WiMAX: Technology for Future Mobile Broadband

From the editor...

Cepstrum wishes a very prosperous New year 2010 to all its readers!

IIT Guwahati's ECE student's body Cepstrum is proud to present to you the 9th issue of its magazine In Phase. We know that you all had to wait for quite some time for this issue but it was all due to technical difficulties the team was going through. We sincerely apologize for the inconvenience caused due to delay. But now In Phase is back to get you in phase with the recent developments in the world of electronics.

This issue features a mixed blend of articles ranging from social to technical, thus giving our readers a knowledgeable yet enjoyable insight of the happenings. The Dilemma by Dr. Amit Mishra talks about the socioeconomic fabric and the choice an engineer should make to be successful. Also featured is the development of networks and the different protocols implemented through time. So all the internet users it would be really fascinating to know about the birth and subsequent stages of networks. And in the cover article we present to you an in-depth introduction to WiMAX, technology for future mobile broadband. I hope you will find the articles interesting and useful.

I would also like to acknowledge that in last edition of In Phase the article on Recession and its effects on electronic industry was written by Aniketh Talwai, a third year student of ECE Department IIT Guwahati.

And once again I'll request you all to kindly send us your invaluable feedbacks and suggestions. In Phase is still in its early years and it needs the support of everyone to reach heights.

Atul Sancheti
Editor-in-Chief
(Final Year B.Tech)

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Dr. Amit Kumar Mishra

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Call for Articles

We are looking for technical as well as non technical and experience sharing articles from students, alumni, faculty members and industry professionals. Articles should be written keeping in mind the diverse range of targeted audience including people with little as well as extensive knowledge of electronics. Please email us at inphase@iitg.ernet.in for any clarifications or suggestions.

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THE DILEMMA

Amit Kumar Mishra

(Amit talks about socioeconomic fabric and the choice to be made by current engineering students!)

After visiting many a developed and developing countries I am shocked to realize that my own country is neither developed not developing! It's in a strange dilemmatic phase yet not defined in any book of economics. Problems are innumerable and so are the causes for such problems. The second part helps in assuring that the first part remains forever. We are undeveloped in the two dimensions of socio-economic fabric. We are poor as well as backward. And development means progress in both the fronts. Even Gandhiji himself has recognized this clearly when he told "*will it lead to swaraj for the hungry and spiritually starving millions*"! This short essay will expound few dimensions of this socio-economic fabric and the contribution that engineering can have on it. Before we start our main body, let me just share with you my comprehension on the meaning of "engineering". Engineering is an art; it's the art of making science work for real practical problems.

One of the major issues under discussion in school books and media is India's growing population. Some speculate that the population of India will become twice that of China by year 2040. It's a frightening though and figure. Indian media goes nuts by this speculation. However I have read a few analysis from foreign media which see this as a great resource! And they are true. When you say 2 billion people, you can see it in two ways. One way is to look at it as two billion mouths to be fed, which implies tremendous pressure on the resources. Another way would be to look at it as a 2 billion strong manpower, a power which is greater than any other resource in the world. So the major challenge in front of us is not to control population. That anyway is not possible in a diverse rainbow nation like India. The main challenge lies in converting these two billion mouths into four billion working hands and two billion thinking brains! And this needs immensely out-of-the-box application of engineering and technology. We have to innovate and fine-tune each and every nook and crannies of engineering to fit to our local needs. Manpower development has been the unquestioned jurisdiction of social scientists. However, the modern problem and futuristic development for socio-economic fabric of India will need engineers much more than social scientists.

Then comes another major thought for concern: scarcity of resources. This naturally leads the discussion to exploitation of nature and environmental degradations. All these need real engineers rather than any other professional. For every problem related to resources and environment, engineering is the answer. Modern day engineer will neither be expected to go to factories and work with engines nor would he be expected to sit in an AC room in front of a computer terminal. Rather he will be involved in projects with more and more component from natural resource and environment engineering problems.

Finally let me put it very crisply that if we are not tackling these problems today, we are definitely going to face the problem of feeding two billion mouths which is an impossible task. And this will cause in a civil war and complete destruction of the socio-economic fabric than anything else. Today is the day for training proper engineers. Engineer students are having more responsibility today than anyone else in the society. Because they not only have to learn and assimilate socio-economic concerns, they also have to do it all by themselves. They do not have the luxury of waiting till government and engineering educational bodies realize the importance of this and infuse these into the curriculum. Hence, my fellow future engineers, please come out of your fools' paradise; look out to the society; realize the grave choice that lies in front of us; and finally metamorphose into societal engineers not mere engineers.

(Dr. Amit Kumar Mishra is an Assistant Professor of ECE Department, IIT Guwahati)

A First Look @ Ubuntu

Ajaykumar Kannan

As a dedicated user of Microsoft's Windows XP, Linux and hence Ubuntu was a turnoff. I, like every other Windows user, believed that in-depth knowledge of programming languages and more importantly, Linux commands was required to use Ubuntu. But after having windows crash, screwing up one laptop and threatening to do the same with another, I decided that I've had it with uncustomizable user interfaces (Or rather an interface which required special software to customize) the "Blue Screen of Death" ,virus problems and slow start-ups. God knows that Windows has wasted enough of my time. So the first step was to get a copy of Ubuntu which was easily available on the intranet and then burn it on a disc. The installation process was easy enough. And the best part of it all is you get to try it before you... Uh... Well, since it's free. . Install it. . . With the live boot feature which lets you try our Ubuntu without having to modify anything on your PC. .That's just. .Well, there's no other word for it. Cool! Once you're running Ubuntu from the disc (Or even Pen Drive) you can install it. One important misconception was cleared. You do not need to know all the Linux commands in order to use Linux. In fact, Linux has a steep learning curve!

Now, on to the actual review. My first look at Ubuntu told me that Ubuntu was stunning! The GUI was much better designed than I had imagined. There are quite a few themes that ship with Ubuntu and many more can be installed. The desktop obviously has a customizable background. The icons on the desktop can be more, rearranged and even changed in size. Ubuntu has multiple virtual desktops. The times when you open more windows than you can count can be a major headache when running Windows but with the multiple virtual desktop feature, it's as easy as a single key combination to switch between them and more importantly, to move a certain window from one desktop to another. This really helps to organize your windows. Enabling the Desktop Cube feature turns Ubuntu into a cube with each side being a single desktop.

Ubuntu allow you to do a dual-boot. That means you can have both Ubuntu and Windows installed on your PC at the same time without having one conflict with the other. When you boot, you get to choose which OS you want to boot into. All software can be installed from Ubuntu's new Software Center. Anything from games to jukeboxes, VLC to Skype. You name it! Ubuntu even comes with an open source replacement for Microsoft Office known as Open-Office. Canonical has introduced a new feature in 9 . 1 0 known as Ubuntu One which provides 2 GB of free online storage or 5 0 GB for $ 1 month. You can use it to back up all your personal data. It allows you the option of being able to retrieve that data from anywhere else on the world. Ubuntu is compatible with almost all of the hardware devices you can think of, without installation of any drivers like in Windows. The support for wireless devices in Ubuntu is just astonishing. It requires absolutely no drivers.

There is a problem with internet in IITG. Everything requires a proxy server. .Setting that up in each and every program is quite a headache. Well, Ubuntu has an answer to that as well. It has a system-wide proxy setting which you only need to apply once. .Ta da!

You're all set!

As for the eye candy that so many users so desperately seek, Ubuntu offers that too. With the installation of a program known as Compiz Setting Manager, Ubuntu literally rocks! It also flies, wiggles, ripples, explodes, burns and everything else you can think of! As for viruses, they don't even come in the same sentence. .As Ubuntu. .See what I mean? The security features available is simply brilliant. Every time you wish to make a system-wide change, your password must be entered. Of course, if you leave your password lying around, well that's just being dumb and Ubuntu can't do anything about that. The Linux OS is built in a way that it is resistant to viruses. In addition to that, Windows viruses don't affect Ubuntu at all. Ubuntu comes with no open ports on public interfaces. When a hacker wants to enter your PC, he needs an open port. . . Well, you get the idea.

The Ubuntu Update Manager does a great job not only updating the system files and software but even all the other software you have installed on your PC. It saves you the hassle of downloading each new update for each of your programs and installing the updates, one by one.

The one area where Ubuntu is weak is gaming. .Games that are made for windows don't work on Ubuntu. Some, but very few, are compatible with Ubuntu after the installation of a compatibility layer known as Wine. Wine is yet another useful software available on Ubuntu. It allows the installation of Windows software on Ubuntu. A piece of good news for the musicians out there. There is an open source replacement for Guitar Pro known as TuxGuitar which is available through the Software Center which plays almost all forms of tablature files. Or you can install Guitar Pro using Wine.

A major advantage of Ubuntu is that it is an OS based on Linux and hence runs all the common Unix software packages and it can process all the common file formats. Another huge advantage is the fact that Ubuntu is open source. Open source doesn't just mean low costs (Or in this case, free) It means that the source code is available and users have the right to modify it. That gives you the power to tune Ubuntu to the maximum extent possible. It also makes it easier to fix bugs. Open source also means that you have the right to modify the source and redistribute it with improvements in the code. It also gives you the right to use the software in any way.
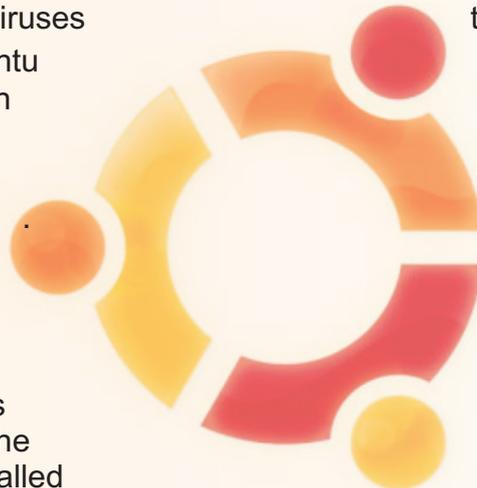
In addition to all that, Ubuntu has a very active forum where you can seek any help that you may require regarding the OS and any related issues. Chances are that the issues that you're having have already been dealt with so all you would need to do would be to search for it.

Ubuntu is not for everybody but the Canonical team is trying to increase the usability of Ubuntu. Also, I'm not saying that Ubuntu is better than Windows or any other operating system. Everyone has their own needs, preferences and expectations. Ubuntu has a lot to offer and is very appealing and does all the work that an IITian needs and much much more. . .

(Ajay Kumar Kannan is a first year student of EEE Department, IIT Guwahati)

INTERNSHIP

Nitesh Sinha

I was one among the recipients of the DAAD Scholarship who got the opportunity to work as an intern in Germany. It would be nothing more than a trite description if I call it 'a trip of a lifetime'. Through this article, I would like to share a few of the multitudes of experiences that I had there.

As soon as a stepped in Germany, a lot many strangers said "Hello" coupled with a pleasant smile. This gave me a very positive first impression about that country which of course, got bettered with each passing day. People in my hostel, my workplace and pedestrians I met on the road, were all very polite and talked in a very affable manner.

The next thing which crossed my mind was a natural admiration for the flawless system existing everywhere. The transportation, be it buses or trams or long distance trains, was all designed for the utmost convenience of the people. The markets, touring sites, etc were all managed smoothly. The detailed attention that had been paid while designing the "system" was quite remarkable. One doesn't need to know anything about the place one is visiting. The ubiquitous maps with all the bus and tram routes never let anyone to get lost.

A major difference exists in the attitude of the people in Europe to those in India when it comes to work. In India, the employers are more concerned with punctuality of the employee and also about the completion of stipulated working hours. On the contrary, in Germany my Supervisors were more focussed on work and provided me with a free will regarding the time at which I came to and left the institute. This helped me to deliver higher efficiency in my work because I could choose the time at which my mind was more productive.

What I did there except for the work was drinking about 300 mugs of free hot chocolate, available in my office, in a span of three months and of course, going on the 'EuroTrip'. Before you jump in to a conclusion of calling me a glutton for the first one, I would like to inform you that other people in my office used to drink 10 mugs of black coffee (it tastes ridiculous) a day. The second thing was not free (as you might have expected). It took 600 Euros to visit Switzerland, Italy and France. One needs to take some 'extreme' measures to fit this trip in that amount (Come to me for the details). But it is surely all worth it. Now I have photographs of me at the most popular tourist places in the world. I also explored Germany in quite detail as well. Berlin is a place to visit if one can. Lots of things to see, great Nightclubs and much more. Added to that, it didn't cost us a single buck as all of it was financed by DAAD itself.

I expect all my juniors who happen to goto Europe to have all this fun and more. But what I would like to advice to all the future IITGians going to Europe is respect the place. They have an adorable system in place and the people there treat outsiders with 'Atithi Devo Bhav' kind of spirit. Please avoid doing things that may ruin our image. A very trivial example would be of bus tickets. They do not have TTs in buses. Anybody can board on them anytime without paying a single buck if one doesn't want to. Checks happen once in a blue moon only. I would request you to get a bus pass. It would cost you 1 Euro a day. Certainly, you will save 70-80 Euros by not paying it. But if you get caught, all the oncoming Indians will be looked down to. So behave responsibly.

Enough of Germany saga, go on to the next article. I also have got a lot of work to do. Best of Luck!

*(Nitesh Sinha is a final year student of ECE Department, IIT Guwahati)*

MEMS SWITCHES:
Is this tomorrow under making?

- Pikkili Hemanth

The word MEMS has become so common-place these days that any student of electronics must have come across it already, without necessarily knowing the intricacies involved. But how many of us really know what MEMS are and also their importance? These devices emerged only in the early 1980s and ever since they have attracted great research scientists in this field due to its promising future. But did they really beat the age-old semiconductor counterparts or do they atleast have the capability to beat them or is it just a hype without scientific backing? Let us look at the underlining jargon which would help us find answers to our questions.

MEMS (or Micro Electro-Mechanical Systems) are a collection of micro-sensors and micro-actuators that work using a microcircuit and have the ability to sense their environment and react accordingly. RF MEMS have become more popular than MEMS operated at any other frequency. RF MEMS refers to the design and fabrication of MEMS for RF (3Hz - 30GHz) integrated circuits. A number of RF MEMS devices are in use such as RF switches (shunt and series), resonators, filters and amplifiers. Each has its own advantages and disadvantages over its traditional semiconductor counterparts. Of the number of MEMS devices that can be made, MEMS switches have been given utmost importance till date and widespread research is being undertaken in this area. We will deal exclusively with the electrostatically actuated MEMS switches.
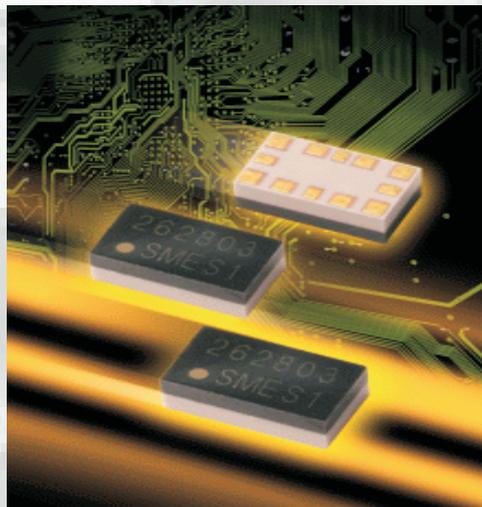
MEMS switches can be actuated by various mechanisms such as Electrostatic actuation, Electromagnetic actuation, Piezo-electric actuation, Piezo-magnetic actuation, Electrostrictive actuation and Thermal actuation. Sometimes two or more actuation techniques can be combined to actuate the switch. For example in the electrostatic actuation technique, piezoelectric or piezomagnetic actuation can be used to give an initial impulse to the switch for a faster switching action. The basic structure of any MEMS switch has two electrodes separated by some distance (one on the beam and the other on the bottom substrate). When a voltage difference is maintained between the top and the bottom electrodes, the electrostatic force of attraction between the beam and the bottom electrode moves the beam downwards thereby decreasing the distance between them. However the stiffness of the beam which acts as a spring, tries to counterbalance this motion. The electrostatic force of attraction decreases as a function of d2 (where d is the gap between the two conductors), whereas the spring force increases as d. So with decrease in the distance between the electrodes, the electrostatic force increases more rapidly than the spring force. Hence at a particular voltage, the spring force can no longer balance the electrostatic force and the beam loses stability thus snapping to the bottom. This voltage is known as the Pull-in voltage. This is the basic electrostatic actuation mechanism. MEMS

switches can be of two types: cantilever switches – fixed only at one end and fixed-fixed switches that are fixed at both ends. They can be used as series or shunt switches depending on the requirement.

There are a number of parameters that decide the quality of a switch such as the transition time, switching rate, switching transients, power handling, impedance matching, available bandwidth, insertion loss, isolation, series resistance, actuation voltage, resonant frequency, intercept points, phase and amplitude tracking and matching and life cycle. Softwares have been developed to test these parameters for any designed switch. However these are not perfectly accurate in their calculations and also any software cannot calculate all the switching parameters. The pull – in voltage calculations and the switching times have been calculated in CoventorWare 2006 for various simple and complex switches and has been seen that switches can be designed with very low pull – in voltages but not with high switching speeds. Even the reliability of the switches is limited to only a few tens or hundreds of millions of cycles when compared to the semiconductor devices which can operate for more than hundreds of billions of cycles.

The other important characteristics of the switches are the insertion loss in the on-state and the isolation in the off-state. Advanced Design System (ADS), IE3D and HFSS can be used to study the RF characteristics of the switches. ADS with its 2D graphics would be more suitable for beginners but advanced users can switch over to IE3D or HFSS. When comparative studies were done in the three softwares, it has been seen that the RF MEMS switches have a relatively low insertion loss in the on-state and high

isolation when the switch is off.

Thus RF MEMS switches have a near-zero power consumption, very high isolation, low off-state capacitances(2-4 fF), very low insertion loss, low intermodulation products and low manufacturing cost of the switches. However, they have their own share of problems which hinder their growth in the electronic industry and also commercialization thus limiting their current use to only radar systems for defense applications, automotive radars, satellite communication systems, wireless communication systems, instrumentation systems, etc. They have a relatively low switching speed, low power handling, high voltage drive, difficult to package them and high packaging costs. MEMS devices, especially switches, have thus had an impulse in the field of electronics but the impulse response has hitherto failed to create wonders. However, the foundations have been laid and the stage all set for the researchers to develop newer and better models which are more performance effective and also cheaper. I personally feel that the day is not too far away when we need to give a grand welcome to the MEMS based devices and say 'Astalavista' to the semiconductor devices.

(Pikkili Hemanth is an alumni of 2005 Batch, ECE Department IIT Guwahati)
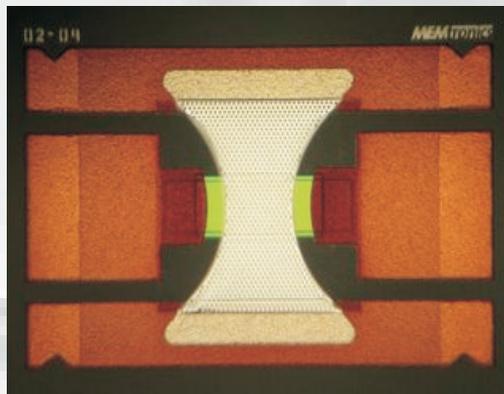
WiMAX

Technology for Future Mobile Broadband

Abhijit Mukhopadhyay

NEED FOR 4G technology: Evolution of WiMAX

In the last two decades, we have witnessed a major paradigm shift in the technology, starting from analog to digital, macro to micro and from fixed(or wired) communication to mobile(wireless) communication. There also has been an exponential growth in both tele-traffic and internet traffic. However, we are on the course of another boom- the growth of Broadband traffic. Until a few years ago, we saw basically two forms of broadband access: 1) Digital Subscriber Line (DSL), which delivers broadband over twisted pair telephone lines, and 2) Cable Modem technology which delivers over coaxial cable TV plants. With the introduction of new devices like iPhones and Netbooks, there has been a rapid surge in the mobile Broadband traffic with a plethora of internet based applications like web surfing, file downloads, emails and other multimedia applications like real-time audio and video streaming, multimedia conferencing and interactive gaming now being accessible on mobile platforms. These devices have ramped up the usage of mobile bandwidth to such an extent that most Bandwidth suppliers face serious challenges in the management and allocation of resources for satisfy this increased traffic.

From the consumer's point of view, the need for good quality of service at reasonable prices will always be there. From the service provider's point of view, with the tremendous increase in the number of consumers and the reduced cost
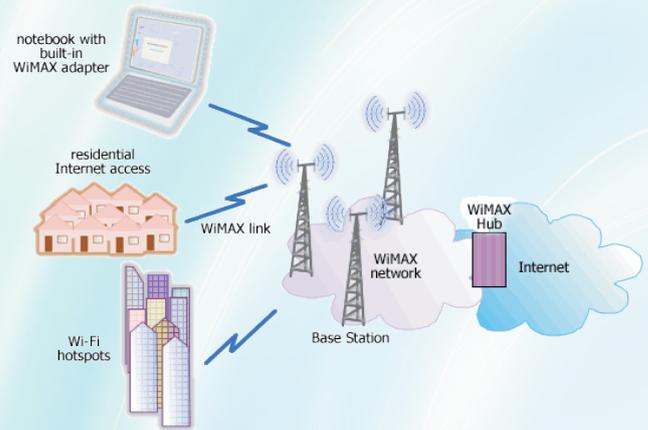

per bit (courtesy to the huge competition in Telecom industry), the only profit earning option left with them is with higher spectral efficiency for the available bandwidth. These demands necessitated the development of the 4G technology that addresses each of the aforementioned issues.

Development of WiMAX

WiMAX (or Worldwide Interoperability for Microwave access) is the most promising and feasible 4G technology (others being 3G-LTE, MC-CDMA, etc), which provides a holistic solution to both fixed and wireless communication requirements. Although the standardization of WiMAX is a recent issue, the basic technology it uses has been long developed. If we look at the basic PHY layer characterization of WiMAX, we will encounter two specific terms- OFDM/OFDMA and MIMO. If we look into the historical background of OFDM(Orthogonal Frequency Division Multiplexing), it was first shown in 1966 by Chang that multicarrier modulation can solve the multipath problem without compromising data rates and in 1977, the simple implementation of OFDM using FFT was demonstrated. There were several attempts to commercial OFDM usage like in digital broadcast. However, the major breakthrough came in 1997 with the evolution of IEEE 802.11(or commonly known as Wi-Fi), which incorporated OFDM for providing wireless LANs in 5GHz UNI band.

In 1998, IEEE formed the 802.16 working
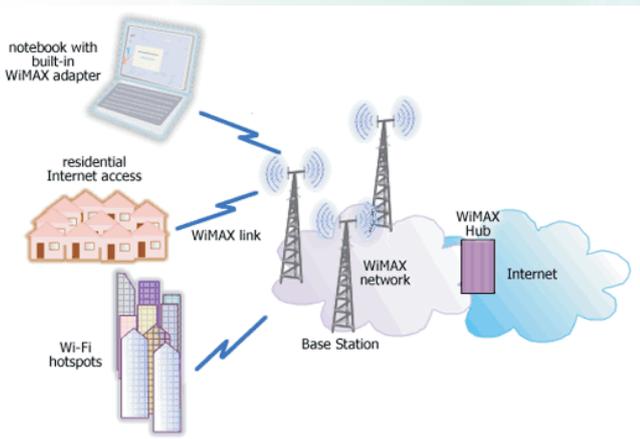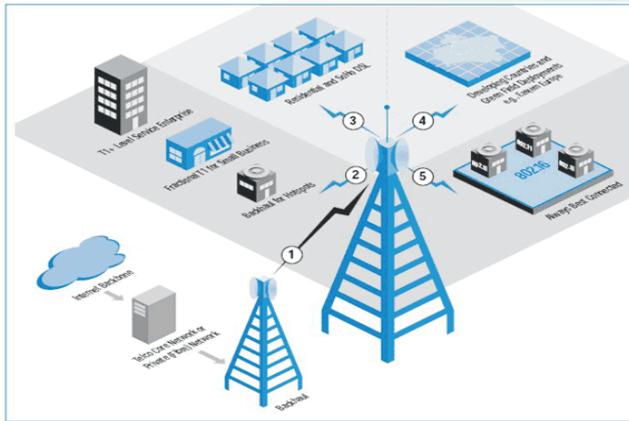
group aimed at developing Wireless MAN in the 10 GHz to 66GHz, basically aimed at delivering high-speed connections. Approved in December 2001, the first standard ,Wireless MAN-SC, specified a PHY layer using single carrier modulation techniques and MAC layer with burst time division multiplexing(TDM) supporting both FDD and TDD. After this several further amendments were made, resulting in IEEE 802.16a in 2003, in which PHY layer was based on ODFM and specified additional MAC-layer support, introducing OFDMA for the first time. Further revision were made resulting in IEEE 802.16-2004 which replaced 802.16, 802.16a and 802.16c with a single standard. However, in 2003, 802.16 group got involved in enhancing the specifications to make provision for vehicular mobility applications, leading to IEEE 802.16e (published as IEEE 802.16e-2005), which we know as WiMAX. Presently, work is going on further enhancement of WiMAX as 802.16m or Advanced-WiMAX.

Salient Features of WiMAX
WiMAX is a wireless broadband service that offers a rich set of features with a lot of flexibility in implementation issues or offering web-based or mobile based services.
1)   WiMAX PHY layer is based on OFDM, a scheme that provides good resistance to multipath and has good performance in NLOS (Non Line of Sight) conditions. It is based on dividing the entire bandwidth into thin slices called subcarriers, which are orthogonal to each other, hence the term OFDM. The breaking down of the channel can be incorporated using simple technique of FFT. Data and other relevant packets like FCH (foot control header), UL-MAP, DL-MAP, etc are transmitted through groups of these subcarriers called as sub-channels.

2)   WiMAX can provide very high peak data rates, in fact, as high as 74Mbps while operating in 20 MHz wide spectrum. On a more general note, using 10Mhz spectrum in TDD scheme with 3:1 downlink to uplink ratio, the peak PHY data rate is about 25 Mbps and 6.7Mbps for downlink and uplink respectively, using 64QAM modulation and 55/6 error correcting coding.

3)   WiMAX provides enormous scalability in data rates depending upon available channel bandwidth. This scalability is supported in OFDMA mode, where FFT size (corresponding to number of subcarriers) may be modulated based on available bandwidth.

4)   WiMAX supports a number of modulation and forward error coding correction(FEC) coding schemes, and provides the additional flexibility of switching amongst them on a per user and per frame basis depending upon channel conditions. For example, Adaptive Modulation and Coding (AMC) is an effective mechanism to maximize throughput in a time varying channel.

5)   WiMAX supports duplexing modes in both time and frequency domains, TDD and FDD, also a half duplex FDD, which has low cost system implementation. However, TDD is preferred for a majority of applications because a) of its flexibility in choosing downlink to uplink data rates ratio b) it has the option of exploiting channel reciprocity c) it is implementable in non-paired spectrum and d) its transceiver design is simple.

6)   Mobile WiMAX intelligently uses OFDM as multiple access control (or OFDMA), whereby different users are allotted different

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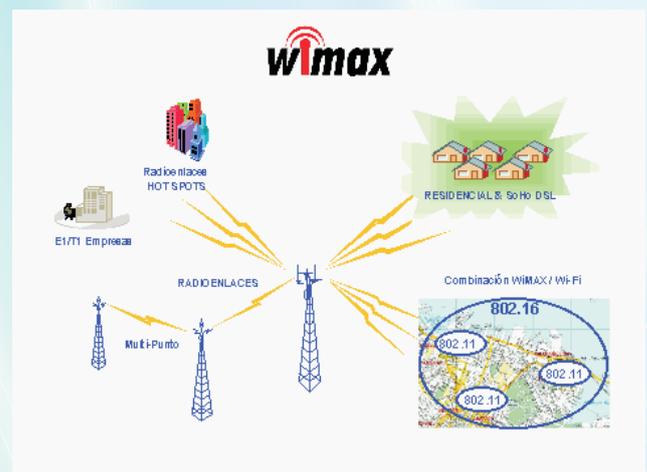
subsets of ODFM tones (or subcarriers). OFDMA significantly exploits frequency diversity and multiuser diversity to improve system capacity.
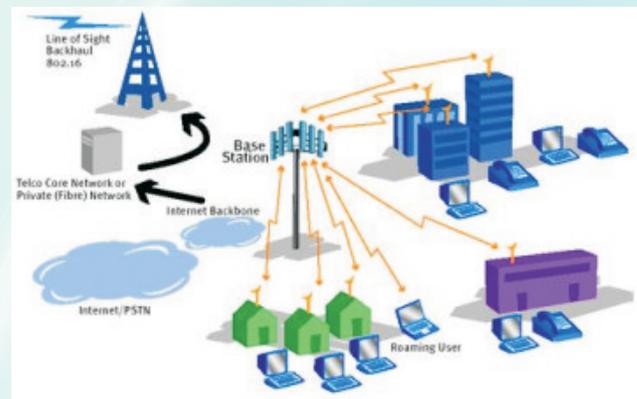
7)   WiMAX standard allows the bandwidth resource to be allocated in frequency, time and space domain and has a flexible mechanism to allocate uplink and downlink resources to different users using a scheduler, which is based on demand basis. In OFDMA-PHY mode, frequency dimension is implemented by allocating different subsets (based on certain Permutation) of OFDM subcarriers to different users. However, in space domain, resources are allocated using the optional advanced antenna systems.

8)   As previously mentioned, simple PHY layer description of WiMAX can be OFDM-MIMO. WiMAX solution has plenty of options of using multiple-antenna techniques such as beamforming, space-time coding and spatial multiplexing, which when implemented in the transceivers can significantly improve overall system capacity and spectral efficiency.

9)   A special feature of WiMAX is its connection-oriented MAC (medium access control) architecture, which supports a variety of applications as well as support for constant bit rate, variable bit rates, real time and non-real time traffic flows. As such, it supports a large number of users, with multiple connections per terminal, each with its own QoS (quality of service) requirement. For example, voice traffic can tolerate small degree of packet loss but in Internet based banking operations, this is an issue. WiMAX as such gives preferential support to high reliability requiring applications to low reliability requiring applications (Service specific Convergence Sublayer).

10)   The mobile WiMAX has inbuilt mechanisms to handle seamless handovers when a mobile station is moving from coverage area of one base station to another, and thus provides minimum disruptive connectivity for delay-intolerant full mobility applications.

11)   Talking in an age when GREEN Technology is much envisaged, WiMAX has built-in support for various power saving mechanisms, which prolongs the battery life of handheld subscriber devices. Unlike present-
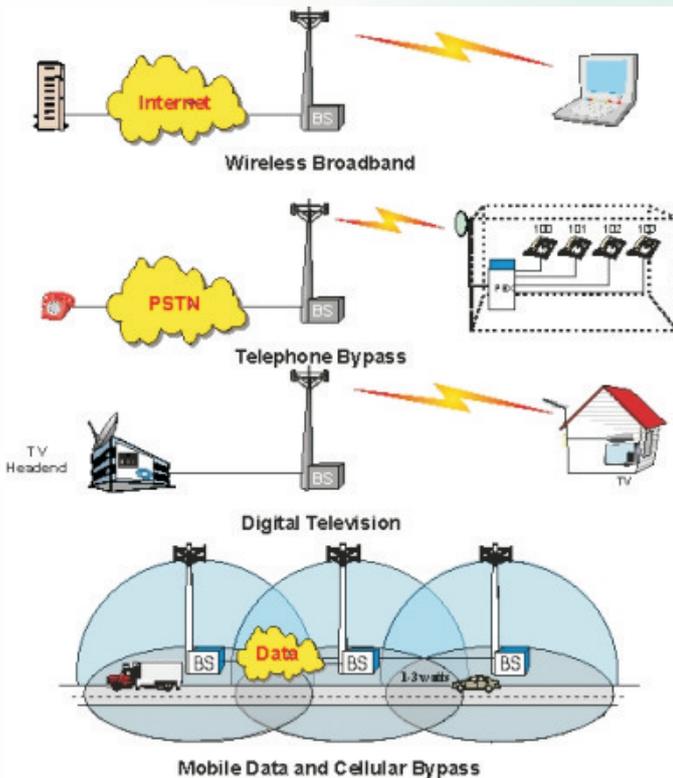
day devices, where power consumption is controlled in two modes- connected mode(when system is connected and power is consumed) and sleep mode(when system is not connected power is not consumed), WiMAX based device incorporates an additional idle mode, due to which power retention of system has increased many folds.

12)   The central dogma of the network architecture of WiMAX is its all-IP platform. This IP architecture based on IP-based protocols allows delivery for all end-to-end services along with QoS, session management, security and mobility. IP based platforms also have provision for declined costcurves of IP processing, easier convergence with other network platform (eg. ATM (Asynchronous Transfer Mode)) and exploitation of the huge ecosystems for application development that exists for IP.

13)   WiMAX provides a robust security and privacy, strong data encryption(using Advanced Encryption Standard(AES)) and has a very flexible authentication architecture based on EAP(Extensible Authentication Protocol), that includes a variety of user credentials, like username/password, digital certificates (which are embedded on the system and can't be replicated) and smart cards.

On a much more comparative analysis of WiMAX with presently existing wireless broadband facilities like 3G (based on CDMA) and Wi-Fi, it has been proven that WiMAX is much more flexible and efficient. Unlike 3G systems which have fixed channel bandwidth, WiMAX defines a selectable channel bandwidth, which can be modulated depending upon user demands. Talking in terms of other parameters like average throughput and system capacity, a pertinent

Wireless Broadband

Telephone Bypass

Digital Television

Mobile Data and Cellular Bypass

measure is spectral efficiency. WiMAX can achieve higher spectral efficiency than 3G systems by including options like multiple antennas, which is being included in 3G as revisions. Moreover, the implementation of MIMO in OFDM based systems is much simpler as compared to MIMO inclusion in CDMA based 3G systems, which require complex transceiver hardware. Amongst other advantages of WiMAX is efficient support of more symmetric links, advanced IP based applications and in built technology that prioritizes traffic nature and controlling QoS accordingly.

Challenges for Broadband Wireless and WIMAX

Despite its technical supremacy over other existing technology and marketing hype, commercial implementation of WiMAX faces a number of challenges in both Business domains as well as in Technical domain which may impede to its market adoption.

Firstly, looking into the business challenges, the rapid evolution of fixed broadband technologies like DSL or cable modem pose a serious threat to WiMAX adoption in mature markets. Although WiMAX might have low infrastructure cost advantage, DSL or cable modem benefit from their declining cost on their CPE (customer-premise equipment) because of their mature

market state. Another serious challenge comes from 3G operators which are being deployed worldwide by operators, which would rather seek performance improvement in existing technology than switching to a new technology. For WiMAX to be successful, they must provide significantly better performance than current alternatives like 3G or Wi-Fi, which being saddled with a number of constraints by make system design a formidable technical challenge. Some of the obvious technical obstructions include developing reliable communication schemes to push broadband data through a hostile wireless channel which is already ridden by other wireless standards, providing robust quality of service with the rampant increase in traffic and exponential increase of consumers. Additional challenges include incorporating various flexibilities that the WiMAX standard promises like preferential quality of service depending upon nature of traffic, seamless handover and roaming and adapting IP-based protocols and architecture in mobile platform and convergence with wired networks.

Despite the presence of all these technological and economical constraints, WiMAX provides a holistic solution to the increased traffic and number of users, and at the same time providing reliable quality to consumers along with providing a big margin of profit for the service providers. In the next decade, we are looking towards an age of "Mobile Internet" or the 4th generation of communication industry and WiMAX might be one of those technologies which provide the solution to the growing needs.

(Abhijit Mukhopadhyay is a third year student of ECE Department, IIT Guwahati)

Network Protocols

Harpreet Singh

We all are familiar with the term Internet. It's the driving force behind everything today. With each computer being connected, little distances are left between any two persons. The way our world has revolutionized after Internet is, phenomenal. Many of you wonder as to how this whole mesh of networks and computers works or how do you get to see websites in USA, sitting in India or anywhere in the world. This article gives a peep into the working of the Internet.

The basic idea behind a network is just 2 or more than 2 systems connected together, sharing information. This simple technique is implemented in the application of Internet. This complex network of systems is used to share and distribute data, files or any other information. This is done through protocols. We can state that protocol is a set of rules that determines or monitors the communication across a network.

There are different kinds of protocols, the most famous one being 'http' (acronym for Hyper Text Markup Language). Since its launch by US military, Internet has seen tremendous growth. It can be said that our growth is synonymous to Internet's growth. A lot of improvement has been recorded in the internet protocols. Owing to this improvement, we have reached a level of excellence in the field of networking.

The list of commonly used protocols is:
1) IP
2) UDP
3) TCP
4) DHCP
5) HTTP
6) FTP
7) Telnet
8) SSH
9) POP3
10) SMTP

A brief summary of some selected protocols is provided hereon.

1) IP (Internet Protocol)

The Internet Protocol (IP) is a protocol which finds its use in communicating data across a packet switched internetwork using the Internet Protocol Suite, also known as TCP/IP. IP is the primary protocol in the Internet Layer of the Internet Protocol Suit and is assigned the task of delivering distinguished protocol datagrams (packets) from the source host to the destination host just based on their addresses. For this to work, the Internet Protocol defines addressing methods and structures for datagram encapsulation. The first major version of addressing structure, now referred to as Internet Protocol Version 4 is still the dominant protocol of the Internet, although the successor, Internet Protocol Version 6 is being deployed actively worldwide.

Owing to the abstraction provided by encapsulation, an IP can be used over a heterogeneous network, i.e., a network connecting computers which may consist of a combination of Ethernet, ATM, FDDI, Wi-Fi, token ring, or others. Each link layer implementation may have its own method of addressing, with a corresponding need to resolve IP addresses to data link addresses. This address resolution is handled by the Address Resolution Protocol (ARP) for IPv4 and Neighbor Discovery Protocol (NDP) for IPv6.

2) TCP (Transmission Control Protocol)

The Transmission Control Protocol (TCP) is one of the core protocols of the Internet Protocol Suite (ICP). TCP is one of the two original components of the suite (the other being Internet Protocol, or IP), therefore the entire suite is commonly referred to as TCP/IP. While IP handles lower-level transmissions across a network as a message makes its way across the Internet, TCP operates at a higher level, concerned only with the two end systems, for instance a Web browser and a Web server. In particular, TCP provides reliable, ordered delivery of a stream of bytes from a program on one computer to another
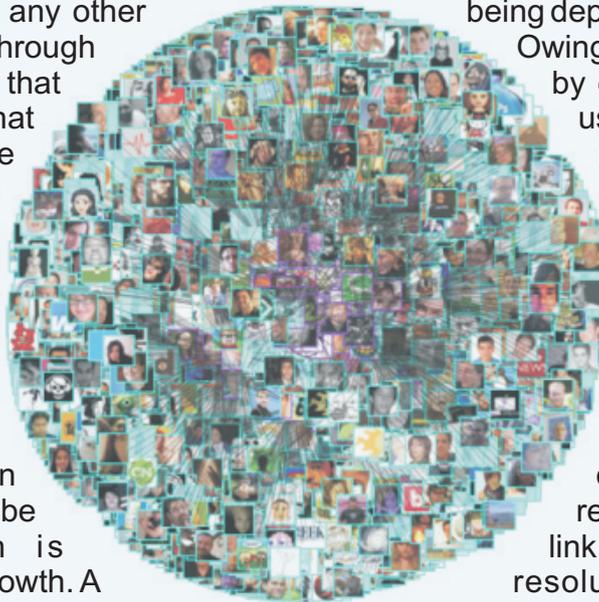
program on another computer. Besides the Web, other common applications of TCP include e-mail and file transfer. Among its other management tasks, TCP controls segment size, the rate at which data is exchanged, and network traffic congestion.

3) HTTP (Hyper Text Transfer Protocol)

Hypertext Transfer Protocol (HTTP) is one of the most well known protocols in today's world. It is used for retrieving inter-linked resources, called hypertext documents. This use led to the establishment of the World Wide Web in 1990 by English physicist Tim Berners-Lee. HTTP is a request/response standard as is typical in client-server computing. A terminology of HTTP is required to understand the basics of it. A client is the application (web browser, spider) or computer used by an end-user, the server is the computer hosting a web site. The client submitting HTTP requests is referred to as the user agent. The responding server is called the origin server. HTTP is not constrained in principle to using TCP/IP, although this is its most popular application via the Internet. Indeed HTTP can be "implemented on top of any other protocol on the Internet, or on other networks." It only presumes a reliable transport; any protocol that provides such guarantees can be used." Hence a client sends a request to the server to access a webpage. Then the server processes that request and replies back to the client.

Resources to be accessed by HTTP are identified using Uniform Resource Identifiers (URIs) —or, more specifically, Uniform Resource Locators (URLs)—using the http: or https URI schemes most commonly known as the web addresses.

4) FTP (File Transfer Protocol)

File Transfer Protocol (FTP) is a standard network protocol used to exchange and manipulate files over an Internet Protocol computer network, such as the Internet. FTP is built on client-server architecture, just like the HTTP and utilizes separate control and data connections between the client and server applications. Client applications were originally interactive command-line tools with standardized command syntax, but graphical user interfaces have been developed for all desktop operating systems in use today. FTP is also often used as an application component to automatically transfer files for program internal functions. FTP can be used with user-based password authentication or with anonymous user access. The Trivial File Transfer Protocol (TFTP) is a similar, but simplified, not interoperable, and unauthenticated version of FTP.

5) SSH (Secure Shell Protocol)

Secure Shell or SSH is a network protocol that allows data to be exchanged using a secure channel between two networked devices. Used primarily on Linux and UNIX based systems to access shell accounts, SSH was designed as a replacement for Telnet and other insecure remote shells. SSH provides confidentiality and integrity of data over an insecure network, such as the Internet. SSH uses public-key cryptography to authenticate the remote computer and allow the remote computer to authenticate the user, if necessary. It is typically used to log into a remote machine and execute commands, but it also supports other features as tunneling, forwarding TCP ports and X11 connections. SSH uses the client-server model. The standard TCP port 22 has been assigned for contacting SSH servers.

The above mentioned protocols were the earlier versions of the protocols which have undergone a sea change since their inception. A new class of protocols has emerged which has led to a speedy and secure Internet. These will be dealt in the next issue but the protocols mentioned till now are the very basic and indispensible indeed. They work on a common client-server based type communication. These protocols have helped us define and design mechanisms that govern the rules using which a certain data packet can be sent over a network. Internet would not have been possible without them.
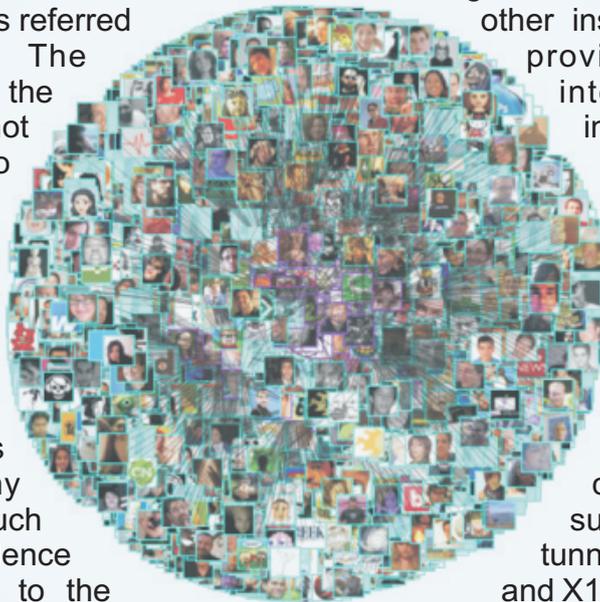
# Analogue circuits are here to stay

Introduction

Electronic circuits can be broadly categorized as being of two kinds – analogue and digital. To describe it crudely, analogue deals with continuous time signals while digital deals with discrete quantized bits of data. People often imagine that the future of electronics is all digital. After all, we are getting digital CD's instead of old analogue tapes and records; digital cameras are replacing film ones and even broadcast television is going digital around the world. However, all this digital content is making analogue ever more important. That is because the real world is analogue. Every one of the digital systems must interact with real world to be useful and that is where analogue adds value.

For readers who are not entirely familiar with modern integrated circuit manufacturing process, a short introduction is in order. Most of modern electronics is produced using silicon integrated circuits for cost, space and scalability reasons. A circuit designer (digital or analogue) designs an electronic circuit using her training and experience. This design information is then converted to a "layout" by mask designers. The layout information is used by the mask vendors to create photolithographic masks with extremely fine features. The manufacturing plant uses several deposit-pattern-etch cycles to create the integrated circuit on silicon wafer. Modern integrated circuit process needs 20-40 such cycles, each cycle depositing one layer. The masks are used in the patterning step, by using shining light through them.

Analogue and Digital

Digital electronics lends itself to abstraction and formalism that allows some of the design process to be automated. Typically, the digital designer describes and simulates the circuit at a high-level of abstraction using a language such as Verilog and uses a synthesizer to convert the description into a lower-level gate netlist. This more detailed circuit can then be simulated using characterization information about the standard gates. A place-and-route software uses the gate level netlist, design
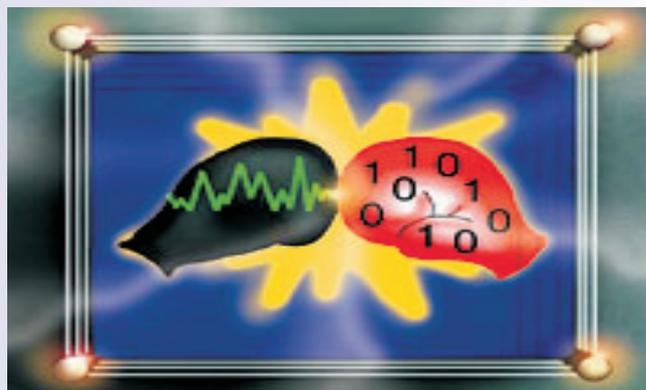
constraints and information about the manufacturing process to create a layout. The above steps are often repeated a few times until satisfactory performance is achieved using computer simulations.

Analogue electronics does not have any general abstraction and formalism. The designer has to be aware of performance of the electronic devices available at her disposal, knowledge of subcircuits that can be used to achieve specific signal conditioning and the experience to understand the interaction of sub-blocks of a design. Once the design is complete, a mask designer typically lays out the circuit using her knowledge and experience to ensure an accurate realisation of the designers circuit. Again, automation is not usually feasible here as the analogue circuit usually needs to get every last iota of performance possible.

Analogue circuits are seldom very large (in terms of number of transistors). However, design complexity is usually much greater than digital circuits. By some estimates, a typical electronic system may have 80% digital circuits and 20% analogue in terms of area, but in terms of design time for the project 20% goes to digital and 80% to analogue. The trend is in the direction of increased analogue complexity. With the latest technology, it is possible to make transistors that are a mere 100nm in size, but they are mostly useful only for digital design. Analogue circuits usually need larger devices to achieve good enough noise performance. This also makes the analogue portion of the circuit more expensive. Both analogue and digital electronics have

advantages and disadvantages. We will list a few in the following paragraphs.

Digital circuit can be programmable. This allows circuits to be versatile and perform different tasks at different times as per the users desire. Analogue circuits, on the other hand, are seldom programmable. They have to designed to perform a specific purpose.

Digital signalling and circuits are more robust in the presence of noise. As long as the signal can be detected, digital circuits can create perfect replication. Analogue signals and circuits suffer from noise and non-linearity induced degradation.

When it comes to interacting with the real world, digital is mostly useless. You need the speaker to produce continuous sound, the microphone to capture everything you say and the camera to take pictures in more than two colors. All long distance transmission of signals is necessarily analogue, because of the phenomenon of dispersion.

When the function is simple, analogue circuits can get the job done using less area and power.

Analogue also helps at the other end, where one needs the best possible speed of processing. For example, while one can use digital circuits to process signals up to say 500MHz bandwidth using current technology, any signal that needs higher bandwidth, must necessarily be analogue. This because digital processing takes time, while analogue happens in real-time.

Types of Analogue Circuits

Analogue circuits can be broadly classified into five categories: linear, data-conversion, interface, power and radio-frequency.

Linear circuits include amplifiers, comparators, operational amplifiers. They are found in plenty in almost any electronic system. Any time a sensor or a transducer is used, the signal typically needs to be amplified before it can be used further.

Data-conversion circuits include analogue-to-digital converters and digital-to-analogue converters. They are the circuits that enable digital electronics to interact with the real world. Interface circuits enable wired communication. They include circuits such as level-translators, equalizers, phase-locked-loops, clock distribution circuits, etc. Some of them enable digital circuits to function (clock generation and distribution) and others allow communication of signals to remote areas.

Power circuits include dc-dc and ac-dc converters. Signal processing requires power and that power is provided by these circuits. For example, every computer must convert the AC line voltage to 12V and the further convert it to lower voltages for various power subsystems.

Radio-frequency circuits include circuits such as mixers, power-amplifiers, detectors etc. They enable wireless communication.

Conclusion

Analogue circuits are essential enabler of the current explosion of electronic circuits. A recent article had found that a modern cellular phone handset has more analogue electronics than the old analogue handsets. While the old analogue handsets used a simple FM circuit for signal transmission an d ran straight off the battery, a modern one uses sophisticated signal encoding and decoding, uses power management to make the most use of the battery and has an FM receiver so you can listen to the music when you are not talking.

Analogue talent is in short-supply and the forecast is for the situation to remain the same for the foreseeable future. Analogue jobs are usually in good supply, even in the downturns. In the last downturn at the turn of the century, while many of the digital circuit positions were eliminated, very few of the analogue ones were.

A fun tour to MATLAB

Debabrata Sengupta

Matlab is probably one of the most powerful and versatile softwares that I've come across. As Barney Stinson would have put it, "It's Awesome!!" and there's no denying that. Typically most articles and presentations on Matlab start with "Everything in Matlab is a matrix". However, in this article, I will not bore you with how to code in Matlab; indeed it's too trivial to be even discussed here. We would rather explore those interesting things in Matlab that are not matrices.

Tic – Toc

Trying to make your code more efficient and fast? Here's one function that you can use as a parameter for estimating the efficiency of your code : 'Tic – Toc' ! Sounds weird, isn't it ? Childish though the name may seem, the function is really cool. Typing tic starts Matlab's own internal stopwatch timer while typing toc stops the timer and displays the time elapsed on the screen. The timing is precise upto 1 microsecond! You can use this pair to estimate the run time of your codes. You can also observe how nesting of for loops is sufficient for introducing a large delay. On a lighter note, try measuring your reading speed with tic and toc. *Tics and Tocs can also be nested!*

GUIDE

GUIDE stands for Graphical User Interface Development Environment. It is Matlab's own interface for building a GUI from scratch. Yes people, you can design your own elegant GUIs for taking in inputs from the user or displaying messages. It's really easy and fun to use. You can simply drag and drop features like radio buttons, text boxes, push-buttons etc onto a blank GUI and then add callbacks to make your GUI fully functional. If you are wondering what callbacks are, just go through Matlab Help yourself… why should I tell you everything ?

Using GUIDE you can build your own calculator which is more powerful than the calculator provided by Windows. Although the idea of building a GUI might appear complex now, I assure you that it's really simple and yet powerful. To give you an feel of how powerful it is, consider this - Techniche '09 was saved a lot
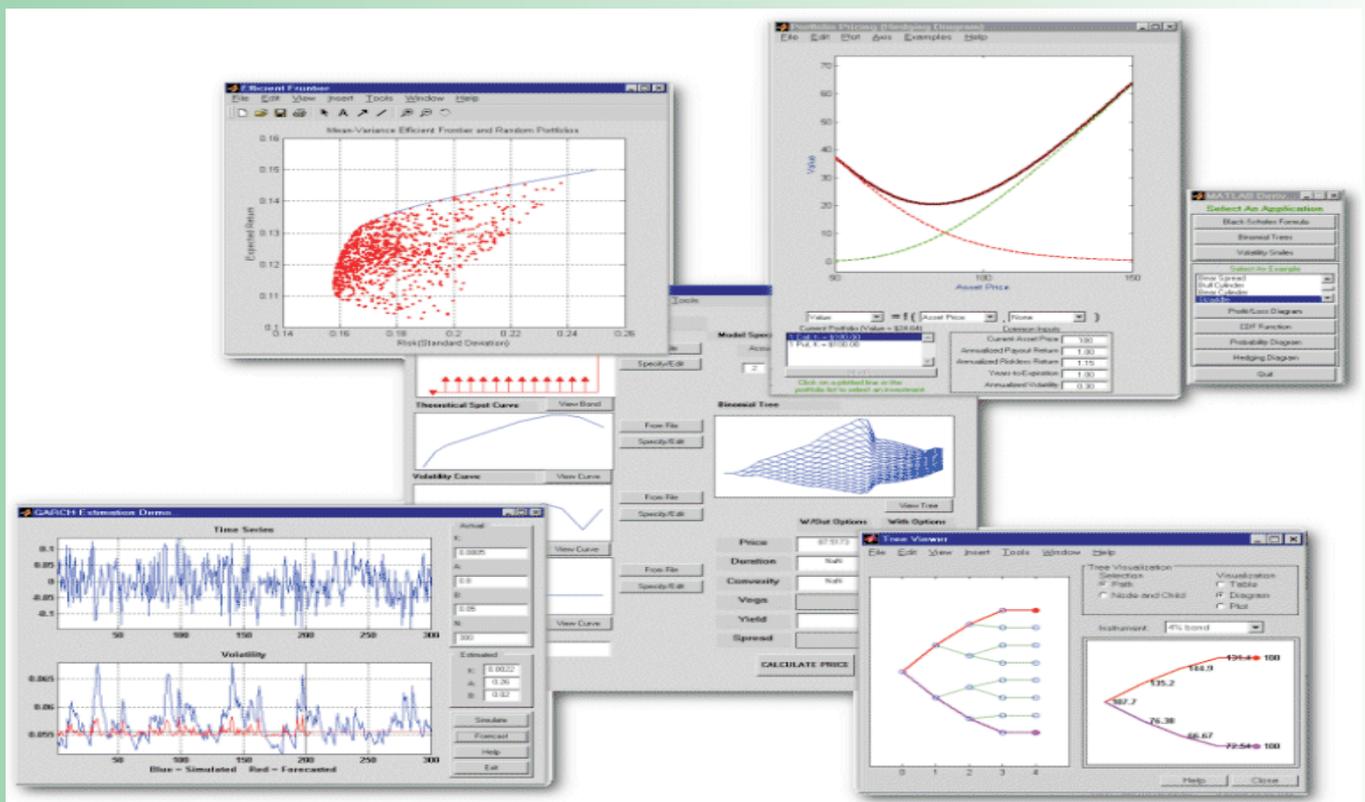
of paperwork because the participant registration and hospitality process was fully automated. In fact, the software that was used was a simple GUI designed using Matlab by one person alone!

You can start GUIDE just by typing guide or clicking on the guide button in the toolbar above.

REPORT GENERATOR

The Matlab Report Generator can be used to create a documentation of your codes and the results that you have obtained. It is a GUI where you can build your report by choosing which pre-defined templates to include. For example, once you have written a your code, using report generator you can automatically run the simulation and then include all plots, tables, values of variables, texts, graphics (pictures), etc. in one comprehensive document. This document is automatically generated with your desired formatting, cover page and other features. The document can be saved in different formats starting from PDF to .doc and .rtf. What I find most attractive in this is the hassle that it saves you – no need to save individual plots and then insert them into your report, no need to manually create tables containing your simulation results – just choose what templates you want and then Matlab does the rest for you, automatically!

You can start the report generator by typing report in the command window.

Sound and Beep

In case you are working with large images, or running really long simulations on Matlab, it takes quite a bit of time (maybe more than 15-20 minutes as well!!). Obviously, it's a much better idea to use your computer for something else during this time rather than staring at the blank Matlab screen, waiting for 'Busy' to change into 'Ready'! But then, how do you know that your simulation's over? That's where the functions sound and beep come in. beep produces the computer's default beep sound once. On the other hand, sound is more versatile and programmable. It takes in as input a vector of values between -1 and 1 and converts this signal into a sound signal and plays it on the speaker. Interestingly (though quite obviously) the sound produced is different for different values of the input vector. If your input is a sinusoid, you can control the pitch of the sound produced by adjusting the frequency of your sinusoid. You can also control the duration of the sound signal by changing the length of your vector.

Adding a short code snippet at the end of your actual simulation codes to produce a sound (using sound or beep) will alert you when the simulation is over, and you can go back to Matlab once again. Cool…. isn't it?

Why?

In case you are feeling a bit philosophical after a long day of hard work on Matlab, try asking yourself any question that has lingered in your mind for long and then turn to Matlab for an answer. Just type why in the command prompt and see what answer Matlab gives you!

why provides a random answer to any question. You can also enter a number as a parameter along with why, eg. why(10). Matlab then displays the 10th answer from its list of 232 answers to all your questions!

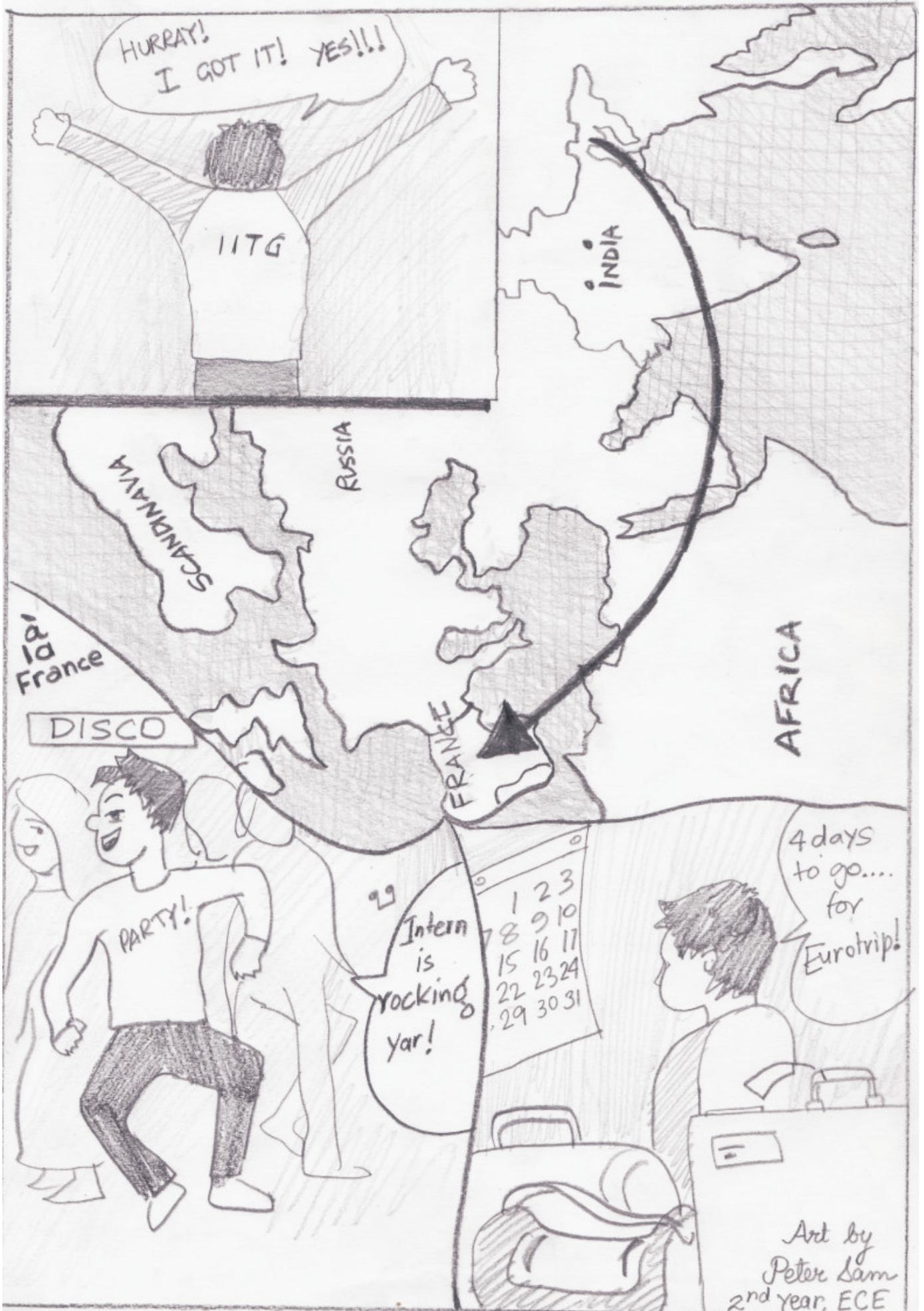In case you are thinking, "This article is all about stuff that I'll never use again …. why am I even reading it?" , type why(27) and see what answer Matlab has in store for you.
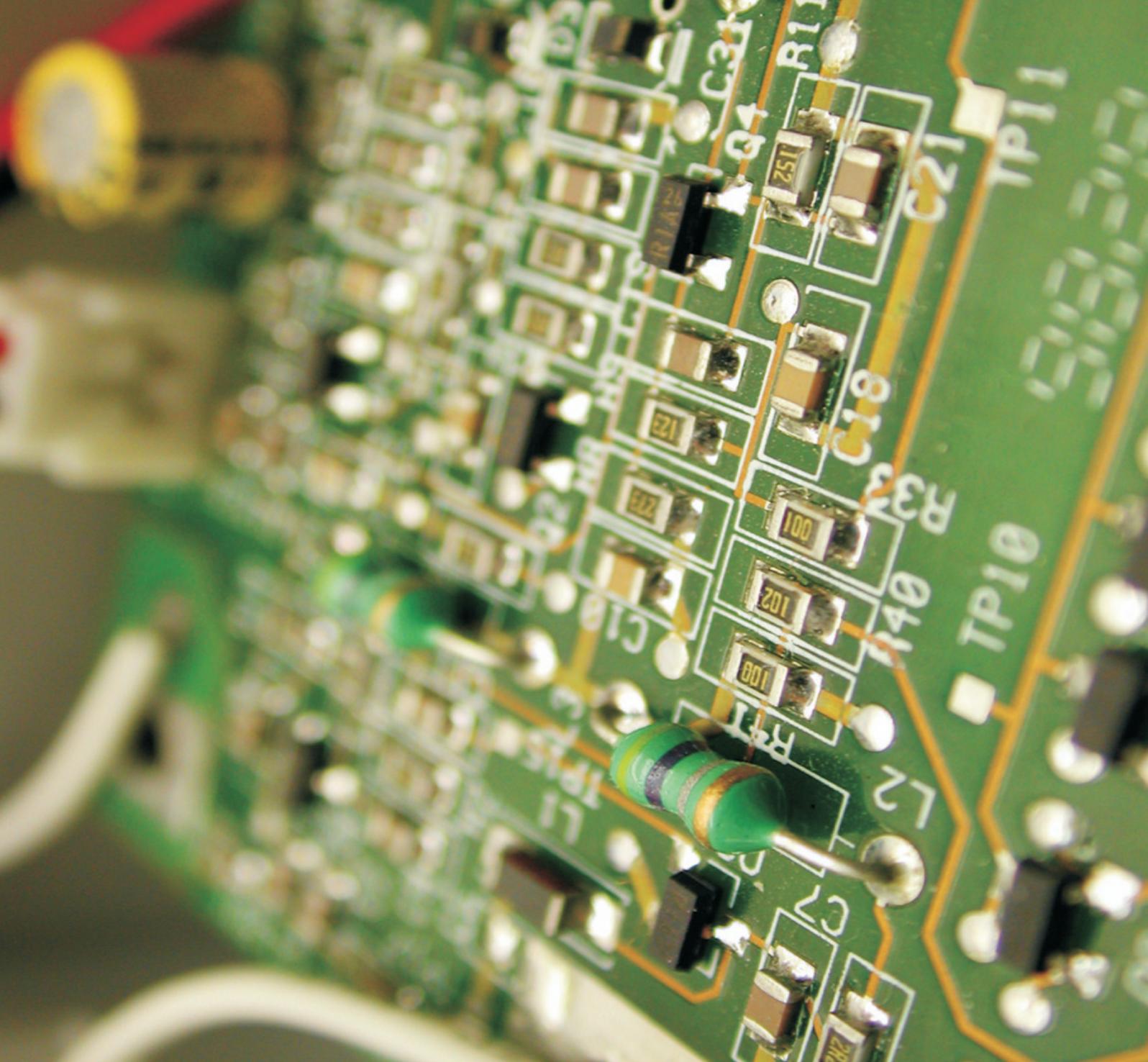
(Debabrata Sengupta is a third year student of ECE Department, IIT Guwahati)

Fun Page

Peter Sam
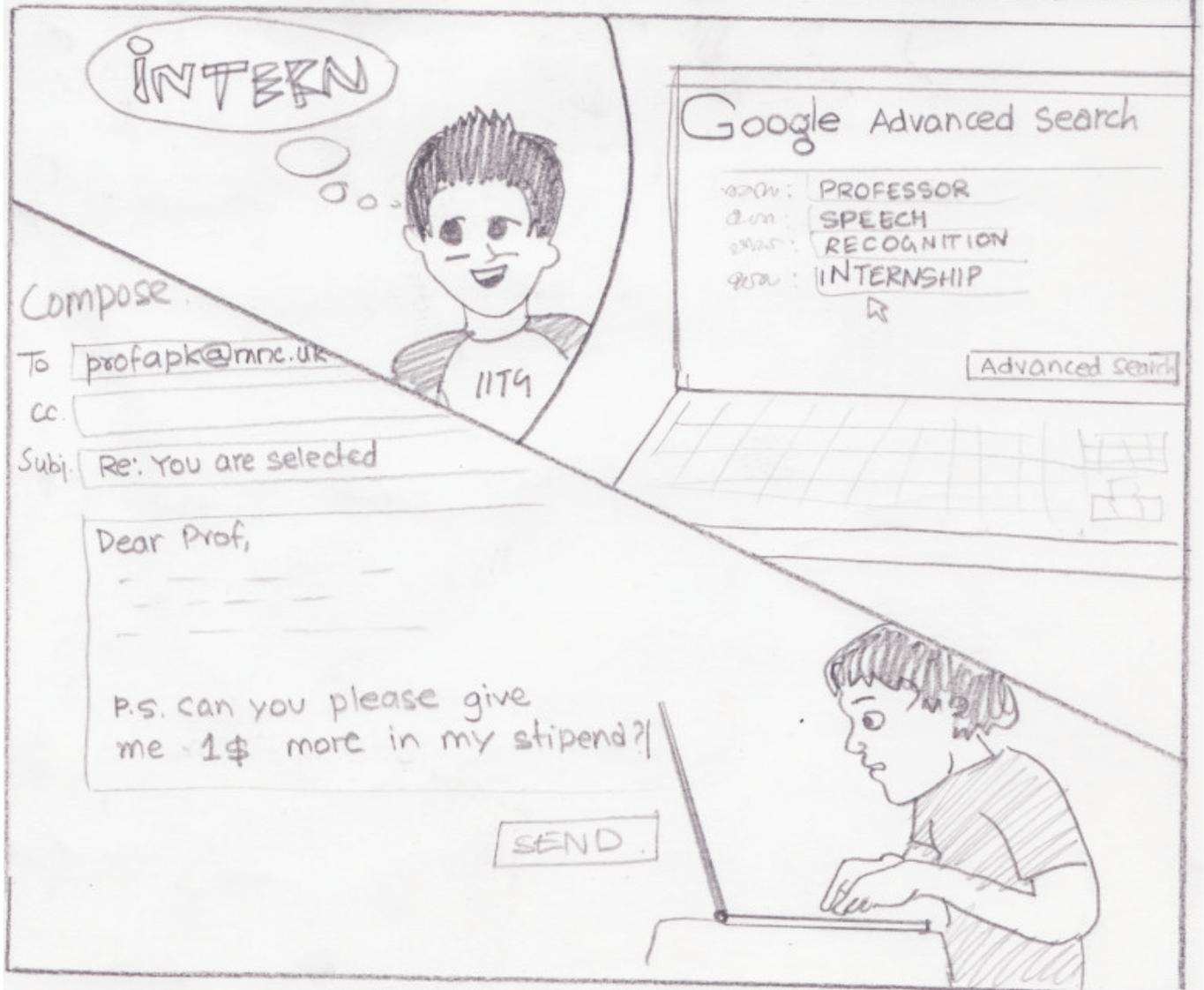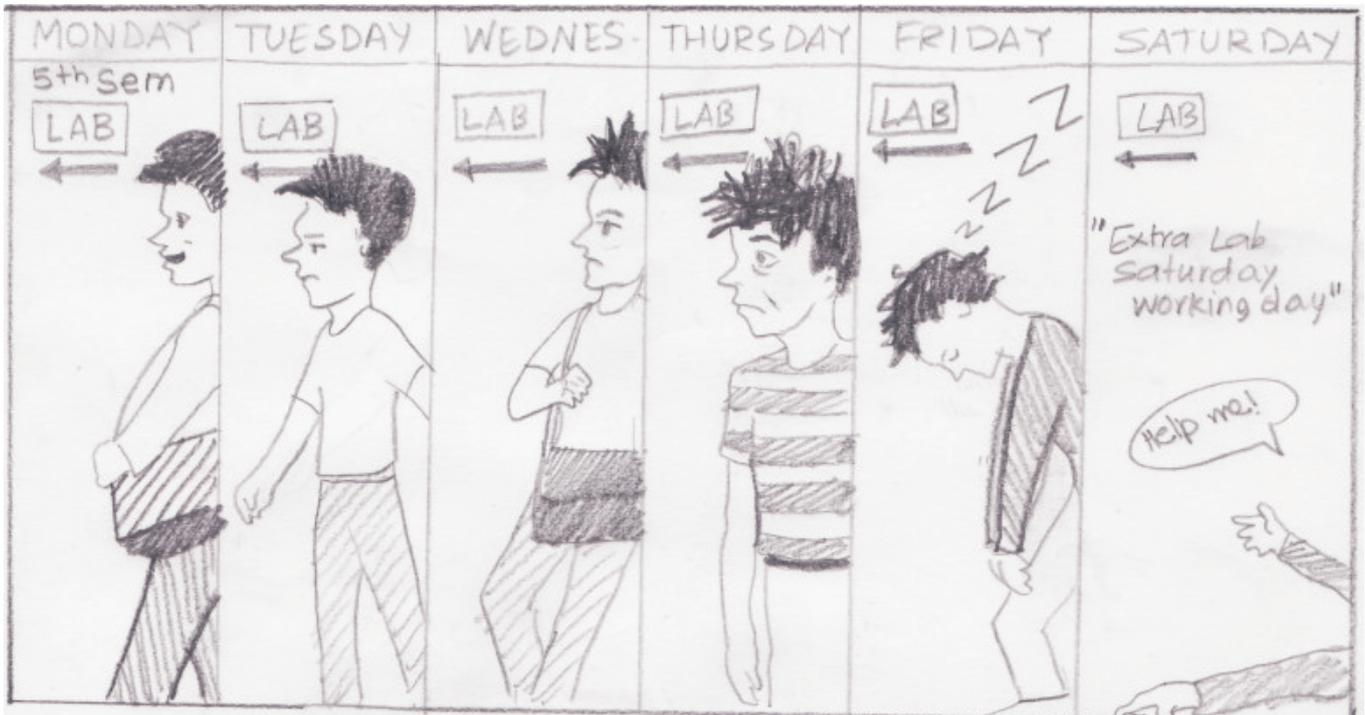
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