guided to some extent by real problems faced by engineers, it leads to research that is more purposeful.

Q. How would you compare India and the US in terms of opportunities in the ECE field?

A. Having limited exposure to the industry in India, I have to go by my understanding of what I have heard or read. I believe that India has a foot in the door to becoming a knowledge superpower. India is already a major player in the software and services industry. From being a middle-man providing support to the producers and the consumers, India is itself moving towards being a big producer and a big consumer. That is a significant shift, because as a producer you create value where it did not exist before, and as a consumer, you provide a reason for the producers to produce. India seems to be on the threshold of a gear change in this engine of value-creation and value-aware-demand. In ECE and related fields the differences in opportunities between the US and India will continue to shrink as long as India continues to take the opportunities that come her way and discover or create new opportunities on her own.

Q. Would you like to share a piece of advice with our readers about how they should plan their career moves.

A. Based on my limited experiences, based on what has served me well, assuming a vast majority of the readers are students at IITG, and assuming a general guideline rather than a strict example is useful, my advice is, be honest and positive. By honest, I mean several things. Be forthright in your assessment of where you are, where you want to be, how to get there. Be a humble follower when you should be, and likewise, a confident leader when you should be. Be connected to reality by being aware of your thoughts, your motivations, your limitations, your duties and your actions. By positive I mean, most importantly, try to keep improving yourself. Try to do the best job in everything you do. How you define "improvement" or "best" depends on how honestly you can judge where you are and where you want to be. Try to improve that ability to judge as well. By positive I also mean be creative. Get into the habit of practicing your innate creativity. We have the brains and the training to actively create value, rather than passively consume it. Even when being a consumer be an active one. Be a good follower (active consumer) and be a good leader (active producer). Let the opportunity to partake in creativity guide your career moves.

Q. Finally, a word for the very first people at IITG, the director, the faculty of the department, the HOD. I'm sure they all would be proud of you.

A. I am and have always been impressed by the positive energy of the IITG Administration and Faculty. In twelve short years the progress made by IITG has been remarkable and most of the credit should go to these nurturing souls. I am grateful and proud to have been, and still be, a part of IITG. I am positive it will continue to grow in stature and fulfill its role in shaping the world.

4G Mobile: Is it time??

Here we are, ready to enter the 4th generation of mobile technology, which would mean multimedia message service, video conferencing, digital video broadcast, high definition TV, and media streaming anytime-anywhere, just in one tiny device. 4G technology will virtually eliminate the differences between a cellular or a wireless or a computer network. Before we go into the details of the advancements, let us take a glimpse on evolution of mobile technology.

The first generation of mobile technology kick started in 1980's was defined on analog cellular phone standards. The first handheld 1G mobile phone was Motorola DynaTAC 8000X which was available in the US market, in 1983. This revolutionary product's main features were, talk time of 30 minutes, 13 x 1.75 x 3.5 inches in dimension, eight hours of standby time, 10 hours to recharge, an LED display and memory to store 30 "dialling locations". But all this came at a hefty price of $3,995 US dollars! The genius behind this innovation was Dr Martin Cooper, a former general manager at Motorola systems division. He was the first person to make a call on a cell phone in April 1973, and quite ironically he made his first call to his rival, Joel Engel, Bell Labs head of research.

In the 1990's 1G made way for the 2G or the second generation, the first digital transmission technology. The standards adopted for 2G networks were GSM, IS-136, iDEN and IS-95 ("CDMA"). Radiolinja was the first 2G network (GSM) which was opened in Finland in 1991. 2G phone systems were characterized by digital circuit switched transmission and the introduction of advanced and fast phone to network signalling. Implementation of digital transmission made it possible to introduce digital data services, such as SMS and email. Later on, further improvements were made and GPRS system was introduced for data transmission, referred as 2.5G. An improved version called EGPRS was introduces in 2003 which is referred as 2.75G.

The third generation of mobile phone standards presently in practice is based on the International Telecommunication Union (ITU) family of standards under the International Mobile Telecommunications programme, "IMT-2000". NTT DoCoMo was the first company to launch a commercial 3G network, named “W-CDMA” in Japan on October 1, 2001 under brand name FOMA. 3G technology offers the user a wider range of more advanced services like wide-area wireless voice telephony and broadband wireless data. It allows the transmission of 384 kbps for mobile systems and 2 Mbps for stationary systems. Application like photo cameras, music players, video players, contactless smartcards for payment functions (wallet phones), Web browsers, email clients are common in 3G handsets.

Now, that you have got a basic idea, let's move towards the upcoming 4th generation. Imagine yourself watching live cricket match between India and Pakistan on your mobile phone. Drinks break, and an advertisement of a furniture company appears. You are simply amazed to see the product, and with a few finger movements, a 3D model of the product appears on the screen, enabling you to have a closer look at it from various angles. You decide to purchase that product, you immediately open web-shopping site on you cellular phone and order the item (the money is, of course, deduced form your mobile smartcard). The match finishes, and one of your friend pings you on mobile instant messenger to share his pleasure on victory of India, and within no time you are in a video chat with him. The conversation ends, and you decide to have a glance at news, and with few gestures, face of a pretty news reader appears on you mobile phone screen!

The above mentioned scenario is not some fairy tale; it is the promise of the 4G technology. This is what the future hold for us, “comfort on the click of a button”. Even today, mobile phones have become much more that a mere device used for transmitting voice. Services like GPRS etc are defining new dimensions of mobile technology.

But the future is much more promising! 4G will be a fully IP-based integrated system of systems and network of networks achieved after the convergence of wired and wireless networks as well as computer, consumer electronics, communication technology, and several other convergences that will be capable of providing 100 Mbit/s and 1 Gbit/s, respectively, in outdoor and indoor environments with end-to-end quality of service and high security, offering any kind of services anytime, anywhere, at affordable cost and one billing. The 4G working group has defined the following as objectives of the 4G mobile technology standard:

1. A spectrally efficient system(in bits/s/Hz and bit/s/Hz/site)

2. High network capacity: more simultaneous users per cell,

3. A nominal data rate of 100 Mbps while the client physically moves (At this rate the content of a DVD can be downloaded within about 5 minutes!) at low speed relative to the station, and 1 Gbps otherwise,

4. A data rate of at least 100 Mbps between any two points in the world,

"The 3G standard has been evolved, but has not proved cost-effective, therefore we plan to leapfrog this generation and develop 4G technology. India has an opportunity with its large market and high technical skills to be a significant player in this field. We are going to set up a National Center for Excellence in this area."

- Dayanidhi Maran, ex-Minister of Comm. and IT, Govt. of India

5. Smooth handoff (technology used for providing roaming facility) across heterogeneous networks,

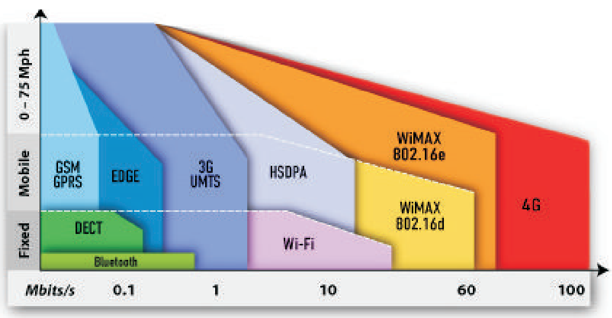
6. Seamless connectivity and global roaming across multiple networks,

7. High quality of service for next generation multimedia support (real time audio, high speed data, HDTV video content, mobile TV, etc),

8. Interoperability with existing wireless standards, and

9. An all IP, packet switched network.

According to the 4G working groups, the infrastructure and the terminals of 4G will have almost all the standards from 2G to 4G implemented. Even though the legacy systems are in place to be adopted in 4G for the existing legacy users, going forward the infrastructure will however only be packet based, all-IP. Also, some proposals suggest having an open platform where the new innovations and evolutions can fit. In summary, 4G will virtually eliminate the difference between a computer network and a mobile network because of IP based packet switching technology. Hence any network application running on a PC such as an instant messenger would be capable of running on mobile phones in the similar fashion. With the introduction of IP based digital TV, HDTV broadcast would also become available on a mobile handset. The promised bandwidths should provide opportunities for previously impossible products and services. The "killer application" is not clear; perhaps the "killer application" is simply to have mobile always on Internet with reasonable charges. Existing 2.5G/3G/3.5G phone operator based services are often expensive, and limited in application. In fact, many companies have already started testing 4G networks.



Data rates for wireless technology

There are a numbers of pre-4G (under experimental use) or 4G (under testing) technologies, such as:

1. VSF-OFCDM, being used by the Japanese company NTT DoCoMo, which has recently tested it at 5 Gbps while moving at 10 km/h. It is planning to release the first commercial network in 2010

2. WiMax (Worldwide Interoperability for Microwave Access), an 802.16e standard, which being developed by WiMAX Spectrum Owners Alliance,

3. WiBro (Wireless Broadband), again an IEEE 802.16e standard, which is being used by Korean telecomm,

4. 3GPP (Third Generation Partnership Project) Long Term Evolution and 3GPP2 Ultra Mobile Broadband.

5. MBWA (Mobile Broadband Wireless Access), an IEEE 802.20 standard.

The Research Institute of China Mobile has also started several projects for the next generation of mobile network technology, under the name, Wireless internet protocol on internet service environment (WIISE). "We do want to do more on this WIISE technology in the next two years with our proprietary intellectual property rights. We do also want to push this self-developed technology internationally", said Wang Xiaoyun, a deputy manager of the institute. Similarly, a Norway based communications company Telenor is carrying out a project "Nett og Mobilitet" for achieving same target.

Though this technology is expected to take a long time to become popular, one cannot help notice that even today cell phones have become one of the icons of modern living symbolising a world of the instantaneous, of the connected and of the disposable. But behind the iconic triviality lie serious issues which affect individuals and society alike. For example, one can't avoid unintentionally invading (or getting invaded) other's privacy. The "anywhere-anytime" connectivity is an addiction: we see people stuck to mobile phones in holy places, in shops, in queues, on roads, filling the nearby persons with information of their family, business, etc. Social structure might receive a tremendous blow as world of a person would get more and more confined. Moments of solitude, when a person does "free thinking", would become less and less prominent, as there will be no spare time left with "everything" in your hand. Adverse effects include degradation in physical capacity & performance of human body, low I.Q., less creativity, lack of emotional feelings, etc. Nothing to do? Just put an earphone, stick your eyes on a small 4"x1" screen, and forget the world!

In spite of all this, witnessing the impact cell phones have had on our lives till date we can surely say that 4G will definitely start a new era of communication and global connectivity, which one only can imagine today.

-Anshuman Shukla,

B.Tech, 4th year

Speech Coding: A review

- invited article from Dr. Rohit Sinha

Speech is the fundamental mode of communication between humans. Despite so much advancement in digital communication technologies in recent years its importance is still remains. In fact, it is the progress made in the field of speech coding or compression that has accelerated the growth of international, mobile and satellite telecommunications. The speech coding refers to various techniques which convert the speech signal to a digital format. Speech coding algorithms attempt to increase the efficiency in transmission or storage while maintaining certain acceptable perceptual quality at a minimum bit rate. In the article we will briefly review the fundamentals behind speech coding technology, standards and highlight the direction of the current research directions.

Theoretical background

The two principle facts which form the basis of all speech coding algorithms are redundancy in speech signals and the properties of human perception. The speech signals contain a lot of redundancy which may be noted in following observations:

1. speech signals have high similarity or correlation among adjacent samples,
2. the shape of the vocal-tract varies slowly with time,
3. voiced speech is quasi-periodic,
4. the transmission code values are not distributed uniformly.

The redundancy from the correlation between samples is manifested in the unevenness of short-term spectrum of speech. This redundancy could be removed by appropriate filtering. The second form of redundancy is used as basis of segmenting the speech signals into frames. The low bit rate coding of voiced speech using sinusoidal or harmonic coding exploits the quasi-periodicity of voiced speech. The fourth form of redundancy forms the basis of various probability coding techniques.

Modern day speech coding algorithms also exploit a number of properties of human perception to achieve high compression. The properties of human perception which find use in speech coding are:

1. Limits of perception: The frequency resolution of the human ear is limited at about 2 Hz. Most of the speech signals are also limited to frequency range of 200-3400 Hz. Thus the information redundant to human ear can be removed using quantization.
2. Masking Effects: The masking refers to phenomenon of failing to perceive of otherwise audible sound by ear due to another one. One example of this is cover up of a weaker sound by a loud sound (intensity masking). Other factors also might contribute to masking are: frequency, temporal separation of the sound, tonality of the masker etc.
3. Sensitivity of perception: It has been found that human ears are more sensitive to lower frequency bands than higher ones. For voiced speech, the pitch (fundamental frequency of vocal cord vibration) and the formant structure (peaks in short-time spectrum) are predominantly located on the low frequency regions. Another important property is the insensitivity of the human ears to phase information in the speech signals.

Performance issues

The performance of a speech coder is influenced by a number of factors: speech quality, coding rate, algorithmic complexity and coding delay. In practice, different coding algorithms are usually a trade-off among them.

- *Speech Quality:* The measure of the quality of speech can be broadly divided into two classes: objective and subjective. Most objective measures are based on signal-to-noise ratio (SNR) which is defined as

$$SNR = \frac{\sigma_s^2}{\sigma_e^2} = \frac{E[s^2(n)]}{E[e^2(n)]}$$

where σ_s^2 and σ_e^2 are powers of the signal and the error (noise), respectively.

The SNR based measures basically indicate how closely the reconstructed speech can follow the original signal. Although these measures are easy to compute and detect the variations in gain and delay, they do not account for the perceptual properties of human ear. In other words the reconstructed speech with high SNR may be perceptually poor to the listeners and vice versa. This is more likely at low transmission rates. Therefore, in low bit rate coding, subjective measures are primarily used. The subjective measures try to quantify how a listener actually perceives the speech based on the score given by the listener. The most commonly used subjective measure is the mean opinion score (MOS). It has a five-level quality scale; the higher the score the better the performance: 5=excellent, 4=good, 3=fair, 2=poor, 1=bad. Am MOS higher than 4.0 is considered as toll quality, 3.5-4.0 as communication quality, 2.5-3.5 as synthetic quality. There are other subjective measure available e.g., the diagnostic rhyme test (DRT- uses a set of isolated words to test the consonant intelligibility, i.e., ability to distinguish similar words), the diagnostic acceptability measure (DAM-similar as MOS but uses more complicated scale) etc. Subjective measures are usually time taking and costly

- *Coding rate:* This rate reflects how much a signal can be compressed. It is usually expressed in bit/sec (bps).
- *Algorithm Complexity:* The complexity of speech coding algorithm is determined by the complexity, memory requirement, power consumption and cost in hardware implementation. Most of the real-time speech coding algorithms are implemented on digital signal processor (DSP) or cusom application specific circuits (ASIC). The algorithm complexity usually

described in terms of MIPS (Million instruction per second), i.e., minimum requirement for a DSP to implement the algorithm.

- *Coding Delay:* The coding delay of speech transmission system is a factor closely related to the quality requirements. Coding delay may be algorithmic (buffering of speech for analysis), computational (the time taken to process stored speech samples) or due to transmision. Only first two concern the speech coder.

Speech coding standards

Traditionally the International Telecommunication Union Telecommunication Standardization Sector (ITU-T, formerly CCITT) has standardized speech coders mainly for telephony 3.4 kHz bandwidth and wideband speech supporting 7 kHz applications. Presently orgaization such as the European Telecommunication Standards Institutes (ETSI), the International Maritime Satellite Organization (INMARSAT), Group Special Mobile (GSM) and US Department of Defense (DoD) also distribute their own standards. Table 1 lists the everal well-known standards and compares their

Standard (Description)	*Bit Rate (kbps)*	*MOS*	*Complexity (MIPS)*	*Delay (ms)*	*Release Year*
ITU G.711 (PCM)	64	4.3	0.01	0.125	1972
ITU G.726 (ADPCM)	40/36/24/16	4.0	5	0.25	1990
FS 1015 (LPC-10)	2.4	synthetic	7	112.5	1984
FS1016 (CELP)	4.8	3.2	16	37.5	1990
FS1024A (MELP)	2.4	3.2	40	45.5	1997
INMARSAT-M (IMBE)	4.15	3.4	40	79	1990
GSM-EFR (ACELP)	13	3.7	16	20	1995

Table 1: Comparison of some of the major speech coding standards.

performance.

Speech coding techniques can be broadly classified into two categories: waveform coding and parametric coding. The waveform the objective is to minimize the error between the reconstructed (decoded) signal and the original signal. Thus in other words it tries to preserve the waveform of the speech signal. The examples of the waveform coding are pulse code modulation (PCM), adaptive differential PCM (ADPCM), adaptive sub-band coding (ASBC) and adaptive transform coding (ATC). These methods achieve good speech quality with relatively simpler algorithmic complexity. These are widely used at the 16-64 kbps range. However further reduction in the coding rate is not feasible due to distortion in the waveform becoming much higher for acceptable quality in perception.

Unlike the waveform coding, the parametric coding methods are based on source-filter model of speech production. The parametric coding methods are characterized by the extracting the features from the speech signal and then encoding them. Thus parametric coding does not require the closeness in waveform to produce high quality reconstructed speech. This fact is shown with help of an example in Fig. 1 by using a 4.8 kbps CELP coder. The original speech signal is “card games are fun to play with” spoken by a male in English. It can be seen that the reconstructed speech has obvious differences in the waveform when compared to original one. But the two have a very similar spectral structure and pitch (fundamental frequency) harmonics. The darker colour in Fig. 1(b) denotes higher amplitude. The parametric coding can achieve lower bit rate than waveform coding, but quality of reconstructed speech lacks in naturalness and clarity.

The typical examples of the parametric coding include channel voice-coder (vocoder), formant vocoder and linear predictive coding (LPC). Among these the LPC is still widely used. There are a number of so-called hybrids were proposed by combing the waveform and parametric coding. Among the most successful ones are Analysis-by-Synthesis (AbS) coders. These coders are based on parametric coding (LPC) but attempt to obtain the optimal excitation under the criterion in the waveform coding. Although a number of codes exists under this class such as multi-pulse excited (MPE) LPC, regular-pulse excited (RPE) LPC, but the most widely used is code exited linear prediction (CELP) coder. These coders can achieve the toll quality speech at 4.8-16 kbps.

In the next issue we will discuss some the salient speech coding techniques and highlight the direction of the current

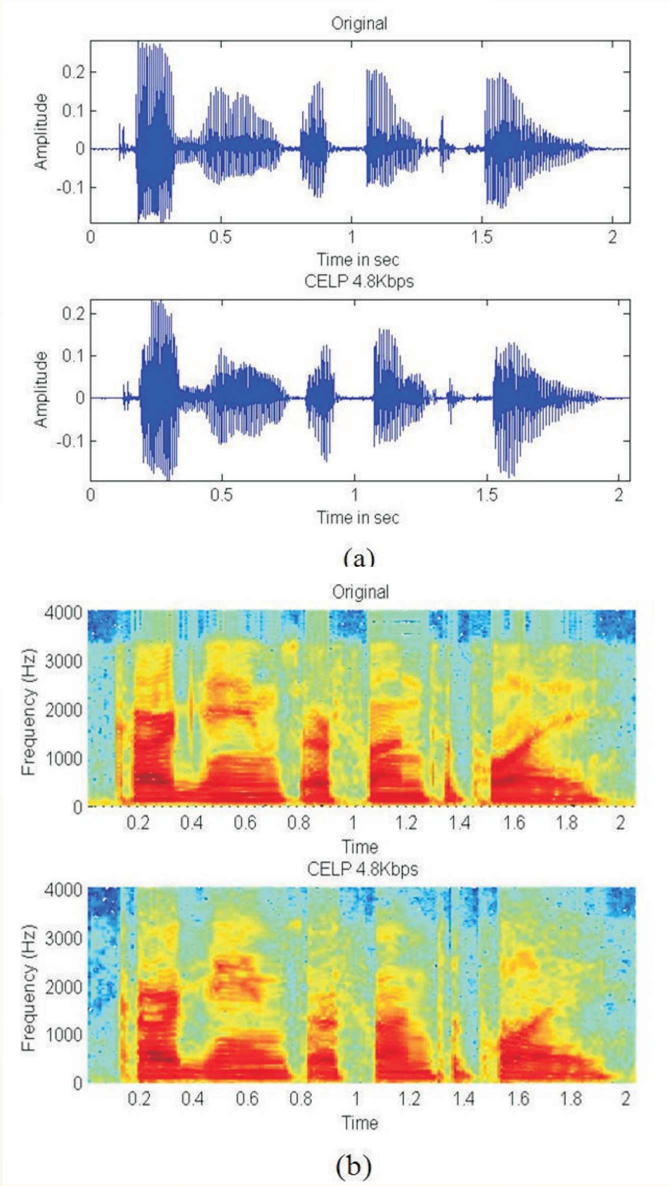


Fig. 1: Comparison between original (8 Khz sampled) speech and reconstructed speech after CELP coding at 4.8 kbps (a) temporal view (b) spectral view.

research.

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Enlightening Soujourn @ MIT

Final year's Pratik Kotkar shares his invaluable experience from a summer internship at the "world's best technical university"

After a long, languid day of lectures on a cold, insipid February evening I returned to my room with just one thing on my mind - sleep! But the day transformed into one I consider, and will always consider, as one which was a turning point in more ways than one in my life. I had got that long awaited email confirming my internship at MIT, an opportunity most, if not all, would consider to be a high point of their career. Keeping high expectations from anything is just about always unwarranted but it was a tough task now to expect anything less than "the best" from arguably the best university in the world for its research and technological prowess.

At MIT's Computer Science and Artificial Intelligence Labs (CSAIL), I was witness to technology and work ethic that surpassed even my very high expectations. If the amazing labs with all the latest gizmos and renowned faculty along with a greatly relaxed student-faculty relation were among the expected things, then there were some enlightening things learnt from the whole sojourn. The first striking view was that of the Stata Center that housed CSAIL, made in the form of crumpled paper it really does stand out as an engineering marvel. Proving what architects say - "To make wrong things work, you must know all the right things first!! ". Perhaps the most prominent feature from the internship was the experience of the work ethic at an institute of such caliber. It did show why from a student point of view the jump from IIT to MIT might just be a leap too long for most! Though knowledge and intelligence may be comparable, the work ethic of students especially in research oriented works was highly commendable. I found spending days and nights together in the labs, working at hours at stretch on the PC, was a rather normal approach.

My project itself was something of an eye opener in many ways. A project aimed for the development and upliftment of rural areas in India being worked upon in the USA. Apart from the topic of research, it was interesting to see how much these guys were really interested in making their work useful for the developing countries, the need for which we fail to realize many times though we stay closest to the areas which need such development. The work itself involved the idea of developing an "Audio Wikipedia".

Wikipedia is of course the most popular online information database. What makes it unique is the possibility of adding and editing information on any topic. The Audio Wiki, as it was called, was a project with a similar background but different aims. We aimed at developing a system accessible through cell phones to users who can listen to information stored in the form of speech recordings on various topics. What is the use of this?? Well, the most important aim of this system is to make such information repositories accessible to the illiterate rural people who have access to telephones but not computers and those who can speak and understand languages but can't read or write. A major challenge in the work was the interface using voice based menus which are in general very tedious .Hence; we are interfacing a "language independent speech recognition system" which allows users to search "keywords" by simply speaking them into their telephones in any language.

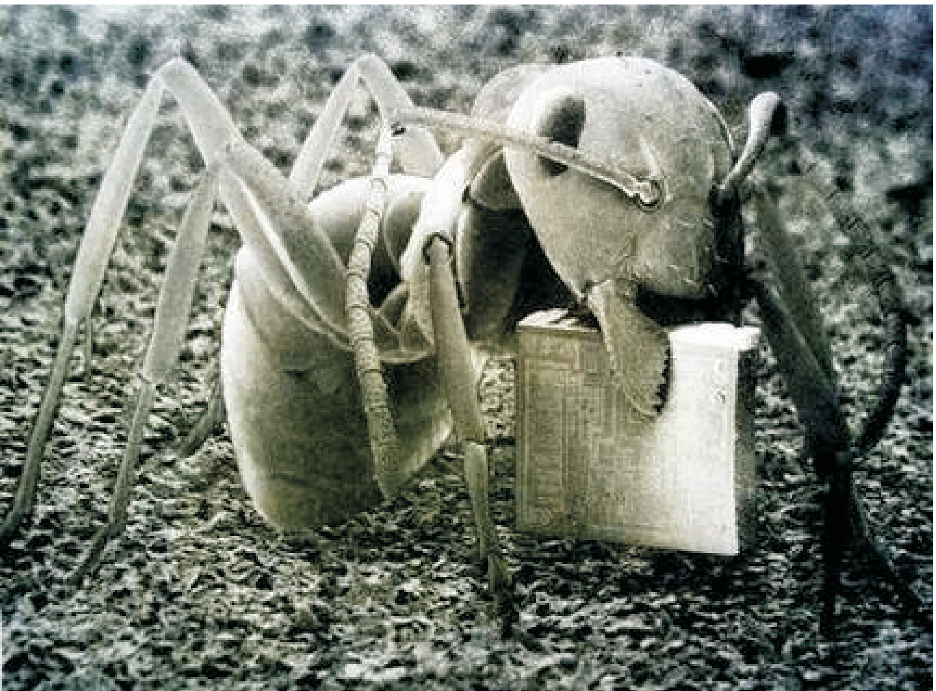
The system itself was built on Asterisk - which is perhaps the most important cog in the Voice over IP (VoIP) revolution currently taking place. Voice over IP is the new telephony technique in which servers based on Asterisk are setup in various regions and connected to each other over the Internet. Thus to make a telephone call from one place to another you only need to call the local Asterisk server and it uses its "free of cost" IP link to the far away Asterisk server . So in effect to make a long distance (STD or ISD) call the user is only charged for the local call to his local Asterisk server!! This whole system is the basis of software such as Skype which allow calling landline telephones at the cost of a dime! As a final prototype for the system, we have set up an audio movie review server in Boston which allows user to leave reviews for movies and listen to them as well. The service is being tested in MIT as of now and will soon be made public.

As challenging and intriguing as the work was, the most important thing for me was the experience. The way of working and the aims of research in a top notch university impressed me as much as the work ethic. It certainly helped me clear the ambiguity of the future in my mind and has given a definite direction to me!!

In the Beginning

The semiconductor industry is projected to be worth $260 billion(US) by 2009. That's saying nothing of all the industries where semiconductor based electronics are used, which is pretty much every industry these days. For e.g the computer industry, consumer electronics (mobiles, televisions), etc. It wouldn't be an exaggeration to say that without the semiconductor industry the world would be a much poorer place. But how did this industry come to be? Beginning this issue, a series of articles will take you through the historical developments and the men and companies responsible for establishing the industry.

a microchip in the mandibles of an ant



Solid state electronics first began in 1874. Ferdinand Braun invented a solid state rectifier. Unfortunately it was a very unstable device and quickly became obsolete with the invention of the vacuum tube.

In 1906, Lee de Forest made the vacuum tube triode or an audion. He used this three terminal device to make an amplifier for audio signals. Thus AM radio was born. Radio revolutionalized communication, allowing widespread dissemination of both information and entertainment to the public. Vacuum tube triode's also lead to the development of computers in the 1940's and 1950's. But their limits were soon reached. They were unreliable, big, they leaked, burned out and consumed too much energy. Clearly something else was needed.

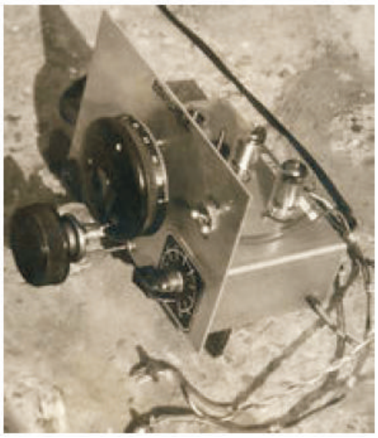
Not many people thought like that. Most people at that time thought that the vacuum tubes could be improved enough to meet all future requirements.

At this time people started accepting that there were possibilities in solid – state devices. To understand this statement one needs to become acquainted with the scientific theories of that time. The extensive understanding of semiconductors which we have today was not present in the 1920s-30s and in fact for some time to come. The theory of quantum mechanics was just being developed and this later on helped to provide a theoretical model of metals, insulators and semiconductors.

By the late 1930's, it was beginning to be more widely accepted that there may be opportunities to create some form of solid-state devices. At this time a man by the name of Mervin Kelly, at Bell Labs, decided in 1936 that he should start a solid-state device group. He challenged a number of people, Bill

Shockley, Russell Ohl, Jack Scaff, and others, to begin work on solid-state devices. Kelly had a feeling that the vacuum tube was not going to be the ultimate answer to electronics. Its reliability and size were such that something needed to be done, besides making more efficient and smaller vacuum tubes. By 1940, Russell Ohl had done a great deal of work, alongwith others at Bell Labs, in an attempt to understand silicon crystals. Ohl learned that depending on how you prepared single crystals of silicon, you could get either n- or p-type silicon.

It is amusing how people figured out the character of the impurities that were causing the difference between the n type and p type. It is said that when Jack Scaff and H. C. Theuerer were cutting up silicon wafers that were n type, they could smell the phosphate as they cut the material. They therefore knew it must be phosphorus impurities. That made a lot of sense because phosphorus has the extra electron. This shows how materials were identified prior to World War II. This was the status of solid-state electronics near the beginning of WWII, and it really did not change all that much during the war except in technology areas influenced by the work on radar. Radar requirements produced a very strong desire to fine-tune solid-state rectifiers, and this resulted in some effort to try to improve silicon and germanium materials.


a radio made using vacuum tubes

(Next time—Was the team at Bell Labs the first to invent the transistor? Or were there others who had gotten there before them. And we will come to see how the invention of the transistor was the result of the jealousy of a brilliant man.)

- Rahul Sangwan (3rd.yr.B.Tech)

Message from the Cepstrum Head

Hi Everyone,

Cepstrum, the ECE Student Society, the community that believes in developing professionals through various extra-curricular activities, is now back with a bang. The vision remains the same as it zoomed in from the past, with our hopes to carry it further down the road, making it an informal forum between the faculty and the students.

I still remember when I attended the orientation of Cepstrum in my first year, Vivekanand (Class of 2006, Ex. Gen Sec. Cepstrum) explaining our batch the significance of unity, and Cepstrum as a strand connecting us together. He told us the ways to use it for our benefit and enhance our knowledge. Since then that has always been our guide for future, be it problems in academics or be it applying for Higher Studies, there was platform for greater good called Cepstrum where every member was ready to contribute as much possible.

Cepstrum has been conducting various activities for the students till now and won't digress from its course. But unlike in the past, we see ourselves advancing towards a greater level of interaction. Interaction here is not only among various communities within the student circle, but in the department as a whole. All under the common banner of Cepstrum, where we think, decide and implement. And in this direction, Cepstrum is proud to launch the first Issue of its magazine "In Phase"- a window for us to be "In Phase" with the latest technological developments. And guess what, Cepstrum is back with a new website and a discussion forum for discussions on virtually any topic.

And what about future plans? Just Log on to www.peteranswers.com ☺ Understood?? Like at peteranswers.com while filing the petition you write the answer, you write your own future. Leave a mark that everyone will remember. And that is how the work is done here.

I personally believe that a student society is alive as long as its members are active. Cepstrum has been thriving in the hearts of ECE students. And it has grown like a tree now, is branching still and we hope it to continue like that. It is like a technical heritage as well as a personal showcase for you to the world.

With this I wish luck to In-Phase and hope that this journey carries on forever.
Let your dreams come true.

Romesh Khaddar
General Secretary 2007-08
Cepstrum – IITG ECE Students Society

Crazy Gadgets

Here's our pick of some cool, crazy gadgets, that only geeks would dare possess. Certainly a lot of imagination has gone into their making and you would need a lot of that to use them as well.

- assorted from 'cyberspace'

USB Powered Darts

The USB-powered darts come in a set of three, are, Mac and PC-compatible and can be controlled via a mouse. The basic idea is that you aim the darts with your mouse and fire them off with the mouse button. They are currently sold out at Marks & Spencer fo £19.50. Really ideal for those cubicled offices, to strike upon unsuspecting colleagues.

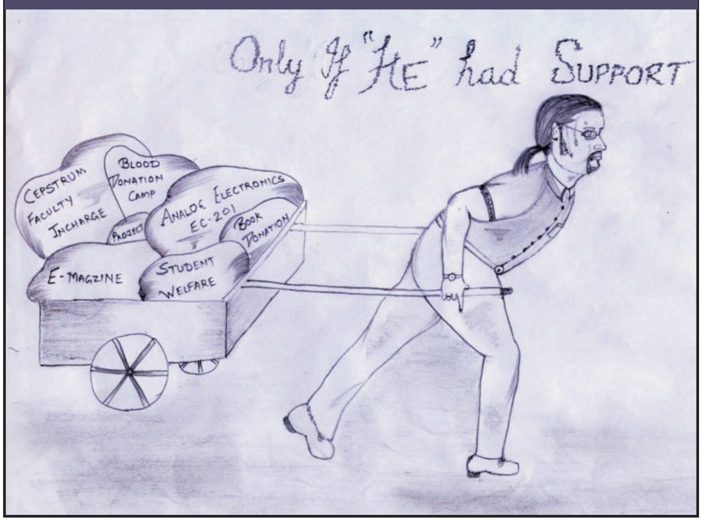
Cardboard Speakers

A company called MUJI, best known for their innovative yet simple products, has come out with speakers made of cardboard and a few electronic components They ship unfolded in a clear plastic pouch - fold them up and they're ready to use. Now that's what we call portability.

RSStroom Reader

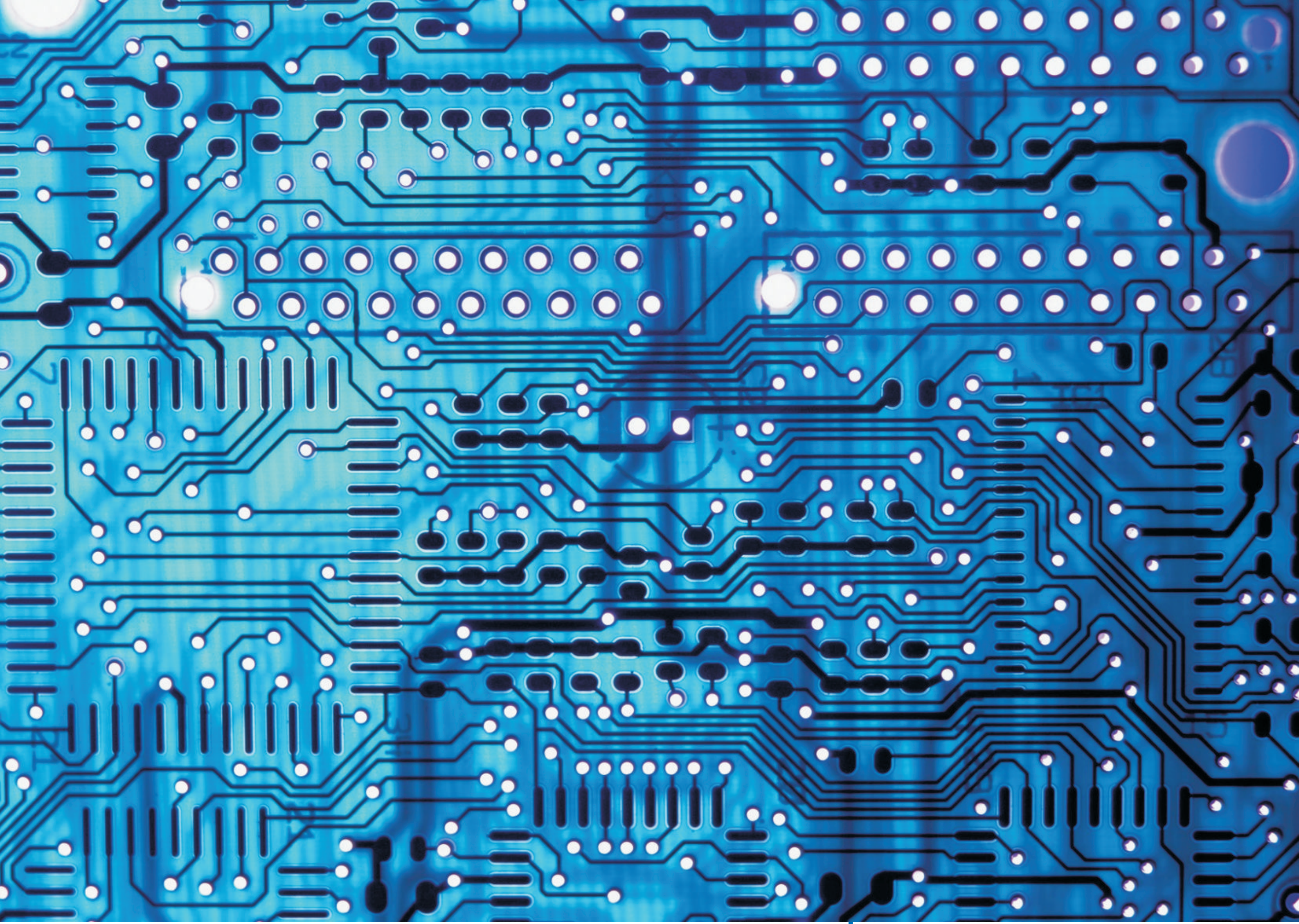
Introducing the RSStroom reader by Yi Tien Electronics, with this gadget you'll be able to print the latest RSS headlines directly on to rolls of toilet paper. It also features Wi-Fi Connectivity, USB 2.0, and RSS 2.0/Atom compatibility. This reader interacts with your toilet bowl "biometrically" which basically means when you sit down this thing will weigh you. Depending on your weight, it'll deliver you a customized news feed.

ECgiri by merath



Call for Articles

Being a monthly magazine, In Phase requires a constant supply of high quality original technical and non-technical articles. This is a request to all the students, specially the research scholars and those pursuing their master's, to share their projects, views, interests and knowledge with us through this magazine. Send in your articles (not more than two pages) to cepstrum@iitg.ernet.in and get in touch with the editors for any clarifications



RIGHT NOW...

Since you have spent this time going through the magazine, we really really need your feedback. And we all know that 'not now' always becomes 'never', so go ahead right now and write to us about what you liked, what you hated, what you'll like to see here, what about the design? and absolutely anything you wanna share with us.

Click here if you are registered at the Cepstrum forum to give us your thoughts or email them to cepstrum@iitg.ernet.in or akash@iitg.ernet.in