

## CURRICULUM VITAE

### Prof. Sugata Sanyal

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### Academic Qualifications:

- **Ph. D.** in Computer Science, Computer Architecture: Some Aspects of Fault-Tolerance and Coding Techniques, University of Mumbai, 1992
- **Master of Technology**, Electronics & Electrical Engineering, IIT, Kharagpur, 1973
- **Bachelor of Engineering**, Electronics and Telecommunication Engineering, Jadavpur University, 1971 [**First Class First (With Honors) + awarded Three Gold Medals**]

### AWARDS and DISTINCTIONS:

- **Senior Member, IEEE**
- **IEEE Distinguished Lecturer**, 1997, area of specialization: Computer Architecture, Parallel Processing, Fault Tolerance and Coding Theory, Network and Computer Security
- Co-recipient of "**Vividhlaxi Audyogik Samsodhan Vikas Kendra Award (VASVIK)**" for Electrical and Electronics Science and Technologies (combined) for the year (1985) for successful and completely indigenous design, development, testing, know-how transfer to production unit (Electronic Corporation of India Limited: ECIL) and final successful live field-trial of a large complex real-time multi-computer based Integrated Data Handling System for On Line Air-Sector Control. **Received Gold Medal, Citation and Cash Award.**

**I played A KEY ROLE IN THIS PROJECT from 1973-1985. No related publication was allowed under the secrecy act. I have helped disseminating complete know-how to multiple Government agencies. 25 such systems have been deployed (as per public knowledge) around Indian Border, each system costing ~Rs. 3 Crore. This was a major national achievement.**

- A 16-bit, Highly Reliable Computer System was designed, developed and tested completely with Peripheral Devices. The Processor acted as the Central Controlling Element for a rugged mobile exchange of the High Availability Computerized System class. **This Real Time system was widely used by Indian Defense Group.**  
**I played A KEY ROLE IN THIS PROJECT from 1977-1980. No related publication was allowed under the secrecy act. Rugged production units were successfully field-tested. Know-how was transferred to multiple agencies: Indian Telephone Industries (ITI), Tata Electric Company (Research & Development), and Bharat Dynamics Ltd.**
- A Computerized system (**3-D Scanning Radar Attachment Project**) was developed which was connected to the 3-D Scanning Radar of the Cyclone Warning Radar Station of the Indian Meteorological Department at Chennai (Madras).  
**The central processor was developed by me [1978-1980] and I had helped the design team in successful system integration, testing and deployment.**

## **Positions held:**

**In Tata Institute of Fundamental Research 1973 – till date:** I am presently holding position of Full Professor in the School of Technology & Computer Science, Tata Institute of Fundamental Research. I am working here from September, 1973.

**In University of Cincinnati, Ohio, USA:** Was invited as Visiting Professor in the Department of Electrical & Computer Engineering and Computer Science in the University of Cincinnati (July– September, 2003), Ohio, USA. Delivered a series of lectures in various US Universities and also had intense interaction with the Research Scholars in the area of Network Security, resulting in research publications.

**Host:** Prof. Dharma P. Agrawal, University of Cincinnati, Ohio, USA.

Email: [dpa@cs.uc.edu](mailto:dpa@cs.uc.edu) URL: <http://www.cs.uc.edu/~dpa>

## **Professional Experience:** [details in Appendix A]

### **(I) Earlier Work (1973-2006) [Research and Development]**

- Work done in the area of Network , Security, Parallel Processing and Computer Algorithms
- Work done in Speech Research and System Development
- Projects of National Importance:
  - (a) Integrated Data Handling System for On-line Air-Sector Control
  - (b) Processor Design and Development
  - (c) 3-D Scanning Radar Attachment Project

### **(II) Present Work (2007- till date) [Research]**

- **PRIDES: Power Resilient Intrusion Detection System For Detecting Sleep Deprivation in Geo-Sensor Network** (with Tapolina Bhattasali, Rituparna Chaki)
- **A New Trusted and Collaborative Agent Based Approach for Ensuring Cloud Security** (with Shantanu Pal, Sunirmal Khatua, Nabendu Chaki)
- **QoS Routing using OLSR with Optimization for Flooding** (with Suman Banik, Bibhash Roy, Parthi Dey, Nabendu Chaki)
- **Modeling Smart Grid using Generalized Stochastic Petri Net** (with Amrita Dey, Nabendu Chaki)
- **Design and development of efficient encryption scheme for Wireless Sensor Networks** (with Dipankar Dasgupta, Department of Computer Science, University of Memphis, USA)
- **Mobile Agent Security** (with Marcin Paprzycki, Systems Research Institute of the Polish Academy of Sciences, Poland)
- **Study of Complexity and Intelligence of Biological and Artificial Complex Systems** (with Barna Iantovics, Petru Maior University of Tg. Mures, Romania)
- **Shortened Hamming Codes Maximizing Double Error Detection** (with Mario Blaum, Universidad Complutense de Madrid & IBM, San Jose, California)
- **New Frontiers of Network Security: The Threat Within** (with Amit Gupta, Nevis Networks, India)
- **Fundamentals of Digital Logic (Book)** (with Bijoy Bandyopadhyay, Institute of Radio Physics & Electronics, Calcutta University, Kolkata)
- **A Note on the Bounds for the Generalized Fibonacci-p-Sequence and its Application in Data-Hiding** (with Sandipan Dey, Microsoft, India; Hameed Al-Qaheri, Kuwait University; Suneeta Sane, VJTI, India)
- **Embedding Secret Data in HTML Web Page** (with Sandipan Dey, Microsoft, India; Hameed Al-Qaheri, Kuwait University)

- **A Multifactor Secure Authentication System for Wireless Payment** (with Ayu Tiwari, IIIT, Allahabad, India and Sudip Sanyal, IIIT, Allahabad, India)
- **Data Hiding Techniques Using Prime and Natural Numbers** (with Sandipan Dey, Cognizant Technology Solutions, India; Ajith Abraham, Norwegian University of Science and Technology, Norway, Bijoy Bandyopadhyay, University of Calcutta, India)
- **Steganography and Steganalysis: Different Approaches** (with Soumyendu Das, Information Security Consultant, India; Subhendu Das, STQC IT Services, India; Bijoy Bandyopadhyay, University of Calcutta, India)
- **Evolution Induced Secondary Immunity - An Artificial Immune System based Intrusion Detection System** (with Divyata Dal, Siby Abraham, Mukund Sanglikar, University of Mumbai; Ajith Abraham, Norwegian University of Science and Technology, Norway)
- **An Iterative Algorithm for Microwave Tomography Using Modified Gauss-Newton Method** (with A.K. Kundu, B. Bandyopadhyay, University of Calcutta, India)
- **An Iterative Algorithm for Microwave Tomography Using Modified Gauss-Newton Method** (with A.K. Kundu, B. Bandyopadhyay, University of Calcutta, India)
- **Development of Audio, Text and Braille Material Delivery System for Visually Impaired Persons** (with Media Lab Asia, Ministry of Communication and Information Technology, Government of India; Webel Mediatronics Limited, Government of West Bengal)
- **A Very Simple Approach for 3-D to 2-D Mapping** (with Sandipan Dey, Anshin Software, Kolkata; Ajith Abraham, Norwegian University of Science and Technology, Norway)
- **Impact of Node Mobility on MANET Routing Protocols Models** (with Bhavyesh Divecha, IIM, Kolkata; Ajith Abraham, Crina Grosan, Norwegian University of Science and Technology, Norway)
- **An Overview of the Evolutionary Trends in Molecular Computing using DNA** (with Abhinav Maurya, Anu Nair, University of Mumbai)

#### **Editorial Responsibility:**

1. [International Journal of Wireless and Mobile Computing](#), Member, Advisory Board of Editors
2. [International Journal of Bio-Inspired Computation](#), Member, Advisory Board of Editors
3. [Informatica](#), Member, Editorial Board
4. [Journal of Information Assurance and Security](#), Member, Editorial Board
5. [International Journal of Theoretical and Applied Computer Sciences](#), Member, Editorial Board
6. [International Journal of Computer Science and Applications](#), Member, Editorial Board

**Honorary Member of Technical Board & Advisory Activities:** [details in Appendix B]

**INVITED TALKS:** [details in Appendix C]

**Committee Membership (2007- till date):** [details in Appendix D]

**List of Publications (1973: Till Date):** [details in Appendix E]

#### **Conference Organization:**

- Was coordinator and co-organizer for the Technical Sessions at the International Conference, TENCON '89 – IEEE Region 10 Conference,

**November, 1989, Mumbai, India, on `Information Technologies for the '90s – Energy, Electronics, Computer Communication'.**

- **Was co-organizer (Supervisor for Experiments) in International Workshop on `Telematics' at the International Centre for Theoretical Physics, Trieste, Italy, September 7 – October 2, 1987.**

**Some Graduate Courses taught at the School of Technology & Computer Science, TIFR:**

- **Network and Security (S. Sanyal): August – December, 2004**
- **Security in Computing (S. Sanyal): August – December, 2005**
- **Theory of Networks (S. Sanyal): August – December, 2006**

## **Appendix A**

### **Professional Experience:**

#### **(I) Earlier Work (1973-2006) [Research and Development]**

- **Summary of Work done in the area of Network and Security and parallel processing and Computer Algorithms**

I have worked and guided work in the area of Parallel Processing, Ad Hoc Network protocol improvement under malicious node attack, Intrusion Detection system, spam-filters, protocol to counter on-line dictionary attacks, One time password system, redundant cluster-based system for ad hoc network, Grid security, multi-path highly reliable data transmission, multilevel adaptive Intrusion Detection system, distributed highly reliable and available Web-server cluster and other areas of Computer Algorithms. Research work has also been done in the area of: Theory and Design of t-Unidirectional Error Correcting and d-Unidirectional Error Detecting Code, and for Fault-Tolerance in Hypercube-based Parallel Architecture.

- **Speech Research and System Development**

I was the Co-Principal Investigator (Co-PI) of the Voice Oriented Interactive Computing Environment (VOICE) project, undertaken as a part of Knowledge Based Computer System (KBCS) Project, Phase II, under the aegis of (the then) Department of Electronics (DOE) (1995-1998) and was the Principal Investigator (PI) for the same (1998-2000). Speech recognition and synthesis systems for Hindi were developed under the project with application prototypes for speech-activated travel guide. A Hindi speech database was also designed developed for speech research community. I have research publications in speech recognition and synthesis.

- **Projects of National Importance: Summary**

1. **Integrated Data Handling System for On-line Air-Sector Control:** This project (1970-1984) got successfully completed in 1984 through all its phases. I did design and development work (1973-1984), was in complete charge of this project for the hardware design, development, maintenance and debugging of the system throughout the software development stage from '79 to '84. This was a tightly-coupled multi-computer system, designed for Air Sector Control and all the associated data handling. M/s ECIL, DAE, produced these multi-crore (each) rupees worth systems

and 25+ systems have been installed in the fields so far. I was a co-recipient of VASVIK award for this work. [1973-1985]

2. **Processor Design and Development:** A 16-bit Highly Reliable Computer System was designed, developed and tested completely with Peripheral Devices. The Processor acted as the Central Controlling Element for a rugged mobile exchange of the High Availability Computer System class. The basic development of this microprogrammed computer around Bit-Slice microprocessor was completed in a relatively short time (September 1, 1977 – December 27, 1977). Rugged production units were successfully field-tested. Know-how was transferred to Indian Telephone Industries (ITI), Tata Electric Company (Research & Development) and Bharat Dynamics Ltd. [1977-1980]
3. **3-D Scanning Radar Attachment Project:** A Computerized system was developed which was connected to the 3-D Scanning Radar of the Cyclone Warning Radar Station of the Indian Meteorological Department at Madras (Chennai). The radar signal was pre-processed by Digital Video Integrating Processor (DVIP), designed and developed at TIFR. Output of the DVIP was fed to the processor, developed by me, for further processing and generation of "rainfall rate map" to be displayed on a video monitor. [1978-1980]

## **(II) Present Work (2007- till date) [Research]**

- **PRIDES: Power Resilient Intrusion Detection System For Detecting Sleep Deprivation in Geo-Sensor Network (with Tapolina Bhattasali, Rituparna Chaki)**

Rapid growth of ubiquitous wireless communication technology enables critical sensor applications such as environmental hazard warnings because wireless sensor network technology is easy to deploy, anytime and anywhere, without any fixed infrastructure, whereas other types of network may not be configured in remote or dangerous environments. Heterogeneous wireless geo-sensor networks are more suitable for real life applications compared to its homogeneous counterpart. Wireless Geo-Sensor Network (WGSNET) is less secure because sensor nodes are deployed in hostile environment where major processes may not be analyzed accurately due to problem of accessibility. Denial of service in geo-sensor network may give rise to unavoidable circumstances. A particularly devastating attack in this category is sleep deprivation attack where target of the intruder is to maximize the power consumption of sensor nodes, so that they stop working. Intrusion detection system is one of the major and efficient defensive methods against attacks in sensor network. Because of different constraints of sensor networks, security solutions have to be designed with limited usage of computation and resources. In this paper, we have presented a brief review of the state of the art security scenario for WGSNETs. Finally, a cluster based five-tiered framework namely PRIDES model has been proposed for heterogeneous wireless geo-sensor network to efficiently mitigate sleep deprivation attack. Simulation results exhibit the effectiveness of the proposed PRIDES model in WGSNET.

- **A New Trusted and Collaborative Agent Based Approach for Ensuring Cloud Security (with Shantanu Pal, Sunirmal Khatua, Nabendu Chaki)**

To determine the user's trust is a growing concern for ensuring privacy and security in a cloud computing environment. In cloud, user's data is stored in one or more remote server(s) which poses more security challenges for the system. One of the most important concerns is to protect user's sensitive information from other users and hackers that may cause data leakage in cloud storage. Having this security challenge in mind, this paper focuses on the

development of a more secure cloud environment, to determine the trust of the service requesting authorities by using a novel VM (Virtual Machine) monitoring system. Moreover, this research aims towards proposing a new trusted and collaborative agent-based two-tier framework, titled *WAY* (Who Are You?), to protect cloud resources. The framework can be used to provide security in network, infrastructure, as well as data storage in a heterogeneous cloud platform. If the trust updating policy is based on network activities, then the framework can provide network security. Similarly, it provides storage security by monitoring unauthorized access activities by the Cloud Service Users (CSU). Infrastructure security can be provided by monitoring the use of privileged instructions within the isolated VMs. The uniqueness of the proposed security solution lies in the fact that it ensures security and privacy both at the service provider level as well as at the user level in a cloud environment.

- **QoS Routing using OLSR with Optimization for Flooding (with Suman Banik, Bibhash Roy, Parthi Dey, Nabendu Chaki)**

Mobile Ad-hoc Network (MANET) is the self organizing collection of mobile nodes. The communication in MANET is done via a wireless media. Ad hoc wireless networks have massive commercial and military potential because of their mobility support. Due to demanding real time multimedia applications, Quality of Services (QoS) support in such infrastructure less networks have become essential. QoS routing in mobile Ad-Hoc networks is challenging due to rapid change in network topology. Consequently, the available state information for routing is inherently imprecise. QoS routing may suffer badly due to several factors including radio interference on available bandwidth and inefficient flooding of information to the adjacent nodes. As a result the performance of the network degrades substantially. This paper aims at the solution for energy efficient QoS routing by best utilization of network resources such as energy and bandwidth. A comparative study shows that despite the overhead due to QoS management, this solution performs better than classical Optimized Link State Routing Protocol (OLSR) protocol in terms of QoS and efficient utilization of energy.

- **Modeling Smart Grid using Generalized Stochastic Petri Net (with Amrita Dey, Nabendu Chaki)**

Building smart grid for power system is a major challenge for safe, automated and efficient usage of electricity. The full implementation of the smart grid will evolve over time. However, before a new set of infrastructures are invested to build the smart grid, proper modeling and analysis is needed to avoid wastage of resources. Modeling also helps to identify and prioritize appropriate systems parameters. In this paper, an all comprehensive model of smart grid have been proposed using Generalized Stochastic Petri Nets (GSPN). The model is used to analyze the constraints and deliverables of the smart power grid of future.

- **Design and development of efficient encryption scheme for Wireless Sensor Networks (with Dipankar Dasgupta, Department of Computer Science, University of Memphis, USA)**

In a prior work on Jigsaw-based encryption algorithm, it was shown that the algorithm was less complex (in terms of number of operations) than the standard AES algorithm; however, we did not demonstrate by any quantitative measure that it was as secure as AES. Further work will investigate (a) the security aspect of the Jigsaw-based encryption algorithm and demonstrate its use in Wireless Sensor Networks (WSN), (b) the performance in wireless channels, and (c) the strength of security against differential cryptanalysis and Brute force attacks. We will also conduct research on Immunology-derived decision support systems for WSN: by monitoring the security situation using multi-level sensory information and applying

the acquired knowledge in ad hoc and/or sensor networks. Accordingly, multiple sensory data will be analyzed to generate actions that can be used to either redefine the route (to avoid sink hole) or even to specifically recruit "special" responses.

- **Mobile Agent Security (with Marcin Paprzycki, Systems Research Institute of the Polish Academy of Sciences, Poland)**

There exist numbers of scenarios where software agents are considered to hold promise for the future of computing. One of them is the vision of software agents utilized in the context of development and implementation of large complex systems. Here, the benefits are grounded in basic principles of software engineering (i.e. decomposition, abstraction and organization) and include faster creation, easier maintenance, scalability, and an overall ease of deployment of complex distributed systems. Separately, agent approach is expected to play a crucial role when dealing with information overload. Here, intelligent software agents are to learn user preferences and act upon them in finding all and only such information that a given user is going to be interested in. Finally, software agents are also very often mentioned in the context of e-commerce, where they are to play a very important role in support of automatic price negotiations and purchase automation. However, one of the key problems that slow down widespread use of software agents is their security. Note that two aspects of software agents make them vulnerable: mobility (agents go to other computers, where they can be "captured") and replay-ability (captured agents can be executed over and over again in a black-box environment, leading naturally to possibility of their re-engineering).

- **Study of Complexity and Intelligence of Biological and Artificial Complex Systems (with Barna Iantovics, Petru Maior University of Tg. Mures, Romania)**

The purpose of the research consists in obtaining more complete theories related with complexity, intelligence, hybrid decision making, and scaling mechanisms for complex systems specialized in difficult problems solving in generally, hybrid medical systems particularly, which will represent the basis of future hybrid medical systems developments, which could cooperatively solve difficult tasks in the medical domain and will have minimal complexity. Hybrid medical systems include humans, like: physicians, nurses, patients etc; computational agents and different medical devices having sensors and effectors; that as a whole has a high complexity and can fulfill task, like: medical decision support, medical diagnosis, computational epidemiology, and tasks in healthcare (patients' monitoring for example).

- **Shortened Hamming Codes Maximizing Double Error Detection (with Mario Blaum, Universidad Complutense de Madrid & IBM, San Jose, California)**

Derived algorithm generates a single error correcting code with a maximum partial double error detection capability for increased protective redundancy without the need for an extra check bit. Since the columns of the parity-check matrix of the code do not contain all possible non-zero vectors, the code has a residual property for double error detection. There are possibilities for the choice of the columns of the parity-check matrix of the shortened Hamming code. Of all possible choices of columns, there is one (not necessarily unique) that maximizes the number of double errors that the code can detect. The purpose of this work is to find a general solution and proving that such a solution is optimal, that is, for the particular choice of parameters, our shortened Hamming code maximizes the number of double errors that can be detected. We are further studying the applicability of this conjecture on other codes to see if they can provide higher return at no or very low extra cost.

- **New Frontiers of Network Security: The Threat Within (with Amit Gupta, Nevis Networks, India)**

Nearly 70% of information security threats originate from inside the organization. The instances of insider threats have been increasing at an alarming rate with the latest trends of mobility (portable devices like Laptop, smart phones and iPads etc), ubiquitous connectivity (wireless connectivity) and this trend increases as more and more web-based applications are made available over the Internet. The Insider threats are generally caused by current or ex-employees, contractors or partners, who have authorized access to the organization's network and servers. Theft of confidential information is often for either material gain or for willful damage. The net result is losses worth millions of dollars in terms of IP theft, leakage of customer / individual information, etc. This work presents an understanding of the Insider threats, attackers and their motives and suggests mitigation techniques at the organization level. ***This methodology is being studied for application in different DAE organizations for providing better security.***

- **Fundamentals of Digital Logic (Book)(with Bijoy Bandyopadhyay, Institute of Radio Physics & Electronics, Calcutta University, Kolkata)**

This book covers Various Number Systems, Boolean Algebra and Logic Gates, Semiconductor Devices, Combinatorial Circuits (Multiplexers etc.), Flip-Flops, Analysis and Synthesis of Sequential Circuits, Timing Circuits, Semiconductor Memory, A to D and D to A Converter. All applicable chapters will have examples in VHDL code.

- **A Note on the Bounds for the Generalized Fibonacci-p-Sequence and its Application in Data-Hiding (with Sandipan Dey, Microsoft, India; Hameed Al-Qaheri, Kuwait University; Suneeta Sane, VJTI, India)**

We first suggest a lower and an upper bound for the Generalized Fibonacci-p-Sequence, a generalization of the Classical Fibonacci sequence, for different values of  $p$ . We show that the ratio of two consecutive terms in generalized Fibonacci sequence converges to a  $p$ -degree polynomial and then prove the bounds for generalized Fibonacci-p sequence, thereby generalizing the exponential bounds for classical Fibonacci sequence. We show how these results can be used to prove efficiency for data hiding techniques using generalized Fibonacci sequence. These steganographic techniques use generalized Fibonacci-p-Sequence for increasing number available of bit-planes to hide data, so that more data can be hidden into the higher bit-planes of any pixel without causing much image distortion. This bound can be used as a theoretical proof for efficiency of those techniques; it explains why more data can be hidden into the higher bit-planes of a pixel, without causing considerable decrease in PSNR.

- **Embedding Secret Data in HTML Web Page (with Sandipan Dey, Microsoft, India; Hameed Al-Qaheri, Kuwait University)**

We suggest a novel data hiding technique in an html webpage. Html tags are case insensitive and hence an alphabet in lowercase and uppercase present in html tag is interpreted in the same manner by the browser. We exploit this case-redundancy and imperceptibility of the changes in case-conversion of html tags from point of view of the browser. The embedded data can easily be recovered by viewing the source of the html page. This technique can easily be extended to embed secret data in any piece of information where the standard interpreter of that information is case-insensitive.

- **A Multifactor Secure Authentication System for Wireless Payment (with Ayu Tiwari, IIIT, Allahabad, India and Sudip Sanyal, IIIT, Allahabad, India)**

Organizations are increasingly deploying wireless based online payment applications. Existing internet based authentication systems use either the Web or the Mobile channel individually to confirm the claimed identity of remote user. The vulnerability is that, access based on only single factor authentication, is not secure enough to protect user data. We propose a new protocol based on multifactor authentication system. It uses a novel approach based on Transaction Identification Code and SMS to enforce another security level with the traditional Login/password system. The system is simple to use and deploy with a limited resources that does not require any change in infrastructure or underline protocol of wireless network. This Protocol is extended as a two way authentications system to satisfy the emerging market need of mutual authentication and also supports secure B2B communication. This increases faith of the user and business organizations on wireless financial transaction using mobile devices.

- **Data Hiding Techniques Using Prime and Natural Numbers (with Sandipan Dey, Cognizant Technology Solutions, India; Ajith Abraham, Norwegian University of Science and Technology, Norway, Bijoy Bandyopadhyay, University of Calcutta, India)**

Our data hiding techniques are improvements over classical LSB data hiding and Fibonacci LSB data hiding technique. We propose two novel embedding techniques, special-cases of our generalized model. The first embedding scheme is based on decomposition of a number (pixel-value) in sum of prime numbers, while the second one is based on decomposition in sum of natural numbers. They not only allow one to embed secret message in higher bit-planes but also do it without much distortion, with a much better stego-image quality, in a reliable and secured manner. Theoretical analysis indicates that image quality of the stego-image hidden by the technique using Fibonacci decomposition improves against simple LSB substitution method, while the same using the prime decomposition method improves drastically against that using Fibonacci decomposition technique, and finally the natural number decomposition method is a further improvement against that using prime decomposition technique.

- **Steganography and Steganalysis: Different Approaches (with Soumyendu Das, Information Security Consultant, India; Subhendu Das, STQC IT Services, India; Bijoy Bandyopadhyay, University of Calcutta, India)**

Steganography is the technique of hiding confidential information within any media. Steganography is often confused with cryptography because the two are similar in the way that they both are used to protect confidential information. The difference between the two is in the appearance in the processed output; the output of Steganography operation is not apparently visible but in cryptography the output is scrambled so that it can draw attention. Steganalysis is the process to detect of presence of Steganography. We have elucidated the different approaches towards implementation of Steganography using 'Multimedia' file and Network IP datagram, as cover. Also some methods of Steganalysis have been discussed.

- **Evolution Induced Secondary Immunity - An Artificial Immune System based Intrusion Detection System (with Divyata Dal, Siby Abraham, Mukund Sanglikar, University of Mumbai; Ajith Abraham, Norwegian University of Science and Technology, Norway)**

The analogy between Immune Systems and Intrusion Detection Systems encourage the use of Artificial Immune Systems for anomaly detection in computer networks. We describe a technique of applying Artificial Immune System along with Genetic algorithm to develop an Intrusion Detection System. This method attempts to evolve this Primary Immune Response to a Secondary Immune Response using the concept of memory cells prevalent in Natural Immune Systems. A Genetic Algorithm using genetic operators- selection, cloning, crossover

and mutation- facilitates this. Memory cells formed enable faster detection of already encountered attacks. These memory cells, being highly random in nature, are dependent on the evolution of the detectors and guarantee greater immunity from anomalies and attacks. The fact that the whole procedure is enveloped in the concepts of Approximate Binding and Memory Cells of lightweight of Natural Immune Systems makes this system reliable, robust and quick responding.

- **An Iterative Algorithm for Microwave Tomography Using Modified Gauss-Newton Method (with A.K. Kundu, B. Bandyopadhyay, University of Calcutta, India)**

An inverse iterative algorithm for microwave imaging based on moment method solution is presented here. A modified Gauss-Newton method has been depicted here to address the nonlinear ill-posed problem. The stabilization term consists of a combination of three weighted discrete derivative operators instead of an Identity matrix as in the Levenberg-Marquardt method based algorithm developed by us. The present algorithm shows a marked improvement over the previous one in the quality of the reconstructed images from synthetic data under noisy condition.

- **Development of Tools for Accessibility and Mobility for the Visually Impaired Persons (with Variable Energy Cyclotron Centre, Department of Atomic Energy, Kolkata; Webel Mediatronics Limited, Government of West Bengal):**

This work allows a visually impaired person to access websites with the help of text to speech. Links will be read out indicating that this is a hyperlink. Static texts also will be read out. A screen reader having voice command interface will allow visually impaired users to control the application through voice commands.

The project also envisages development of a mobility-aid device for visually impaired persons. The device will be developed using ultrasound sensors. It will be body worn or hand-held. Audio beeps of different frequencies will be generated based on different obstacles. One sensor shall be focused on the floor / path. The other shall recognize environmental obstacles in front.

- **Development of Audio, Text and Braille Material Delivery System for Visually Impaired Persons (with Media Lab Asia, Ministry of Communication and Information Technology, Government of India; Webel Mediatronics Limited, Government of West Bengal)**

Delivery system of audio 'reading' material and e-Text reading material through screen reading software for the visually impaired persons is being developed. It is very difficult to 'read' a large book in recorded audio or e-Text format without the facility of 'browsing' i.e. presentation of a document in hierarchical web style non-linear format is very important to make it accessible by visually impaired persons. We are developing a hand-held-device with that will play audio and e-Text files kept in such format. A web site will host large number of audio and e-Text books. Content include text books, novels, newspaper summaries, journals, articles, etc. The hand-held-device shall be used for offline listening / reading. Internet radio will be used for transmitting information of interest for blind community. It will involve a streaming medium that presents listeners with a continuous "stream" of audio.

- **A Very Simple Approach for 3-D to 2-D Mapping (with Sandipan Dey, Anshin Software, Kolkata; Ajith Abraham, Norwegian University of Science and Technology, Norway)**

Many times we need to plot 3-D functions e.g., in many scientific experiments. To plot this 3-D functions on 2-D screen it requires some kind of mapping. Though OpenGL, DirectX etc 3-D rendering libraries have made this job very simple, still these libraries come with many complex pre-operations that are simply not intended. Also to integrate these libraries with any kind of system is often a tough trial. This paper presents a very simple method of mapping from 3-D to 2-D, that is free from any complex pre-operation and it will also work with any graphics system where we have some primitive 2-D graphics function. Also, we discuss the inverse transform and how to do basic computer graphics transformations using our coordinate mapping system.

- **Impact of Node Mobility on MANET Routing Protocols Models (with Bhavyesh Divecha, IIM, Kolkata; Ajith Abraham, Crina Grosan, Norwegian University of Science and Technology, Norway)**

A Mobile Ad-Hoc Network (MANET) is a self-configuring network of mobile nodes connected by wireless links to form an arbitrary topology without the use of existing infrastructure. In this paper, we have studied the effects of various mobility models on the performance of two routing protocols, Dynamic Source Routing (DSR-Reactive Protocol) and Destination-Sequenced Distance-Vector (DSDV-Proactive Protocol). For experiment purposes, we have considered four mobility scenarios: Random Waypoint, Group Mobility, Freeway and Manhattan models. These four Mobility Models are selected to represent possibility of practical application in future. Performance comparison has also been conducted across varying node densities and number of hops. Experiment results illustrate that performance of the routing protocol varies across different mobility models, node densities and length of data paths.

- **An Overview of the Evolutionary Trends in Molecular Computing using DNA (with Abhinav Maurya, Anu Nair, University of Mumbai)**

This work addresses usage of the biochemical molecule of DNA to solve computational problems. DNA computers use strands of DNA to perform computing operations. The computer consists of two types of strands – the instruction strands and the input data strands. The instruction strands splice together the input data strands to generate the desired output data strand. Since the instruction strands are generic nucleotide codes for the various operations, DNA computers meet the accepted standard for being classed as true computers according to the Turing machine concept. A strong point in favor of DNA computing is the potential storage capacity of DNA, which far exceeds that of the most advanced silicon storage devices. A major challenge that DNA circuit engineers face is the difficulty of predicting circuit performance at the design stage, with the consequence that actual construction requires significant experimental effort, even for very simple circuits.

- **ACRR: Ad-hoc On-Demand Distance Vector Routing with Controlled Route Requests (with Jayesh Kataria, University of Mumbai; P.S. Dhekne, BARC)**

Reactive routing protocols like Ad-hoc On-Demand Distance Vector Routing (AODV) and Dynamic Source Routing in Ad-Hoc Wireless Networks (DSR) which are used in Mobile and Ad-hoc Networks (MANETs) work by flooding the network with control packets. There is generally a limit on the number of these packets that can be generated or forwarded. But a malicious node can disregard this limit and flood the network with fake control packets. These packets hog the limited bandwidth and processing power of genuine nodes in the network while being forwarded. Due to this, genuine route requests suffer and many routes either do not get a chance to materialize or they end up being longer than otherwise. In this paper we propose a non cryptographic solution to the above problem and prove its efficiency by means of simulation.

- **Mobile Ad Hoc Network Security Vulnerabilities (with Animesh K. Trivedi, Rajan Arora, Rishi Kapoor, Sudip Sanyal, IIIT, Allahabad; Ajith Abraham, Norwegian University of Science and Technology, Norway)**

The routing protocols used in the current generation of mobile ad hoc networks, are based on the principle that all nodes will cooperate. However any node could misbehave. Misbehavior means deviation from regular routing and forwarding protocol assumption. It may arise for several reasons, unintentionally when a node is faulty or intentionally when a node may want to save its resources. To save battery, bandwidth, and processing power, nodes should not forward packets for others. Without any counter policy, the effects of misbehavior have been shown to dramatically decrease network performance. Depending on the proportion of misbehaving nodes and their strategies, network throughput could decrease, and there could be packet losses, denial of service or network portioning. These detrimental effects of misbehavior can endanger the entire network. We deliberate on all these issues in our work.

- **An LSB Data Hiding Technique Using Natural Numbers (with Sandipan Dey, Anshin Software, Kolkata; Ajith Abraham, Norwegian University of Science and Technology, Norway)**

In this work, a novel data hiding technique is proposed, as an improvement over earlier work in this field. First we mathematically model and generalize our approach. Then we propose our novel technique, based on decomposition of a number (pixel-value) as sum of natural numbers. The particular representation generates a different set of (virtual) bit-planes altogether, suitable for embedding purposes. They not only allow one to embed secret message in higher bit-planes but also do it without much distortion and in a reliable and secured manner, guaranteeing efficient retrieval of secret message. Analysis indicates that image quality of the stego-image hidden by the technique using the natural number decomposition technique improves drastically against that using prime & Fibonacci decomposition techniques. Experimental results show that stego-image is visually indistinguishable from cover-image.

- **Whole Genome Comparison on a Network of Workstations (with Marcin Paprzycki, SWPS and IBS PAN, Warsaw, Poland; Rajan Arora, IIIT, Allahabad; Maria Ganzha, EUH-E, Elblag and IBS PAN, Warsaw, Poland)**

Whole genome comparison consists of comparing or aligning genome sequences with a goal of finding similarities between them. Previously we have shown how SIMD Extensions used in Intel processors can be used to efficiently implement the, genome comparing, Smith-Waterman algorithm. Here we present distributed version of that algorithm. We show that on somewhat outdated hardware we can achieve speeds upwards of 8000 MCUPS; one of the fastest implementations of the Smith-Waterman algorithm.

- **Applying SIMD Approach to Whole Genome Comparison on Commodity Hardware (with Marcin Paprzycki, SWPS and IBS PAN, Warsaw, Poland; Rajan Arora, IIIT, Allahabad; Maria Ganzha, EUH-E, Elblag and IBS PAN, Warsaw, Poland)**

Whole genome comparison consists of comparing or aligning two genome sequences in hope that analogous functional or physical characteristics may be observed. In this work, we present an efficient version of Smith-Waterman algorithm, for which we utilize sub-word parallelism to speedup sequence to sequence comparison utilizing the Streaming SIMD Extensions (SSE) on Intel Pentium processors. We compare two approaches, one requiring

explicit data dependency handling and the other built to automatically handle dependencies. We achieve a speedup of 10-30 and establish the optimum conditions for each approach.

## Appendix B

### **Honorary Member of Technical Board & Advisory Activities:**

- Selection Committee Member for Department of Information Technology, Government of India, at CDAC, Mumbai (October 15-16, 2011)
- CISAG (Computer Installation and Security Audit Group, DAE): Member, 2005 – 2011.
- Advisory Board Member for ERP (Enterprise Resource Planning) Implementation at ITER India, Institute for Plasma Research, DAE, 2010.
- Advisory Board Member of Institute for Vocational Education & Training, IGNOU, 2010.
- UTI (Unit Trust of India): From 2001 till date. ERP (for EPFO: Employees Provident Fund Organization) and other Computerization issues, Technical Board Member.
- KRIBHCO (Krishak Bharati Co-op Limited, Govt. of India): 2009: Invited Technical Board Member, for their ERP planning and program issues, 2009. Acted as an Expert for certification of their technical approach in this area.
- ECIL has started (March, 2009) an exercise of capacity building in the ERP domain and ECIL wishes to establish a Centre of Excellence. I am on their board of Advisors for helping them define the best ERP products, both commercially as well as on the technology front.
- BALBHARATI - Maharashtra State Bureau of Text Book and Curriculum Research, popularly known as BALBHARATI. Member of Technical Committee which has helped finalize the ERP solution for them in September, 2008.
- MAHAGENCO (Maharashtra State Power generation co. Ltd): 2007-2008 - Invited Technical Board Member of MAHAGENCO, for reviewing the total ERP implementation of their organization.
- SIDBI (Small Industries Development Bank of India): From 2004 - 2008. ERP & other Computerization issues of SIDBI, Technical Board Member.
- CMPFO (Coal Mines Provident Funds Organization): From 2005-2007. As a Technical Board Member helped formulating ERP & Computerization requirement, selection process of their vendor & methodology. The successful implementation of the ERP system helped connect all Coal Mines of India, helped streamline their Pension, and Provident Fund issues.
- Advised ECIL, ITI, BDL, BARC, ITER-India (Institute for Plasma Research) and many other Government organizations in their Technical Program for various computerization programs [’70s till date].
- Helped Crompton Greaves Limited as a Technical Expert for their Computer and Electronics oriented activities as well for their Technical Man-power augmentation [1987 – 1989]
- Helped CDOT (Centre for Development of Telematics) for their Technical Development and Man-power augmentation [1984 – 1988]
- Helped Tata Electronic Co. (Research and Development) for their (i) PDP 11/34 Emulation, based on Am 29000 processor for developing enhanced and rugged processor [1985]: this computer was used by TEC for an Indian Defense Project, (ii) IMP-16 Emulation, based on Am 2901 bit-slices, [1978]. This improved the performance of their system, manifold.

## Appendix C

### INVITED TALKS

1. "New Frontiers in Network Security Threats Within", at 2010 Second Vaagdevi International Conference on Information Technology for Real World Problems; Organized by Vaagdevi College of Engineering, Warangal, AP-506005, INDIA, December 09- 11, 2010,
2. Inaugural Talk at the University of Mumbai, Kalina, Mumbai, "Dealing with Dream - A Teacher's Perspective" at the Refresher Course on the theme "Advancements in Computer Science and its Application", Invited by the UGC Academic Staff College and University of Mumbai, on 28-January-2010.
3. Chaired main lecture session in the One Day THEME SYMPOSIUM of DAE on "SOCIAL COMPUTING" at the Variable Energy Cyclotron Centre, DAE, Kolkata, on May 12, 2008.
4. Invited lecture on "Multifactor Authentication and Security" on 7th January, 2008, Monday at the Variable Energy Cyclotron Centre, Kolkata.
5. Invited Lecture on "A Multifactor Secure Protocol for Wireless payment with secure web Authentication using mobile devices" at North Eastern Hill University (NEHU), Shillong, Meghalaya on December 8, 2007.
6. Invited Lecture on "Multifactor Authentication and Security" for Appraisal Workshop for Department of Information Technology, Government of India sponsored Institutes and IIT, Guwahati, on December 1, 2007.
7. Invited Lecture on "Information System Security" on 6th October, 2007, held at DA-IICT, Gandhinagar, invited by IEEE Gujarat Section and IEEE Student Branch DA-IICT.
8. Multi-factor Authentication / Security at the Indian Institute of Information Technology, Allahabad, October 14, 2006.
9. Series of lectures on Network Security at the University of Cincinnati, Iowa State University, University of Iowa and Oklahoma State University. July – September, 2003.
10. A Method of Secure Data Transfer Over Computer Networks, Plenary Lecture at the Third IEEE International Conference on Intelligent Systems Design and Applications (ISDA'03), Tulsa, Oklahoma, USA, August 10-13, 2003.
11. Network Security in Today's Age, Kalinga Institute of Industrial Technology, Bhubaneswar, Orissa, February, 2003.
12. Next Generation Internet (Internet2) and Next Generation Internet Protocol, Kalinga Institute of Industrial Technology, Bhubaneswar, India, February, 2003.
13. Embedded in Systems, Computer Society of India (CSI), Annual Students Convention, SNTD University, Mumbai, March 20, 2002.
14. Network Security, Computer Society of India (CSI), 2001 Annual Convention, Kolkata, Nov 20, 2001.
15. Next Generation Internet: Future of Communication, Jadavpur University, Kolkata, July 14, 1999.
16. System Architectures – Latest Trends, Modern Trends in Computer Technology, 1998, CAT, Indore, November 10, 1998.
17. High Speed ATM Communications, Department of Radio Physics and Electronics, Science College, Calcutta University, January 21, 1998.
18. Asynchronous Transfer Mode Switches, IEEE Distinguished Visitor Program Lecture, IIT, Kharagpur, July 2, 1997.
19. Advances in Computer Sciences, Department of Science and Technology sponsored BOYSCAST program evaluation committee, BARC, 1995.
20. Methodology of Design of Computers – 4 lectures at the BARC Training School, June, 1981.
21. Design of Microprogrammed Computers using Bit Slice Microprocessors – 3 lectures - February, 1981, at IIT, Bombay, organized by the Indian Physics Association.
22. Advanced Computer Architecture, a Workshop, conducted by me, at TIFR, August, 1978.

## Appendix D

### Committee Membership (2007- till date)

1. The 7th International Symposium on Wireless Sensor Network Technologies and Applications for Smart Space (WTA 2011), Jeju, Korea, December 12-15, 2011, Member, International Advisory Committee.
2. The Third International Conference on Advance Cognitive Technologies and Applications (COGNITIVE 2011), September 25-30, 2011, Rome, Italy. Member, Advisory Chairs and Member, Technical Program Committee.
3. International Workshop on Next Generation Intelligent Medical Decision Support Systems (MedDecSup 2011). Tg. Mures, Romania, September 18-19, 2011, Member, International Scientific Committee.
4. 2011 IEEE Symposium on Computational Intelligence on Cyber Security (CICS), IEEE Symposium Series on Computational Intelligence (SSCI 2011) in Paris, April 11-15, 2011. Member, International Program Committee.
5. 2nd Vaagdevi International Conference on Information Technology for Real World Problems, Vaagdevi College of Engineering, Warangal, Andhra Pradesh, India, December 9-11, 2010. Member, International Advisory Committee.
6. The Second International Conference on Advanced Cognitive Technologies and Applications (COGNITIVE 2010), November 21-26, 2010, Lisbon - Portugal. Member, Technical Program Committee.
7. The International Conference on Management of Emergent Digital Eco Systems (MEDES 2010) in cooperation with ACM SIGAPP and IFIP WG 2.6, October 26-29, 2010, Kasetsart University, Bangkok, Thailand. Member, International Program Committee.
8. 11th International Conference on Mobile Data Management (MDM 2010), Kansas City, Missouri, USA. May 23-26, 2010. Member, Program Committee.
9. 4th International Conference on Computers & Devices for Communication (CODEC-09), Institute of Radio Physics & Electronics University of Calcutta, Kolkata, India. December 14 - 16, 2009. Member, National Advisory Committee.
10. The First International Conference on Advanced Cognitive Technologies and Applications (COGNITIVE 2009), Athens/Glyfada, Greece. November 15-20, 2009. Member, Technical Program Committee.
11. DAE-BRNS Seminar on Applications of Computer and Embedded Technology (SACET), Variable Energy Cyclotron Centre, Kolkata. October 28-29, 2009, Member, National Advisory Committee.
12. Second IEEE International Conference on the Applications of Digital Information and Web Technologies (ICADIWT 2009), London Metropolitan University, UK. August 4-6, 2009. Member, International Program Committee.
13. First International Conference on 'Networked Digital Technologies' (NDT 2009) (technically co-sponsored by IEEE Communications Society) Ostrava, The Czech Republic. July 29 - 31, 2009. Member, International Program Committee.
14. Fourth International Conference on Wireless Communication and Sensor Networks (WCSN-2008), December 27-29, 2008. Jointly organized by IIIT, Allahabad and IET-DAVV, Indore. Member, International Advisory Committee.
15. First International Workshop on Knowledge Acquisition, Reuse and Evaluation (KARE 2008) In conjunction with the fourth IEEE International Conference on Signal-Image Technology & Internet Based Systems (SITIS 2008). Bali, Indonesia. December 2, 2008. Member, International Program Committee.

16. The Eighth International Conference on Intelligent Systems Design and Applications, ISDA '08 Kaohsiung City, Taiwan. November 26-28, 2008. Member, International Program Committee.
17. The Fifth International Conference on Soft Computing as Transdisciplinary Science and Technology (CSTST'08), Hosted by the "University of Cergy Pontoise", Cergy-Pontoise/Paris, FRANCE, October 27-31, 2008. Member, International Program Committee.
18. First IEEE International Conference on the Applications of Digital Information and Web Technologies (ICADIWT 2008), VSB- Technical University of Ostrava, Czech Republic. August 4-6, 2008. Member, International Program Committee.
19. Invited expert on the Technical Committee on June 13, 2008 & May 22, 2008, to interview candidates in Computer Science for the J. N. Tata Endowment Scholarship for higher studies abroad.
20. The Second International Conference on Digital Information Management (ICDIM'07), Lyon-France. October 28-31, 2007, Member, International Program Committee.
21. Seventh International Conference on Intelligent Systems Design and Applications, ISDA'07, Rio, Brazil. October 22-24, 2007. Member, International Program Committee.
22. International Workshop on Secure Information Systems (SIS'07), WISLA, Poland. October 15-17, 2007. Member, International Program Committee.
23. EUROCON 2007: The IEEE Region 8 International Conference on "Computer as a Tool", Warsaw, Poland. September 9-12, 2007, Member, Scientific Committee.
24. Third International Security Symposium on Information Assurance and Security (IAS07), Manchester, UK, August 29-31, 2007. Member, Technical Program Committee.
25. 6th International Conference on Computer Information Systems and Industrial Management Applications (CISIM 2007), Elk, Poland, June 28-30, 2007. Member, International Scientific Committee.
26. Information and Communication Technologies Second International Symposium (ICTIS'07), Fez, Morocco. March 25-27, 2007. Member, Scientific Committee.
27. Sixth Working IEEE/IFIP Conference on Software Architecture. WICSA 2007, Mumbai, India. January 6 - 9 2007. Sponsorship Chair.

## Appendix E

### List of Publications (1973: Till Date):

#### Book Chapters:

1. Siby Abraham, Sugata Sanyal, Mukund Sanglikar, "Application of reciprocally induced coevolution in Mathematics", a book chapter in "Advanced Computational Technologies," Calin Enachescu, Florin Gheorghe Fillip, Barna Iantovics (Eds.). Romanian Academy Publishing House, 2011. ISBN: 978-973-27-1678-6, 2011.
2. Sugata Sanyal, Ayu Tiwari and Sudip Sanyal, "A Multifactor Secure Authentication System for Wireless Payment", Emergent Web Intelligence: Advanced Information Retrieval Book Series: Advanced Information and Knowledge Processing, Ed: Chbeir Richard et al, First Edition, 2010, Chapter 13, pp. 341-369, XVI, ISBN: 978-1-84996-073-1 (Print); 978-1-84996-074-8 (Online), Springer Verlag London Limited, 2010, DOI: 10.1007/978-1-84996-074-8\_13.
3. Sandipan Dey, Hameed Al-Qaheri and Sugata Sanyal, "Embedding Secret Data in HTML Web Page", 1st International Conference on Image Processing and Communications, September 16-18, 2009, Bydgoszcz, Poland. Published in book: Image Processing & Communications Challenges, Ed. Ryszard S. Choras and Antoni Zabtudowski, Academy Publishing House EXIT, Warsaw 2009, pp. 474-481. ISBN: 978-83-60434-62-8.
4. Animesh Trivedi, Rajan Arora, Rishi Kapoor, Sudip Sanyal, A. Abraham, and Sugata Sanyal, "Mobile Ad Hoc Network Security Vulnerabilities"; Encyclopedia of Information Science and Technology. Second Edition, Publishers: Idea Group Inc. USA, ISBN 978-1-60566-027-1. Edited by Mehdi Khosrow-Pour. Information Resources Management Association, USA, October, 2008, Vol. 5, pp. 2557-2561.
5. Sugata Sanyal, S. Iyengar, N. M. Singhi and P. V. Narurkar, "System Fault Diagnosis using Artificial Intelligence Techniques", Artificial Intelligence Handbook, Ed. B. R. Bairi, BARC, January, 1992, Indian Physics Association.
6. Sugata Sanyal and P. V. S. Rao, "Data Conversion Principles", Data Conversion Applications Handbook, Chapter 2, John Wiley, New York, USA, 1985.

#### Refereed Journals:

1. Manoj Rameshchandra Thakur, Divye Raj Khilnani, Kushagra Gupta, Sandeep Jain, Vineet Agarwal, Suneeta Sane, Sugata Sanyal, Prabhakar S. Dhekne; "[Detection and Prevention of Botnets and malware in an enterprise network](#)"; [International Journal of Wireless and Mobile Computing](#); Editor-in-Chief: Zhihua Cui; Scheduled for publication in Vol.5, No. 2, 2012. ISSN (Online): 1741-1092; ISSN (Print): 1741-1084.
2. Shantanu Pal, Sunirmal Khatua, Nabendu Chaki, Sugata Sanyal; "A New Trusted and Collaborative Agent Based Approach for Ensuring Cloud Security"; Annals of Faculty Engineering Hunedoara International Journal of Engineering; scheduled for publication in Vol. 10, Issue 1, January 2012. ISSN: 1584-2665.
3. Suman Banik, Bibhash Roy, Parthi Dey, Nabendu Chaki, Sugata Sanyal; "QoS Routing using OLSR with Optimization for Flooding"; International Journal of Information and Communication Technology Research; Vol.1 No.4, August 2011. ISSN: 2223-4985.
4. Amrita Dey, Nabendu Chaki, Sugata Sanyal; "Modeling Smart Grid using Generalized Stochastic Petri Net"; Accepted in July 2011 in the Journal of Convergence Information Technology (JCIT). ISSN: 1975-9320.
5. Siby Abraham, Imre Kiss, Sugata Sanyal, Mukund Sanglikar, "Finding Numerical Solutions of Diophantine Equations Using Steepest Ascent Hill Climbing", in Annals of Faculty Engineering Hunedoara - International Journal of Engineering (ANNALS-2011-2-15), Vol. 9, No 2, pp. 91-96, May, 2011 (ISSN 1584-2665) [Published earlier in Proceedings of International Symposium on Advanced Engineering & Applied Management - 40th Anniversary in Higher Education (1970-2010). Organized by University Politehnica Timisoara, Faculty of Engineering, Hunedoara, 4-5 November, 2010, Hunedoara, ROMANIA].

6. Anjan Kumar Kundu, Bijoy Bandyopadhyay and Sugata Sanyal, "A Microwave Imaging and Enhancement Technique From Noisy Synthetic Data", in Annals of Faculty Engineering Hunedoara - International Journal of Engineering (ANNALS-2011-1-27), Vol. 9, No 1, pp. 175-178, February, 2011 (ISSN 1584-2665) [Published earlier in Proceedings of International Symposium on Advanced Engineering & Applied Management - 40th Anniversary in Higher Education (1970-2010). Organized by University Politehnica Timisoara, Faculty of Engineering, Hunedoara, 4-5 November, 2010, Hunedoara, ROMANIA].
7. Sandipan Dey, Hameed Al-Qaheri, Suneeta Sane and Sugata Sanyal, "A Note on the bounds for the Generalized Fibonacci-P Sequence and its Applications in Data-Hiding", International Journal of Computer Science and Applications, Editor-in-Chief: R. Akerkar. Published by: Technomathematics Research Foundation, ISSN 0972-9038, Vol. 7, No 4, 2010, pp. 1 - 15.
8. Siby Abraham, Sugata Sanyal and Mukund Sanglikar, "Particle Swarm Optimization Based Diophantine Equation Solver", International Journal of Bio-Inspired Computation (IJBIC), ISSN (Online): 1758-0374; ISSN (Print): 1758-0366, Editor-In-Chief: Zhihua Cui; Volume 2, No. 2, 2010, pp. 100 - 114. DOI: 10.1504/IJBIC.2010.032126
9. Rolly Seth, Rishi Kapoor, Hameed Al-Qaheri, and Sugata Sanyal, "Piecemeal Journey to 'HALCYON' World of Pervasive Computing: From Past Progress to Future Challenges", INFORMATICA, ISSN: 0350-5596 Slovenia, Managing Editor: Matjaz Gams; Volume 34, No. 2, 2010, pp. 189 -198.
10. Hameed Al-Qaheri, Sandipan Dey and Sugata Sanyal, "Hiding inside HTML and Other Source Codes", International Journal on Image Processing and Communications, Poland, Editor-in-Chief: R. S. Choras; Volume 14, No. 2-3, 2009, pp. 59 - 68.
11. Koustubh Kulkarni, Sudip Sanyal, Hameed Al-Qaheri and Sugata Sanyal, "Dynamic Reconfiguration of Wireless Sensor Networks", International Journal of Computer Science and Applications, Editor-in-Chief: R. Akerkar. Published by: Technomathematics Research Foundation, ISSN 0972-9038, Vol. 6, No 4, pp. 16-42, 2009.
12. Sandipan Dey, Ajith Abraham, Bijoy Bandyopadhyay and Sugata Sanyal, "Data Hiding Techniques Using Prime and Natural Numbers" Journal of Digital Information Management, ISSN 0972-7272, Volume 6, No 3, pp. 463-485, 2008.
13. Soumyendu Das, Subhendu Das, Bijoy Bandyopadhyay and Sugata Sanyal, "Steganography and Steganalysis: Different Approaches", International Journal of Computers, Information Technology and Engineering (IJCITAE), Vol. 2, No 1, June, 2008, Serial Publications.
14. Sandipan Dey, Ajith Abraham and Sugata Sanyal, "A Very Simple Approach for 3-D to 2-D Mapping", International Journal on Image Processing and Communications, Poland, Editor-in-Chief: R. S. Choras; Volume 11, No. 2, pp. 75 - 82, 2007.
15. Bhavyesh Divecha, Ajith Abraham, Crina Grosan and Sugata Sanyal, "Impact of Node Mobility on MANET Routing Protocols Models", Journal of Digital Information Management, Volume 5, Number 1, pp. 19-24, 2007.
16. Abhinav Maurya, Anu Nair and Sugata Sanyal, "An Overview of the Evolutionary Trends in Molecular Computing using DNA" , International Journal of Computers, Information Technology and Engineering (IJCITAE), Vol. 1, No 2, pp 87-92, December, 2007, Serial Publications.
17. Jayesh Kataria, P. S. Dhekne and Sugata Sanyal, "ACRR: Ad-hoc On-Demand Distance Vector Routing with Controlled Route Requests", International Journal of Computers, Information Technology and Engineering (IJCITAE), Vol. 1, No. 1, pp 9-15, June 2007, Serial Publications.
18. Animesh K Trivedi, Rajan Arora, Rishi Kapoor, Sudip Sanyal and Sugata Sanyal, "A Semi-distributed Reputation-based Intrusion Detection System for Mobile Ad hoc Networks", Journal of Information Assurance and Security (JIAS), Volume 1, Issue 4, December, 2006, pp. 265-274.
19. Vipul Goyal, Virendra Kumar, Mayank Singh, Ajith Abraham and Sugata Sanyal, "A New Protocol to Counter Online Dictionary Attacks, Computers and Security", Volume 25, Issue 2, pp. 114-120, Elsevier Science, March, 2006. This paper is now listed in the top 25 articles of the COMPUTER SCIENCE (Computer and Security)
20. Vasudevan R. A., Abraham A and Sanyal S., "A Novel Scheme for Secured Data Transfer over Computer Networks", Journal of Universal Computer Science, Vol. 11, Issue 1, pp 104-121, 2005.
21. Sugata Sanyal, Rangarajan A. Vasudevan, Ajith Abraham and Marcin Paprzycki, "Grid Security and Integration with Minimum Performance Degradation", Journal of Digital Information Management , Vol. 2, Issue 3, pp 122-126, September, 2004.

22. Dhaval Gada, Rajat Gogri, Punit Rathod, Zalak Dedhia, Nirali Mody, Sugata Sanyal and Ajith Abraham, "A Distributed Security Scheme for Ad Hoc Networks", ACM Crossroads, Special Issue on Computer Security. Volume 11, 2004, pp. 1-17.
23. Arathi Ramani, Salim Vora and S. Sanyal, "The Next Generation Internet protocol"; Informatica. Vol. 26, No. 1, May, 2002, pp 27-45.
24. Aniruddha Sen, Prabhakar S. Dhekne and Sugata Sanyal, "Review of Knowledge Based Computer Systems - 2000"; Vivek, Vol.14, No. 1, January, 2001, pp 19-31. Editor: S. Ramani, NCST, Mumbai, India
25. D. K. Ray-Chaudhuri, N. M. Singhi, S. Sanyal and P. S. Subramanian, "Theory and Design of t-Unidirectional Error Correcting and d-Unidirectional Error Detecting Code", IEEE Transactions on Computers, Vol. 43, No 10, October 1994, pp. 1221-1226. [Cited in: Asymmetric binary covering codes : Joshua N. Cooper and Robert B. Ellis, Department of Mathematics, University of California at San Diego, La Jolla, California. E-mail: jcooper@math.ucsd.edu, rellis@math.ucsd.edu; And Andrew B. Kahng, Department of Computer Science and Engineering, University of California at San Diego, La Jolla, California, E-mail: abk@cs.ucsd.edu].
26. S. Sanyal, 'Fast Matrix Operations through Semi-Systolic Array Architecture', Computer Science and Informatics, Journal of Computer Science of India, Vol. 20, No 2, 1990, pp 39-46.
27. S. Sanyal and P.V.S. Rao, 'Design of a High Reliability Self Diagnosing Computer using Bit Slice Microprocessor', Euromicro: Journal of microprocessing and Microprogramming, North Holland, Vol. 22, 1988, pp 325-331.
28. N. Krishnakumar and S. Sanyal, 'Associative Algorithm in PASCAL/A' Journal of IETES, ISSN 0970-1664, Vol. 29, No 4, October, 1988, pp 115-122.
29. S. Mukherjee and S. Sanyal, 'Simulation of Dataflow Computer and some results' Computer Science and Informatics, Journal of Computer Society of India, Vol. 16, No 2, 1986, pp 9 - 19.
30. S. Sanyal and K. N. Venkataraman, 'Single Error Correcting Code maximizes System Efficiency', Computer Design, Vol. 17, No 5, May, 1978, pp 175-184. Chronicled in the Reliability Information Analysis Center, Department of Defense, USA.
31. S. Sanyal, 'An Algorithm for Non-Restoring Division', Computer Design, Vol. 16, No 5, May 1977, pp 124-127. A patent (US) was taken, Title: High speed digital divider having normalizing circuitry, United States Patent 4380051, by Inventor : Fette, Bruce A., based on this work, sponsored by Motorola, Inc. (Schaumburg, IL,USA)

### **Proceedings of Confernces (Refereed):**

1. Bidyut Biman Sarkar, Sugata Sanyal and Nabendu Chaki, A Distributed Framework for Tele Health Monitoring System; at IEEE-ACM Proceedings of the International Conference on Wireless Technologies for Humanitarian Relief (ACWR2011), Amrita University, Amritapuri Campus, Amrita Vishwa Vidyapeetham, Clappana P. O., Kollam - 690525, INDIA.
2. Sugata Sanyal, Ajit Shelat, Amit Gupta, New Frontiers in Network Security Threats Within, at 2010 Second Vaagdevi International Conference on Information Technology for Real World Problems; Organized by Vaagdevi College of Engineering, Warangal, AP-506005, INDIA, December 09- 11, 2010.
3. Chinmay Kumar Nayak, Jayalakshmi Surendran, Shabbir Merchant, U. B. Desai and Sugata Sanyal, Error Concealment of H.264 Encoded Video through a Hybrid Scheme, at International Conference on ACM Management of Emergent Digital EcoSystems (MEDES 2010) in cooperation with ACM SIGAPP and IFIP WG 2.6, October 26-29, 2010, Organized by National Electronics and Computer Technology Center Thailand (NECTEC) and Kasetsart University, Bangkok, Thailand. Program Chair: Richard Chbeir (Bourgogne University, France).
4. S. Sanyal, R. Bhadauria and C. Ghosh, Secure Communication in Cognitive Radio Networks , 4th International Conference on Computers & Devices for Communication, CODEC-2009, December 14-16, 2009, Organized by Institute of Radio Physics & Electronics, University of Calcutta, Kolkata, India
5. A. K. Kundu, B. Bandyopadhyay and S. Sanyal, An Iterative Algorithm for Microwave Tomography Using Modified Gauss-Newton Method, 4th Kuala Lumpur International Conference on Biomedical Engineering, Biomed-2008, 25-28 June 2008 ,Kuala Lumpur, Malaysia, (Eds.) N.A. Abu Osman, F. Ibrahim, W.A.B. Wan Abas, H.S. Abd Rahman, H.N. Ting: Biomed 2008, Proceedings 21, pp. 511-514, 2008. <http://www.springerlink.com> © Springer-Verlag Berlin Heidelberg 2008

6. Divyata Dal, Siby Abraham, Ajith Abraham, Sugata Sanyal and Mukund Sanglikar, Evolution induced Secondary Immunity: An Artificial Immune System based Intrusion Detection System, 7th International Conference on Computer Information Systems and Industrial Management Applications (CISIM'08), Ostrava, The Czech Republic, June 26-28, 2008. IEEE Computer Society press, USA, ISBN 978-0-7695-3184-7, pp. 61-66, 2008. WON THE BEST PAPER AWARD IN THE CISIM 2008 CONFERENCE
7. Sandipan Dey, Ajith Abraham and Sugata Sanyal "An LSB Data Hiding Technique Using Natural Numbers", IEEE Third International Conference on Intelligent Information Hiding and Multimedia Signal Processing, IIHMSIP 2007, Nov 26-28, 2007, Kaohsiung City, Taiwan, IEEE Computer Society press, USA, ISBN 0-7695-2994-1, pp. 473-476, 2007.
8. Sandipan Dey, Ajith Abraham and Sugata Sanyal "An LSB Data Hiding Technique Using Prime Numbers", Third International Symposium on Information Assurance and Security, August 29-31, 2007, Manchester, United Kingdom, IEEE Computer Society press, USA, ISBN 0-7695-2876-7, pp. 101-106, 2007.
9. Arpith Jacob, Sugata Sanyal, Marcin Paprzycki, Rajan Arora and Maria Ganzha, "Whole Genome Comparison on a Network of Workstations", D. Kranzmueller et. al.(Eds.) "Proceedings of the ISPDC 2007, 6th International Symposium on Parallel and Distributed Computing Conference, Hagenberg, Austria", July 5-8, 2007, pp 31-36, IEEE CS Press, Los Almitos, CA.
10. Arpith Jacob, Sugata Sanyal, Marcin Paprzycki and Maria Ganzha, "Applying SIMD Approach to Whole Genome Comparison on Commodity Hardware", R. Wyrzykowski et al (Eds.): "PPAM 2007 Conference, Seventh International Conference on Parallel Processing and Applied Mathematics, Gdansk, POLAND," September 9-12, 2007; Lecture Notes of Computer Science-4967, pp. 1220-1229, 2008.
11. Bhavyesh Divecha, Ajith Abraham, Crina Grosan and Sugata Sanyal, "Analysis of Dynamic Source Routing and Destination-Sequenced Distance-Vector Protocols for Different Mobility models"; First Asia International Conference on Modeling and Simulation, AMS2007. 27-30 March, 2007, Phuket, Thailand. Publisher: IEEE Press.
12. Ayu Tiwari, Sudip Sanyal, Ajith Abraham and Sugata Sanyal, A Multifactor Security Protocol For Wireless Payment-Secure Web Authentication using Mobile Devices", IADIS International Conference, Applied Computing 2007, Salamanca, Spain. 17-20 February, 2007
13. Jayesh Kataria, P.S. Dhekne, and Sugata Sanyal, A Scheme to Control Flooding of Fake Route Requests in Ad-hoc Networks, Third International Conference on Computers and Devices for Communications, CODEC-06, pp. 198-201. Institute of Radio Physics and Electronics, University of Calcutta, December 18-20, 2006, Kolkata, India
14. Animesh Kr Trivedi, Rishi Kapoor, Rajan Arora, Sudip Sanyal and Sugata Sanyal, RISM - Reputation Based Intrusion Detection System for Mobile Ad hoc Networks, Third International Conference on Computers and Devices for Communications, CODEC-06, pp. 234-237. Institute of Radio Physics and Electronics, University of Calcutta, December 18-20, 2006, Kolkata, India
15. Vipul Goyal, Virendra Kumar, Mayank Singh, Ajith Abraham and Sugata Sanyal, CompChall: Addressing Password Guessing Attacks Information Assurance and Security Track (IAS'05), IEEE International Conference on Information Technology: Coding and Computing (ITCC'05), USA. April 2005, pp 739-744, IEEE Computer Society.
16. Vipul Goyal, Ajith Abraham, Sugata Sanyal and Sang Yong Han, The N/R One Time Password System. Information Assurance and Security Track (IAS'05), IEEE International Conference on Information Technology: Coding and Computing (ITCC'05), USA, April, 2005. pp 733-738, IEEE Computer Society.
17. Ajith Abraham, Ravi Jain, Sugata Sanyal and Sang Yong Han, SCIDS: A Soft Computing Intrusion Detection System, 6th International Workshop on Distributed Computing (IWDC-2004), A. Sen et al (Eds.). Springer Verlag, Germany, Lecture Notes in Computer Science, Vol. 3326. ISBN: 3-540-24076-4, pp. 252-257, 2004.
18. Sugata Sanyal, Ajith Abraham, Dhaval Gada, Rajat Gogri, Punit Rathod, Zalak Dedhia and Nirali Mody, Security Scheme for Malicious Node Detection in Mobile Ad Hoc Networks, 6th International Workshop on Distributed Computing (IWDC-2004), A. Sen et al (Eds.). Springer Verlag, Germany, Lecture Notes in Computer Science, Vol.3326. ISBN: 3-540-24076-4, pp 541-542, 2004.
19. R. A. Vasudevan, A. Abraham, S. Sanyal and D. P. Agrawal, Jigsaw-based Secure Data Transfer over Computer Networks, IEEE International Conference on Information Technology: Coding and Computing, 2004. (ITCC '04), Proceedings of ITCC 2004, Vol 1, pp 2-6, April, 2004, Las Vegas, Nevada.

20. Sampada Chavan, Khusbu Shah, Neha Dave, Sanghamitra Mukherjee, Ajith Abraham and Sugata Sanyal, Adaptive Neuro-Fuzzy Intrusion Detection Systems, IEEE International Conference on Information Technology: Coding and Computing, 2004. (ITCC '04), Proceedings of ITCC 2004, Vol. 1, pp 70-74, April, 2004, Las Vegas, Nevada.
21. R. Vasudevan and Sugata Sanyal, [A Novel Multipath Approach to Security in Mobile and Ad Hoc Networks \(MANETs\)](#), Proceedings of International Conference on Computers and Devices for Communication (CODEC'04), Kolkata, India, 2004., pp. CAN\_0412\_CO\_F\_1 to CAN\_0412\_CO\_F\_4.
22. Agrawal D. P., Deng H., Poosrala R. and Sanyal S., Secure Mobile Computing, Proceedings of the 5th International Workshop on Distributed Computing (IWDC-2003), S. R. Das et al (Eds.), Springer-Verlag, Germany, Lecture Notes in Computer Science, Vol. 2918, ISBN: 3-540-20745-7, pp 265-278, (2003).
23. Ojha A., Deng H., Sanyal S. and Agrawal D. P., Forming COUNCIL based clusters in Securing Wireless Ad Hoc Network, International Conference on Computers and Device Communication, CODEC-2004, Jan 1-3, 2004, Kolkata, INDIA.
24. Vipul Goyal, Sugata Sanyal, Dharma P. Agrawal, "Vcache: Caching Dynamic Documents", Proceedings of the 6th International Conference on Information Technology (CIT-2003), India, Dec 2003, pp. 338-342.
25. Ojha A. and Sanyal S, An Overview of Cryptographic Hash Functions in Data Encryption System, Proceedings of IEEE ACES (EPIC), Kolkata, India, December (2002).
26. Shah, J.T.; Desai, M.P.; Sanyal, S.; Inductance characterization of small interconnects using test-signal method. Thirteenth International Conference on VLSI Design, Kolkata, India, 2000. 3-7 January, 2000 pp.376 – 379.
27. S. Sanyal, High Speed Asynchronous Transfer Mode Communications, Proceedings of International Conference on Computers and Devices for Communications (CODEC-98), pp 169-174, 1998, Calcutta.
28. A. Sen and S. Sanyal, Access to Computerized Information Base by Voice, Proceedings of International Conference on Computers and Devices for Communications (CODEC-98), pp 251-254, 1998, Calcutta.
29. Aniruddha Sen, Xavier Furtado and Sugata Sanyal, Technological Relevance of Speech Synthesis in India. Proceedings of the 31st Annual Convention of the Computer Society of India, 30th Oct-3rd Nov, 1996, pp. 38-45, Bangalore, India, Tata McGraw-Hill pub. Co. Ltd.
30. Iyengar Shrinivas, S. Sanyal and N M Singhi, Fault-Tolerance in Hypercube-based Parallel Architectures, First International Workshop on Parallel Processing (IWPP'94) , Bangalore, 26-31 December, 1994, pp 430-434.
31. S. Sanyal, S. Iyengar, A. A. Roy, N. N. Karnik, N M Mengale, S B Menon and Wu Gengfeng, Defuzzification method for a faster and more accurate fuzzy control, TENCON-1993, Beijing, 1993, Region 10 International Conference on `Computers, Communications, Control and Power Engineering', Vol. 4, pp. 316-318.
32. S. Iyengar, N Apte, A. A. Roy, S. Sanyal, N M Singhi and Wu Gengfeng, A Multiprocessor Communication Architecture for High Speed Networks, TENCON'93, Beijing, 1993 Region 10 International Conference on `Computers, Communications, Control and Power Engineering', Vol.1, pp. 262-265.
33. Iyengar S., N M Singhi and S. Sanyal, `Advanced Computer based on Fuzzy Inference Engine for Control System Applications', Proceedings of the National Symposium on Computer Applications in Power Plants, Board of Research in Nuclear Sciences, DAE, Dec 8-10, 1992, BARC, Mumbai, pp 511-516.
34. Iyengar S, S. Sanyal and N M Singhi, `Design Methods for Cost Optimal High reliability Computer Architecture', Proceedings of the National Symposium on Computer Applications in Power Plants, Board of Research in Nuclear Sciences, DAE, Dec 8-10, 1992, BARC, Mumbai, pp 523-528.
35. Iyengar S., S. Sanyal, N M Singhi and S. Venkatesan, `Issues in the Design of a Dedicated Fuzzy Controller for Automatic Control Application', Proceedings of the Conference on AI Applications in Physical Sciences, Indian Physics Association, January 15-16, 1992, BARC, Mumbai, pp D2: 1-16.
36. S. Sanyal, `A Systolic Array with Broadcast Mechanism for Fast Matrix Operations', Proceedings of the National Seminar on Parallel Computer Systems and their Applications, Indian Physical Society, Oct 29-30, 1990, VECC, Calcutta, pp 18-31.
37. S. Sanyal, Design of Fault Tolerant Computer Systems using Graded Components; 12th International Conference on Fault-Tolerant Systems and Diagnostics, Prague, September 4-7, 1989.

## Technical Notes:

1. Sugata Sanyal, Dhaval Gada, Rajat Gogri, Punit Rathod, Zalak Dedhia and Nirali Mody, Security Scheme for Distributed DoS in Mobile Ad Hoc Networks Technical Report, 2004, School of Technology & Computer Science, TIFR
2. Arpith Jacob, Sugata Sanyal, [Whole Genome Comparison using Commodity Workstations](#) Technical Report, 2003, School of Technology & Computer Science, TIFR, work done when Arpith Jacob was a trainee from Department of CSE, VIT, Vellore, INDIA.
3. S. M. Joshi, S. Banerjee, S. Srikumar and S. Sanyal, Grid Files for a Relational Database Management System, Technical Report No 11, CSC Group, TIFR, 1983. This report was referred to by J. Nievergelt et. al. in their seminal paper, J. Nievergelt, Hans Hinterberger, Institute for Informatik, ETH; Kenneth C. Sevcik, University of Toronto. The Grid File: An Adaptable, Symmetric Multikey File Structure, ACM Transactions on Database Systems (TODS) archive Volume 9, Issue 1, March, 1984) Table of contents Pages: 38-71, 1984, ISSN:0362-5915, Reference: 12. The work reported by us is the only known practical implementation of this Grid File concept (1981 to 1983).
4. S. Sanyal and P. V. Shankar, A Note on Control Memory Minimization in Microprogrammed Digital Computers, IEEE Computer Repertoire, 1976.