"ALAN TURING CENTENARY YEAR - INDIA CELEBRATIONS"

3-Day Faculty Development Program on "Alan M. Turing – Simplification in Intelligent Computing Theory and Algorithms"

Organized by
Foundation for Advancement of Education and Research

In association with

Computer Society of India - Division II [Software]
NASSCOM, IFIP TC - 1 & TC -2, ACM India Council

Co-sponsored by
P.E.S Institute of Technology

Venue
PES Institute of Technology, Hoskerehalli, Bangalore

Date : 18 - 20 December 2012

Compiled by :
Prof. K. Rajanikanth
Trustee, FAER

FAER

Foundation for Advancement of Education and Research

G5, Swiss Complex, 33, Race Course Road, Bangalore - 560001
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Alan Mathison Turing
(1912 – 1954)

PREFACE

Alan Mathison Turing was born on June 23rd 1912 in Paddington, London. Alan Turing was a brilliant original thinker. He made original and lasting contributions to several fields, from theoretical computer science to artificial intelligence, cryptography, biology, philosophy etc. He is generally considered as the father of theoretical computer science and artificial intelligence. His brilliant career came to a tragic and untimely end in June 1954. In 1945 Turing was awarded the O.B.E. for his vital contribution to the war effort. In 1951 Turing was elected a Fellow of the Royal Society.

Association for Computing Machinery (ACM) instituted an award in honor of Turing in the year 1966.This award, called A.M. Turing Award, is given annually by the ACM to "an individual selected for contributions of a technical nature made to the computing community". The Turing Award is recognized as the "highest distinction in Computer science" and "Nobel Prize of computing".

This is the birth centenary year of this genius, Alan Mathison Turing! Several events have been organized and are being organized round the world in the context of this Turing Birth Centenary.

As a part of the **"Alan Turing Centenary Year - India Celebrations"**, Foundation for Advancement of Education and Research (**FAER**) is organizing a 3-Day Faculty Development Program (FDP) on **"Alan M. Turing – Simplification in Intelligent Computing Theory and Algorithms"** during 18th – 20th December, 2012. FAER is organizing this program in association with Computer Society of India, Division II [Software], NASSCOM, IFIP TC - 1 & TC -2, and ACM India Council.

The seed idea for this workshop emerged during the discussions that Prof. D. K. Subramanian, President, FAER had

with Dr. T. V. Gopal, Chairman, CSI Division II [Software] regarding the Turing Centenary Year Celebrations in India. Dr. K N Balasubramanya Murthy, Principal & Director, PES Institute of Technology kindly agreed to host the program. Dr. Y. Narahari, Chairman, Department of Computer Science and Automation generously provided us the resources developed by the students of his department and also gave us valuable contacts for resource persons. Dr. K. Rajanikanth, Mr. Mahesh Jain, Dr. V. Gopalakrishna, Mr. K. Sridhar of FAER and Prof. S. S. Shylaja and Mr. Vinay of PESIT contributed significantly in the organization of this program. Several distinguished scholars accepted our invitation to be resource persons for this program. Their details and the abstracts of their talks are included in this booklet. A list of the Turing Award Winners in chronological order along with their major contributions is also provided in this booklet. Mr. Venkatesh turned the draft of this booklet in to the beautiful form in which it is being presented to you. Prof. D. K. Subramanian's guidance in all the phases gave all of us the confidence required to undertake the difficult task of organizing this FDP and bringing out this booklet.

18th December, 2012

Dr. K. Rajanikanth
Trustee, FAER

Foundation for Advancement of Education and Research (FAER)

FAER is a non-profit registered trust started by several academics and industry leaders in 2004, with the main objective of improving the quality of education and research through a series of activities like

- Faculty empowerment programs in advanced and inter disciplinary areas
- Using advanced technologies to conduct programs which enable interaction among expert industry faculty, students and regular faculty across several institutions
- Encouragement to students to improve innovation and experimentation through contests like Motorola scholar programs, Intel DST business plan contests
- Skills enhancement program for students in areas such as web design, PC servicing and repairs etc
- Joint research programs for students and faculty in engineering colleges through mentoring by research professors at IISc and industry experts
- Development of relevant and modern curriculum for engineering degree courses in consultation with experts from academia and industries
- Setting up of laboratories in polytechnics and engineering colleges.

The foundation has the support of several engineering institutions across the country, a number of industries, some government departments and a large number of academicians from institutions like IISc, IITs, NITs and Industry. FAER acts like a facilitator and conducts programs across several institutions. Some of the programs initiated and conducted by FAER in last six years include:

- More than twenty faculty development programs covering diverse topics like wireless systems, software testing, digital exchanges, automation of power substations, power

conditioning devices, field programmable gate arrays, micro controllers, PC servicing, sensors, RF measurements etc. conducted with resource experts from different industries like Intel, Dlink, Electro Systems Associates, Auro power, Integra Micro Systems, Agilent Technologies, ABB Ltd. etc.

- Conducting the Motorola scholar program for six years covering a large number of engineering institutions across the country.
- Introduction of a post diploma program on software testing in polytechnics. This program is approved by the Directorate of Technical Education and AICTE.
- Reach-to-teach program conducted by expert faculty to many students and faculty in several institutions through two way interactive video streaming approach (this is a full semester course).
- Assistance to World Bank assisted TEQIP (Technical Education Quality Improvement Program) in Karnataka and in many other states of India.
- Support and assistance to Mahithi Sindhu and ICT program for high schools run by the State Government of Karnataka.

In the coming years, FAER is planning to initiate new programs (a) to encourage interaction between industry and academic institutions by facilitating mentoring by experts to deliver practical and industry relevant projects by students (b) to address the digital divide associated with students from disadvantaged groups and rural areas (c) to inculcate and improve the research directions at a number of engineering institutions.

Dr. V. Gopalakrishna
Vice President, FAER

PES Institute of Technology Bangalore

The Peoples Education Society (PES) established in 1972, runs a group of premier institutions, offering a multitude of courses in diploma, undergraduate and post graduate degrees in Science, Commerce, Pharmacy, Engineering, Medicine and Management.

PES Institute of Technology (PESIT), the flagship institution of the group, has become, over the years, one of the most sought after colleges for its high standards. It is the vision of PESIT **to create technologically superior and ethically strong global man power**. PESIT has been rated #1 in the State and #23 in the country by the prestigious Data Quest-IDC survey (Data Quest, June 2006). It has also been rated #2 in the South India by EFY (2009).

PESIT offers 4-year engineering undergraduate programs in the disciplines of Mechanical, Electronics, Telecommunication, Computer Science, Information Science, Electrical & Electronics, Bio-Technology and Civil, and M.Tech courses in Manufacturing Science, VLSI Design & Embedded Systems, Computer Science, Digital Electronics & Communication Systems, Automotive Engineering, Software Engineering, Bioinformatics, Power Electronics, Microelectronics & control systems, Intelligent Systems and Web Technologies. Additionally, PESIT offers 2-year MBA and 3-year MCA programs too. The institution has been consistently a frontline university rank-getter. The intellectual wealth of PESIT includes an impressive number of Ph.Ds and an illustrious band of teachers. The institution actively facilitates its faculty in their pursuit of research activities. Faculty and students have ample opportunities to work on several R&D projects funded by ISRO, ARDB, DRDO, VTU, GTRE, NRB, DST and AICTE. The adequate infrastructure on PESIT campus is completely equipped with spacious classrooms with audio-visual facilities, elaborate library, 20 Mbps internet connectivity, spacious auditorium,

multiple seminar halls, several computer centres, lab facilities etc. Seven of the eight departments have received Research Centre recognition from VTU.

It has also implemented Campus Wide Quality Improvement Program (CWQIP), dissemination of Progress Report, Support Programs Report, etc. Computing facilities for the students are open beyond college hours. The college also offers student scholarships, distinction awards, awards to rank-holders, student assistantship etc. In addition, the college has an effective in-house pre-placement training – SHAPE. Under its Community Development Program, PESIT gives free seats to five Kannada medium rural students and organizes several society-oriented activities.

PESIT is the 36th institution in the world under the program *Partners for the Advancement of Collaborative Engineering Educaton* (PACE), an international initiative by the world automotive leader General Motors. It is also the first institute in South East Asia to receive this recognition. Under the program, PESIT will receive software and hardware related to automotive engineering from leading industries such as HP, Sun Microsystems, UGS and EDS. The staff and students of Mechanical Engineering of PESIT will be trained in the use of these software and hardware. In addition, PESIT has an ongoing international collaborative research activity in the area of computer networking with the Old Dominian University.

PESIT has signed several MoUs with several industries. PESIT has very well equipped and maintained hostels for both boys & girls accommodating about 700 boys and 200 girls. The college also has elaborate outdoor and indoor sports facilities for Cricket, Tennis, Football, Badminton, Table Tennis etc.

Dr. K.N.B. Murthy
Principal & Director, PESIT

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Resource Persons

- Dr. R. K. Shyamasundar
- Dr. David Maier
- Dr. K. Gopinath
- Dr. S. Ramani
- Dr. V. Vinay
- Dr. Sriram Rajamani
- Mr. Mahesh Kumar Jain
- Dr. Y. Narahari
- Dr. Srinivas Padmanabhuni
- Dr. C. Subramanian
- Dr. V. Ramaswamy
- Dr. Kavi Mahesh
- Dr. L. Sunil Chandran
- Dr. T. V. Gopal
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KSCST

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- ACM India Council
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- Bapuji Institute of Engineering & Tech., Davanagere
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- Dr. T. V. Gopal, Anna University

Dr. K. Rajanikanth
FAER

3-Day Faculty Development Program on
"Alan M. Turing – Simplification in Intelligent Computing Theory and Algorithms"

Programme Schedule

Day 1: 18.12.2012 – Theme: Computing

Time	Event
08:30 to 09:30 AM	Registration
09:30 to 10:00 AM	Inauguration (Chief Guest: Dr. R. K. Shyamasundar)
10:00 to 11:00 AM	Computing Legacy of Alan Turing – Dr. R. K. Shyamasundar
11.00 – 11.15 AM	Tea Break
11:15 to 12:15 PM	Why Database Languages are Simpler than Turing Complete – Dr. David Maier
12:15 to 01:00 PM	Alan Turing – By Dr. K. Gopinath
01.00 to 01.30 PM	Prof. R. Narasimhan – By Dr. S. Ramani
01:30 to 02:00 PM	Lunch
02:00 to 03:00 PM	Turing and Complexity – Dr. V. Vinay
03:00 to 03:30 PM	Project Proposal – Dr. S. Geetha
03:30 to 04:00 PM	Tea Break
04:00 to 05:00 PM	A Tour of Database Landscape – Dr. David Maier
5.00 PM	High Tea

Day 2: 19.12.2012 – Theme: Cryptography, Other Areas

Time	Event
09:30 to 10:00 AM	Turing Award Winners – Part I
10:00 to 11:00 AM	Research Papers 1 & 2: Dr. Jeya Bharathi, Dr. K. S. Basavarajappa
11:00 to 11:15 AM	Tea Break
11:15 to 12:15 PM	Automating Program Verification: The search for abstractions using counter-examples – Dr. Sriram Rajamani
12:15 to 12:45 PM	Edsger W. Dijkstra – By Mahesh Kumar Jain
12.45 to 01.15 PM	Project Proposal Presentation – Dr. Jeya Bharathi
01:15 to 02:00 PM	Lunch
02:00 to 03:45 PM	Panel Discussion "Future directions of research on computing" Dr. Y. Narahari, Dr. Srinivas Padmanabhuni, Dr. C. Subramanian, Dr. V. Ramaswamy, Dr. Kavi Mahesh
03:45 to 04:00 PM	Tea Break
04:00 to 05.00 PM	Rainbow Coloring of Graphs - Dr. L. Sunil Chandran
5.00 PM	High Tea & Networking

Day 3: Theme - Artificial Intelligence, Machine Learning, Other Areas

Time:	Event
09:30 to 10:30 AM	"In"formation - Boole, Shannon and Turing - Dr. T. V. Gopal
10:30 to 11:30 AM	Cryptography and Cognition - Dr C. E. Veni Madhavan
11:30 to 11:45 AM	Tea Break
11:45 to 12:15 PM	John Von Neumann – By Dr. P. C. P. Bhatt
12:15 to 01:15 PM	Plenary Session
01:15 to 02:00 PM	Lunch
02:00 to 02:30 PM	Turing Award Winners – Part II
02.30 to 03.00 PM	Project Proposal Presentations – Dr A. Askarunisa – Vickram College of Engineering
03.00 to 04.00 PM	Valedictory Function
04:00 PM	High Tea and Networking

Computing Legacy of Alan Turing

Dr. R. K. Shyamasundar
Tata Institute of Fundamental Research, Mumbai

Abstract: *Alan Turing is considered one among the twentieth century's 100 greatest minds. The invention of stored-program-universal computer by him is arguably the most influential mathematical abstraction of the 20th Century that changed the whole world for good. While this invention became one of the cornerstones of computer science, Turing was best known during his time as the genius who broke some of Germany's most secret codes during the war of 1939-45. While he was a theoretician's theoretician, he had an immense practical outlook. In this talk, I will touch upon his pioneering contributions to computing from theory to practice*

Dr. R.K. Shyamasundar is a Senior Professor and JC Bose National Fellow at the Tata Institute of Fundamental Research and was the Founder Dean of the School of Technology and Computer Science. His principle areas of research are: Specification, Design and Verification of reactive and real-time systems, Programming Languages, Logics of programs, Formal methods, Computer and Network & Information Security. He has over 250 peer reviewed publications and supervised more than 35 Ph.D. students. He is a Fellow IEEE, Fellow ACM and a ACM Distinguished Speaker. He is a Fellow of the Indian Academy of Sciences, Fellow of the Indian National Science Academy, Fellow of the National Academy of Sciences, India, Fellow of the Indian National Academy of Engineering and Fellow of TWAS (Academy of Sciences for the Developing World, Trieste.)

Why Database Languages are Simpler than Turing Complete

Prof. David Maier
Portland State University & National University of Singapore

Abstract: *Turing computability has been the benchmark for computational expressiveness since the beginnings of modern computer science. It is equivalent to many other systems and languages, such at the lambda calculus, partial recursive functions, cellular automata, fixed and stored program models, semi-Thue systems and type-0 grammars. However, data manipulation languages, such as SQL and QBE, along with formalisms such as tuple calculus and relational algebra, lack the full power of a Turing-complete language. This talk explores the benefits of this "simplicity" in terms of system behavior and execution efficiency. We discuss properties that data languages have that are not shared with computationally complete languages. We then turn to extensions to data languages that attempt to regain some of the expressive power while retaining most of the desirable properties.*

Dr. Maier is Maseeh Professor of Emerging Technologies at Portland State University. Prior to his current position, he was on the faculty at SUNY-Stony Brook and the Oregon Graduate Institute. He has spent extended visits with INRIA, University of Wisconsin–Madison, Microsoft Research and National University of Singapore. He is the author of books on relational databases, logic programming and object-oriented databases, as well as papers in database theory, object-oriented technology, scientific databases and dataspace management. He is a recognized expert on the challenges of large-scale data in the sciences. He received an NSF Young Investigator Award in 1984 and was awarded the 1997 SIGMOD Innovations Award for his contributions in objects and databases. He is also an ACM Fellow and IEEE Senior Member, and serves on the Board on Mathematical Sciences and their Applications of the National Research Council. He holds a dual B.A. in Mathematics and in Computer Science from the University of Oregon (Honors College, 1974) and a PhD in Electrical Engineering and Computer Science from Princeton University (1978).

Alan M. Turing

Dr. K. Gopinath
Department of Computer Science and Automation
Indian Institute of Science, Bangalore

Abstract: *I will first discuss the origins of computational devices, computational models and notions of algorithms historically and specifically discuss Alan Turing's many contributions and how they have impacted developments worldwide.*

Dr. K. Gopinath is a professor at Indian Institute of Science in the Computer Science and Automation Department. His education has been at IIT-Madras (B.Tech'77), University of Wisconsin, Madison (MS'80) and Stanford University (PhD'88). He has also worked at AMD (Sunnyvale) ('80-'82), and as a PostDoc ('88-'89) at Stanford and also at Sun Microsystems Labs ('90). His research interests are primarily in the computer systems area (Operating Systems, Storage Systems, Systems Security and Systems Verification).

Prof Rangaswamy Narasimhan - A Pioneer in Computational Intelligence Research

Dr. Srinivasan Ramani
Bangalore

Abstract: *Prof R. Narasimhan is known as the designer of India's first digital computer, TIFRAC. However, his life-long research interest was with computational models of intelligence. In many ways his areas of interest in computer science overlapped a lot with Turing's areas of interest. His pioneering research in interpreting images in terms of two dimensional grammars is one part of his work which attracted world-wide attention. This led to the rise of what has been called the syntactic approach to pattern recognition. But Narasimhan recognized that formalizing two dimensional structures using grammars was only one way of constructing computational models for vision.He broadened his outlook by collaborating with pioneers in related fields. Like Turing did, Narasimhan showed a keen interest in biological questions. How do animals recognize images? What can we learn from major advances being made in neurophysiology of vision?He strongly argued for learning from animal studies to understand human behavior. If humans evolved from animals, there has to be continuity in the way intelligent behavior has involved. Computational models of behavior based on ad-hoc theories did not impress him. His approach emphasized the value of simulating animal and human behavior to understand the very nature of intelligence. He rejected much of the then popular approaches to artificial intelligence as a form of hacking!*

He devoted most of his research life to study natural language behavior. He believed like Turing that computational models could give us insight into language behavior and enable us to create a technology for language-using machines. He and his students also worked on language learning. How do children learn language? Does grammar play a central role in language behavior? He systematically argued for the importance of semantic and pragmatic knowledge (by this he meant knowledge of the world around them that lay persons have, not specialists) in enabling meaningful language behaviour. His work pitted him strongly against the dominant theory in linguistics in the sixties and seventies – a syntax-centric notion of language competence.

He was the guru for all of us interested in the issues of fundamental research in computer science, outlined above. He was never seduced

by me-too research and was always willing to take a stand of his own on major issues. He foresaw, respected and supported the tremendous developments that software technology made in the last three decades of the twentieth century. However, his first love was always the great problems of computer science. One may understand how to build smart phones and smart tools, but nothing equals the attraction of trying to understand language, learning, thought and intelligent behavior.

Had he been alive to see Narasimhan's work, Turing would have highly approved of Narasimhan's choice of research questions and his approaches. Both were true practitioners of fundamental research issues.

Dr. Srinivasan Ramani has served as the founding director of the National Centre for Software Technology (NCST). While at NCST, he played a key role in creating India's academic network, ERNET, which brought the Internet to India. He moved to Bangalore in 2001 to serve as the first director of Hewlett Packard Labs India. He has served as a member of the Expert Panel of Advisors of the United Nation's Task Force on ICT for Development, as President of the Computer Society of India, as President of the International Council for Computer Communication and as Professor at the International Institute for Information Technology, Bangalore. His current passion is technology for education.

Turing and Complexity

Dr. V. Vinay
LimberLink Technologies, Bangalore

Abstract: *We will look at the extraordinary accomplishments of Alan Turing in his short life. We will then see the effect of the Turing machine in defining Computational Complexity Theory. We will end by providing a framework to glimpse the famous P vs NP problem.*

Dr. V. Vinay is the Chairman of LimberLink Technologies which is engaged in the improvement of Engineering Education under the umbrella of Jed-i. He was formerly a professor at the department of Computer Science and Automation at IISc. He was a co-inventor of the Simputer and is a co-founder of Strand Life Sciences.

A Tour of the Database Landscape

Prof. David Maier
Portland State University and National University of Singapore

Abstract: *For many years "database management system" was synonymous with relational technology and SQL. The past decade, however, has seen a proliferation of new data management technologies, such as stream-processing engines, column stores, NoSQL and NewSQL databases, MapReduce and array databases. This diversity has emerged through revisiting and revising requirements and assumptions in light of changing application demands, hardware capabilities and infrastructure characteristics. We will examine a range of these systems, to consider what motivates their development, what assumptions they make, and they differ from a conventional DBMS. We then discuss how many future information systems will likely require several of these technologies used in concert.*

Automating Program Verification: The search for abstractions using counter-examples

Dr. Sriram Rajamani
Microsoft Research India, Bangalore

Abstract: *Even though checking if a program satisfies a property is undecidable, much progress has been made in automatic program verification. In this talk, we will describe a verification technique, which automatically constructs abstractions from a program to do verification, called counter-example guided abstraction refinement (or CEGAR). To check if a program P satisfies a property CEGAR chooses a candidate abstraction A, and if A does not satisfy, a counterexample witnessing this is used to iteratively refine A. This gives a semi-algorithm for checking if P satisfies. This technique has found widespread use in program verification, automatic theorem proving, program synthesis, and more recently, even in machine learning! In this talk, we will survey these developments, without assuming much background from the audience.*

Dr. Sriram Rajamani is Assistant Managing Director of Microsoft Research India and "area champion" for two research areas: (1) Programming Languages and Tools and (2) Security and Privacy.

Sriram's research interests are in programming languages, programming tools and software productivity. Several of his projects have had influence in both academia and industry, the most notable one being the SLAM project, which is the basis for Microsoft's Static Driver Verifier (A decade of software model checking with SLAM from CACM July 2011). Together with Tom Ball, he was awarded the CAV 2011 Award for "contributions to software model checking, specifically the development of the SLAM/SDV software model checker that successfully demonstrated computer-aided verification techniques on real programs." He is also co-winner of Most Influential PLDI Paper award for PLDI 2001 (for this paper) and SIGSOFT Best Paper Award for FSE 2006 (for this paper). Prior to moving to the India lab, Sriram was most recently manager of the Software Productivity Tools group in Microsoft Research

Redmond. Sriram has a PhD in Computer Science from the University of California at Berkeley, MS in Computer Science from the University of Virginia, and a BE in Computer Science from Anna University College of Engineering, Guindy, in Chennai. In a previous life Sriram has worked as a programmer for over 5 years writing telecommunication software and electronic design automation software. He uses his first-hand experience in the realities of commercial software development to guide his choice of problems and approaches to research in software productivity.

Sriram is an Adjunct Professor at the Indian Institute of Technology in Hyderabad. He serves on the on the editorial board of CACM. He co-founded the ISEC conference in India, and serves on the executive committee of the Special Interest Group on Software Engineering (SIGSE) in India. He co-founded the Mysore-Park workshop series, and serves as chair of its scientific board.

Edsger Wybe Dijkstra

Mahesh Kumar Jain
Integra Micro Systems, Bangalore

Abstract: *The talk is about the pioneer, Edgser Wybe Dijkstra (Turing award 1972), of Computer science who laid the basic foundation for Structured Programming (created Algol 60) and Formal Verification System in sixties of last century. He defined distributed programming and many constructs like Semaphores which led to formalism in resource sharing. His Shortest Path Algorithm led to building of efficient routers, his "self stabilization theory" gave alternative way of building reliability in distributed systems. He was a man who barely used computers for programming but contributed significantly to computer Science. In this talk, we remember his contributions to salute the great pioneer of Computer Science.*

Mahesh Kumar Jain is the Cofounder of Integra Micro Systems and other associated companies. He graduated in B Tech (Ch E) from IIT, Kanpur; and acquired ME (Automation) from IISc, Bangalore. He has more than 35 years of experience in Software Industry and 15-20 years of programming in UNIX/C environment.

His other interests include promotion/participation of Foundation for Advancement in Education and Research (FAER), Fair Climate Network (FCN), Bangalore Foundation (NBF), Social Emergency Services (108), Serving Formal Banking & Insurance for Un-served /underserved section of society (i25 RMCS).

Rainbow Colouring of Graphs

Dr. L. Sunil Chandran
Department of Computer Science and Automation
Indian Institute of Science, Bangalore

Abstract: *Consider an edge coloring c : E(G) ! N, (not necessarily proper) of a graph G. A rainbowpath between two vertices is a path such that no two edges in the path have the same colour.The colouring c is called a rainbow (edge) colouring of G if there is a rainbow path between every pair of vertices in G with respect to c. The rainbow connection number rc(G) of a graph G, is the minimum number of colours required in a rainbow coloring of G. For example the rc(Kn) = 1, for the complete graph Kn on n vertices, rc(T) = n−1 for a tree T on n vertices. Note that rc(G) is defined only when G is connected.*

In this talk, we will discuss about two recent results regarding rainbow connection number, from our research group. Both the results lead to approximation algorithms for rainbow coloring special classes of graphs.

1. We show that for every bridgeless graph G with radius r, rc(G) _ r(r + 2). This bound is the best possible for rc(G) as a function of r, not just for bridgeless graphs, but also for graphs of any stronger connectivity. We further show that for every bridgeless graph G with radius r and chordality (size of a largest induced cycle) k, rc(G) _ rk. The proof is constructive and leads to an (r+2)-factor approximation algorithm in the former case, and k-factor approximation algorithm in the latter case.

2. We show that for every connected graph G, with minimum degree at least 2, the rainbowconnection number is upper bounded by c(G) + 2, where c(G) is the connected domination number of G. Bounds of the form diameter(G) _ rc(G) _ diameter(G)+c, 1 _ c _ 4, for many special graph classes follow as easy corollaries from this result.

This includes interval graphs, AT-free graphs, circular arc graphs, threshold graphs, and chain graphs all with minimum degree at least 2 and connected. From the proof, we can get additive c-factor approximation algorithms where c is a constant, for all the above special classes.

Dr. L. Sunil Chandran is Associate Professor in the Department of Computer Science and Automation, Indian Institute of Science, Bangalore. He has both Ph. D and M.E from the Department of CSA, Indian Institute of Science, Bangalore and B.Tech from R.E.C, Calicut. He worked as Post doc at Max-Planck Institute and as Fellow for Informatik, Germany.

He won the MSR India Outstanding Young faculty Award (2009) by IISc (given for faculty members below the age 40). He was selected as Associate of Indian Academy of Sciences, Bangalore (2009-2012). He was awarded NASI young scientist platinum jubilee award (2008) by National Academy of Sciences, India (NASI), Allahabad. He is also the recipient of INSA young scientist award (2007) by the Indian National Science Academy. He was awarded Prof. Sisir Kumar Chatterjee Research Fund (2006), by the Indian Institute of Science. He received Infosys fellowship for Ph.D students (1999–2002). He has over 42 Journal papers and 21 Conference papers.

"In"formation - Boole, Shannon and Turing

Dr. T. V. Gopal
Anna University, Chennai

Abstract: *Computer science is not about computers, it is about computation and information.*

Boolean algebra was developed in 1854 by George Boole in his book "An Investigation of the Laws of Thought". Claude Shannon founded both digital computer and digital circuit design theory in 1937 through his Master thesis (at MIT) demonstrating that electrical application of Boolean algebra could construct and resolve any logical, numerical relationship.

Turing machines model computations with unbounded state. They allow us to reason about what problems are computable or not. This lecture is a modest attempt at positioning "Computers" as sublime undercurrent in an "Analog World" which operated primarily on transforming the real world into a representation rather than attempting to model.

Dr. T. V. Gopal obtained his B.E (Electronics and Communications) from Osmania University, Hyderabad, M.Tech (Computer Science) from Hyderabad Central University, Hyderbad and Ph.D in the area of "Distributed Operating Systems" in the year from Anna University.

His areas of interest include Operating Systems, Distributed Computing, Usability Engineering, Information Architecture, Object Oriented Technologies, Software Quality, Nano-Computing, Science and Spirituality etc.

Dr. T V Gopal is the Chairman, CSI Division II [Software] and Advisor for the "CSI Communications"- a monthly publication of the Computer Society of India. He is an Expert Member of the Editorial Advisory Board of the International Journal of Information Ethics. Dr. T V Gopal has published around 42 Research Papers. He also has 6 papers in the area of Science

and Spirituality. Dr. T V Gopal has authored four books and co-edited 3 conference proceedings.

Dr. Kalaignar M Karunanidhi, the then Chief Minister of Tamilnadu, has honored him on 29.07.2000, in his chambers with a token memento in appreciation of his work related to the preparation of Computer Science Textbooks for Plus I and Plus II students of Government of Tamilnadu.

Dr. T V Gopal is consulting to several leading industries. He was awarded National Award at High School Level Declamation Contest in 1979 and Virendra Gupta – Best Student Paper [Post Graduates] by Computer Society of India, 1988. He is a recipient of "Rashtriya Gaurav Award" and "Siksha Rattan Award" by the India International Friendship Society. The India International Publishing House has selected him for the Best Citizens of India Award. Dr. T V Gopal has been presented "Mother Teresa Excellence Award - 2012" by the Integrated Council for Socio - Economic Progress, Thrissur, Kerala.

Turing Points - Cryptography and Cognition

Dr. C.E. Veni Madhavan
Department of Computer Science and Automation
Indian Institute of Science, Bangalore

Abstract: *The work of Turing is on the nature of computability and the nature of intelligence. I discuss these two facets of his work.*

In the first part, I discuss the applied work of Turing on the cryptanalysis of the Enigma code. Cryptography and cryptanalysis, of importance to the military, are equally relevant to the civilian digital world. I discuss the computational complexity of cryptanalysis of symmetric and public key ciphers. I also discuss some aspects of our work on integer factoring.

In the second part, I discuss the seminal ideas of Turing leading to the modern frameworks for computation and thinking. The Turing test is a simple, yet profound conceptual discriminator for anthropocentric principles of human versus machine intelligence.

I close with a verse, which I composed for the IISc commemoration meeting on Turing.

Dr. C.E. Veni Madhavan is Professor in the Department of computer Science and Automation, Indian Institute of Science, Bangalore. He obtained his B.E.(Electrical Engineering) from College of Engineering, Madras, M.E (Control Systems) from BITS Pilani, and PhD (Control theory) from Indian Institute of Science.

He worked in the industry, Air India (1976-1977), National Informatics Center (1977-1982), before joining the Computer Science and Automation department of IISc, in 1983, where he is currently a professor.

He was invited to head the DRDO laboratory, SAG, New Delhi, during 2000-2003. His teaching, research and development activities are in the areas of algorithms for geometric, algebraic, arithmetic and combinatorial problems. His current

work on cryptanalysis and steganalysis are on the problems of large-scale integer factoring and statistical analysis.

His recent research interests include cognitive network modeling of verbal and visual fields. The work combines analytic, machine learning methodologies with cognitive task experimentation to arrive at assessments of text summarization, translation and understanding.

He has worked on many scientific, industrial consulting and development projects sponsored by government and corporate sectors in these areas. He has published over 75 papers in refereed journals and conferences, and delivered over 150 invited talks in national conferences and universities. He has guided 15 PhD, 11 MS and over 80 ME theses. He has handled several R&D projects sponsored by government and industry. Recent major project engagements are in the areas of cryptanalysis (MCIT), cryptography (TCoE-DOT) and cognitive networks (DST).

He is the co-author of a recently published book on Public-key Cryptography. He obtained in 2001, an award by the Mathematical Association of India, for distinguished services in mathematics education and research. He obtained in March 2011, an award by IISc, for Excellence in Research in Engineering. He and co-authors obtained a Best Paper Prize in July 2011, in Boston USA, in the Annual Conference of the Cognitive Science Society.

He is an Associate Faculty of the Centre for Neuroscience of IISc. He was the Chief Executive of the Society for Innovation and Development (SID) of IISc, during 2006-2012. He is closely associated with the professional bodies, the Cryptology Research Society of India, and the Ramanujan Mathematical Society. He also works very closely with the government policy and R&D funding panels of DST, MCIT, DRDO, IFCPAR and NRB in his capacity as Member or Chairman.

John Von Neumann

Dr. Pramod Chandra P. Bhatt
Bangalore

Abstract: *In this presentation we shall begin by exploring the poly-math persona of John von Neumann by citing numerous contributions he made to various fields within Mathematics and some aspects of Physics. We shall next elaborate the stored program concept enunciated by him and the initial computing machines architecture where he contributed. We shall also dwell upon the role played by Konrad Zuse – who perhaps did not receive the same adulation and accolade as John von Neumann did. Zuse did come up with the concepts which included design of computers and languages to support programming. Finally, we will elaborate on In-memory computing to reinforce data centric approach to computing followed today while retaining the basic stored program concept as the basis of architecture.*

Dr. Pramod Chandra P. Bhatt: After nearly four decades of teaching and research, Prof. Pramod Chandra P. Bhatt now offers freelance consulting to companies and industry bodies on various aspects of Technology. Much of his professional work has been around the area of Design Automation that includes modeling, simulation and logic synthesis. He has also worked on distributed AI systems and algorithms.

Prof. Bhatt started his teaching career in 1965 at IIT Kanpur, and then moved to IIT Delhi in 1969, and retired from IIT Delhi in 1996. Prof Bhatt also worked as a visiting professor at the University of Ottawa, McGill University, Montreal (Canada), Universities of Dortmund, Paderborn and Bochum (Germany), and Kochi University of Technology (Japan). He returned to India in 2001 and became a senior professor at the IIIT-Bangalore. His consulting assignments have included most of the well known IT companies in India. Prof. Bhatt was also Advisor to India Semiconductor Association (ISA) for their Technovation Program. Prof. Bhatt has been on the editorial panel of the International Journal of Computers and Mathematics, Parallel Processing Letters, Journal of Scientific

Computing, and the International Journal of Pattern Recognition and Artificial Intelligence. He also authored a successful and definitive book on Operating Systems (An Introduction To Operating Systems: Concepts And Practice; PHI India). Prof. Bhatt has a M.E. from Calcutta University and a PhD from IIT Kanpur. He has also been a Konrad Zuse Fellow at the University of Dortmund.

Panel Discussion

"Future Directions of Research on Computing"

Dr. Y. Narahari : Moderator

Y. Narahari is currently Professor and Chair at the Department of Computer Science and Automation, Indian Institute of Science, Bangalore. The focus of his current research is to apply Game Theory and Mechanism Design to Internet Economics, Electronic Commerce and Social Network Analysis problems. He is the lead author of a recent research monograph entitled "Game Theoretic Problems in Network Economics and Mechanism Design Solutions" published by Springer, London in 2009. He is an elected Fellow of the following Institutions and Academies: IEEE, New York (FIEEE); Indian National Science Academy (FNA); Indian Academy of Sciences (FASc); Indian National Academy of Engineering (FNAE); and the National Academy of Sciences (FNASc). He is a Senior Editor of the IEEE Transactions on Automation Science and Engineering. He is currently a DST J.C. Bose National Fellow.

Dr. Srinivas Padmanabhuni : Member

Dr. Srinivas Padmanabhuni is a Principal Research Scientist and Associate Vice President at Infosys Labs, the research and innovation arm of Infosys Technologies Limited, Bangalore, India. He is the Vice President of ACM India. A prolific researcher and thought leader, he has four granted patents, around 15 filed patents, one published book by Wiley, one book in process, several book chapters, multiple journal and conference papers, to his credit, in addition to marquee invited talks and editorial positions.

He supervises the Software Engineering research at Infosys. Dr. Srinivas specializes in Software Engineering, Web services, Service Oriented Architecture, Business Process Management, and Grid technologies alongside pursuing interests in semantic web, autonomic computing, intelligent agents, and enterprise architecture. He has been selected for Who's Who in Asia 2007

first edition, and Who is Who in the World and Americas 2009 editions. He is currently the chairperson of ACM Bangalore chapter and is a founding member of ACM India council. He is an active member of ACM, IEEE, and SIGSOFT. Prior to Infosys, Dr. Srinivas has worked in multiple capacities in startups out of Canada and USA. Dr. Srinivas holds a doctorate degree in computing science from University of Alberta, Edmonton, Canada. Prior to Ph.D he secured his B.Tech and M.Tech in computer science from Indian Institutes of Technology at Kanpur and Mumbai respectively.Specialties: Research, Publishing, Enterprise architecture, Solution architecture, Thought leadership.

Dr. C. Subramanian : Member

Dr. C. Subramanian obtained his BSc(Engg.) in Electrical Engineering from University of Kerala and ME and PhD in Electrical Engineering and Computer Science respectively from IISc, Bangalore.

He has a total experience of 38+ years comprising Design and Development in Aerospace industry (34 Yrs) in the domains of Software, Avionics & Electrical systems and Simulation at ARDC(HAL) and Software Industry (4+Yrs) at BAeHAL Software Ltd., Bangalore as CEO. He is currently working as HOD and Professor of Aerospace Engineering at the International Institute for Aerospace Engineering and Management and also as Professor of Computer Science and Engineering at the School of Engineering and Technology of Jain University, Bangalore from 2009 onwards. He received the following awards for professional achievements:

- Excellence in Design from HAL in recognition of the outstanding contributions in Aircraft Design and Development
- Udyog Rattan (2007-08) from IES (Institute of Economic Studies, Delhi) in recognition of achievements in productivity, quality, innovation and management in the IT sector

- Bharathiya Shiomany Puraskar (2008-09) from IES (Institute of Economic Studies, Delhi) for enhancing the image of India
- Rashtriya Rattan (2008-09) from Citizens Integration Peace society, Delhi for outstanding individual achievements and distinguished services to the nation

He has published and/or presented more than 45 technical papers at international and national levels and won awards for the papers presented more than once.

His extra-curricular activities include reading articles on technical developments and philosophy and participating / witnessing sports and games.

Dr. V. Ramaswamy : Member

Dr. V. Ramaswamy got his Ph. D. from Madras University in 1982 specializing in Functional Analysis. He has served in St. Xaviers college, Palayamkottai (1982 – 1983), Birla Institute of Technology and Science, Pilani (1983 – 1985) and Birla Institute of Technology, Ranchi (1985 – 1989) before joining Bapuji Institute of Engineering and Technology, Davangere in October 1989. He has also worked in Terengganu Adavanced Technical Institute, Malaysia (1998 – 2000), University College of Technology and Management, Malaysia (2005 – 2007) and in Jain University, Bangalore (2009 – 2011). In B I E T, Dr. V. Ramaswamy has played crucial roles in starting the Departments of Master of Computer Applications, Information Science and Engineering, M. Tech in Computer Science and Engineering and Doctoral program in Computer Science. Under his guidance, five have already been awarded Ph. D. degrees in the areas of Image Processing, Cryptography, Fuzzy Graphs, Fuzzy Automata and Multi mobile Agents. Four more are carrying out their Ph. Ds in the areas of Natural Language Understanding, Software Engineering, Ant colony optimization and Approximation algorithms. He has presented a paper in an International Conference in Boston University and has written a book on Discrete Mathematical Structures with Applications to Combinatorics besides lecture notes on Automata Theory. He also has published several papers in national and International

Journals. Since September 2011, Dr. V. Ramaswamy is holding the position of Principal in B I E T, Davangere.

Dr. Kavi Mahesh : Member

Dr. Kavi Mahesh is a Professor of Computer Science at PES Institute of Technology, Bangalore, India where he heads the Centre for Ontological Engineering. He is also a Principal Consultant with the Knowledge Management Group at Infosys Ltd. His areas of interest are knowledge management, epistemology, ontology, classification studies, and text processing and unstructured data management. He has two US patents and has published two books, 13 book chapters and over 50 papers (with an h-index of 17 and a g-index of 30). Notable among these are the recent textbook Theory of Computation: A Problem-Solving Approach (Wiley, 2012) and Ten Steps to Maturity in Knowledge Management (Chandos Pub. UK, 2006). He was previously with Oracle Corporation, USA and New Mexico State University and has consulted with Hewlett Packard, United Nations and EasyLib.com. He holds an M. Tech. in Computer Science from the Indian Institute of Technology, Bombay (1989) and an MS (1991) and a PhD (1995) in Computer Science from Georgia Institute of Technology, Atlanta, USA.

Original Research Papers

As a part of the program, FAER invited researchers to submit their original research contributions. Presented below are the abstracts of the research papers received.

MODELING FOR SOFT COMPUTING PARAMETERS ON DIABETES MELLITUS WITH THE ADMINISTRATION OF PALATABLE DIET USING JOSLIN'S PRINCIPLE FOR VARIOUS BODY FRAMES

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[1]Dept. of Mathematics, Indian Institute of Technology, Roorkee, Uttarakand, India
[2]Dept. of Mathematics, Bapuji Institute of Engineering and Technology, Davangere, Karnataka, India

Abstract: Soft computing model is presented using the administration of palatable composition of quantitative diet and insulin to study hyperglycemia and hypoglycemia. Major metabolic defects in carbohydrate lead to diabetes mellitus, which in turn place an undue stress on protein and fat catabolism for the availability of energy. Blood sugar and insulin levels are calculated under the palatable composition of protein (P), fat (F) and carbohydrate(C). Men and Women aged 25 years and above and juvenile aged ½ year and upto 20 years with three different body frames [small, medium, large] are employed in the analysis. Fasting blood glucose 200 mg /100 ml or more and fasting blood glucose above 140mg/100ml with a high post prandial blood glucose are the conclusive values of hyperglycemia to correlate the non-palatable diet among the various body frames. Determination of total calories employed in the calculations is on the basis of total weight in kilograms (kg) with 30 calories per kg for body weight maintenance, 20 calories per kg for body weight reducing and 40 calories per kg for body weight increasing. In the present model, the inputs of quantitative diets are chosen as 700 to 2700 calories per day for Juvenile (aged ½ year to 20 years), 1300 to 2700 calories per Men and Women (aged 25years and above) with three different body frames. Closed

form solutions are obtained for solving the simultaneous differential equations for blood sugar and insulin levels using Joslin's principle for palatable composition of quantitative diet.

Study of Morphisms and Modeling of Gene Structure in n-cut Graph Splicing Scheme

[1]S.JeyaBharathi, [2]R.Anusha, [3]J. Suganya Devi,

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Engineering College, Madurai , India

Abstract: In this paper, we analyze the structural properties of n-cut Graph Splicing Scheme of double stranded DNA molecules through morphism techniques. It had been proved that every n-cut spliced semi graph is a Class P Computational Complexity Problem. Here the behavior of the gene splicing model is represented by Ordinary Differential Equation which level to keep the system solvable.

TURING AWARD WINNERS

(Adapted from the document prepared by Ashutosh Bhatia, Deepak Vishwakarma and Govind Sharma and edited by Suvam Mukherjee, Department of Computer Science and Automation, Indian Institute of Science, Bangalore)

The ACM A.M. Turing Award is an annual prize given by the Association for Computing Machinery (ACM) to "an individual selected for contributions of a technical nature made to the computing community". It is stipulated that "the contributions should be of lasting and major technical importance to the computer field". The Turing Award is recognized as the "highest distinction in Computer science" and "Nobel Prize of computing". ACM instituted this award in the year 1966.

The award is named in honor of Alan Mathison Turing (1912–1954), a British mathematician and computer scientist. He made fundamental advances in theoretical computer science, computer architecture, algorithms, formalization of computing, and artificial intelligence. Turing was also instrumental in British code-breaking work during World War II. Turing is frequently credited for being the Father of theoretical computer science and artificial intelligence.

Recipients of Turing award are invited to give the annual A.M. Turing Award Lecture. As of now the Turing award includes a cash prize of $250,000, which currently is being underwritten by Intel and Google.

The first recipient, in 1966, was Alan Perlis, of Carnegie Mellon University. Frances E. Allen of IBM, in 2006, was the first female recipient in the award's forty year history. The 2008 award also went to a woman, Barbara Liskov. Till date, Dabbala Rajagopal Reddy (aka Raj Reddy), in 1994, is the only Indian to have received this award.

Turing Award Winners in Chronological Order

1966: Alan Jay Perlis

Alan Jay Perlis is the first recipient of the Turing award. He received the award for his influence in the area of advanced programming techniques and compiler construction. He played a leading role in developing the ALGOL-60, arguably one of the most influential programming languages in history. Equally important during those years was Perlis' leadership in helping to mold the nascent field of Computer Science into an academic discipline.

1967: Maurice Wilkes

He is best known as the builder and designer of the EDSAC in 1949, the first computer with an internally stored program. He came up with a new design principle, microprogramming that greatly simplified the logical design of the new computer.

1968: Richard Hamming

He received the award for his work on numerical methods, automatic coding systems, and error-detecting and error-correcting codes. His fundamental paper on the topic of Error detecting and error correcting codes, appeared in April 1950 in the Bell System Technical Journal. This paper created an entirely new field within information theory.

1969: Marvin Minsky

He received the award for his central role in creating, shaping, promoting, and advancing the field of Artificial Intelligence. Many consider his 1960 paper, "Steps toward Artificial Intelligence," to be the call-to-arms for a generation of researchers. That paper established symbol manipulation — divided into heuristic search, pattern recognition, learning, planning, and induction—to be at the center of any attempt at understanding intelligence.

1970: James Hardy Wilkinson

He received the award for his research in numerical analysis to facilitate the use of the high-speed digital computer. He was a British mathematician who became the leading expert in a new, and important, field that emerged after World War II, *matrix computations.*

1971: John McCarthy

He received the award for his work in the field of Artificial Intelligence, a brand name that he created! His work has emphasized epistemological problems—the problems of what information and what modes of reasoning are required for intelligent behavior. He also created the (LISt Processor) language LISP which became an important tool in artificial intelligence research and is still widely used. He also made substantial contributions to the algebraic languages ALGOL 58 and 60. McCarthy developed a timesharing system, concurrent with Fernando Corbato's CTSS, which was an essential precursor to computer networking.

1972: Edsger Wybe Dijkstra

He received the award for fundamental contributions to programming as a high level intellectual challenge. His "Go to Statement Considered Harmful" published in a letter-to-the-editor in CACM in March 1968 led to an explosion of interest in the concept of "Structured Programming"! His significant contributions include the development of a theory of non-determinacy, an effective tool for reasoning about programs and simplifying program design and the development of "predicate transformers" as a basis for defining program semantics.

1973: Charles William Bachman

He received the award for his outstanding contributions to database technology. By creating the Integrated Data Store (IDS), and advocating forcefully the concepts behind it, he was very influential in the creation of the data base management system as we know it today. Bachman was the first Turing Award winner without a Ph.D., the first to be trained in engineering rather than science, the first to win for

the application of computers to business administration, the first to win for a specific piece of software, and the first who would spend his whole career in industry.

1974: Donald Ervin Knuth

He received the award for his major contributions to the analysis of algorithms and the design of programming languages, and in particular for his contributions to the "art of computer programming" through his well-known books in a continuous series by this title. In 1977 he began developing a new typesetting system to enable high quality computerized typesetting. Knuth's system revolutionized digital typesetting. His TeX was an early success story for the free and open-source software movement.

1975: Allen Newell and Herbert Alexander Simon

Allen Newell is chiefly remembered for his important contributions to artificial intelligence research, his use of computer simulations in psychology, and his inexhaustible, infectious energy. He was a co-developer of the first list-processing language (IPL) and of programs designed to use heuristics in solving problems, especially the Logic Theorist and General Problem Solver. He also contributed to advances in speech recognition and human-computer interaction.

Herbert Alexander Simon’s main work was in the development of heuristic programming. He was a co-developer of the first list-processing language (IPL) and of programs designed to use heuristics in solving problems. Newell was Simon’s PhD student.

1976: Michael Rabin and Dana Stewart Scott

Michael Robin and Dana Stewart Scott in their paper "Finite Automata and Their Decision Problem" introduced the idea of nondeterministic machines, which has proved to be an enormously valuable concept. This classic paper has been a continuous source of inspiration for subsequent work in this field.

Rabin’s work on cryptography started off with a puzzle given to him by another Turing award winner, John McCarthy. It

resulted in the groundbreaking paper "Degree of Difficulty of Computing a Function and a Partial Ordering of Recursive Sets", which was the starting point for his later advances in the theoretical study of computational complexity particularly in relation to cryptography. His later work concerns cryptographic problems for preventing piracy on the internet.

Scott-Strachey semantics has proved to be one of the most influential works in theoretical computer science. One of Scott's major contributions was the theoretical work that allowed the difficult subjects of loops and recursive functions to be included into this denotational semantic structure. He proposed the theory of equilogical spaces as a replacement for domain theory when attempting to define denotational semantics for programming languages, particularly functional languages.

1977: John Backus

He received the award for profound, influential, and lasting contributions to the design of practical high-level programming systems, notably through his work on FORTRAN, and for seminal publication of formal procedures for the specification of programming languages. Backus collaborated with Peter Naur, in developing the Backus-Naur Form (BNF) notation. BNF represented a significant milestone in the formalization of programming languages. Backus eventually made contributions to functional programming with the creation of a new language, FP (Functional Programming).

1978: Robert Floyd

He received the award for having a clear influence on methodologies for the creation of efficient and reliable software, and for helping to found important subfields of computer science, namely, the theory of parsing, the semantics of programming languages, automatic program verification, automatic program synthesis, and analysis of algorithms. Floyd's mathematical analysis was the beginning of a long series of attempts by him and others to prove a program correct before it was released to users. He also invented many important practical algorithms like Floyd–

Warshall shortest path algorithm, Floyd-Sternberg algorithm, etc.

1979: Kenneth Iverson

He received the award for his pioneering effort in programming languages and mathematical notation resulting in what the computing field now knows as APL, for his contributions to the implementation of interactive systems, to educational uses of APL, and to programming language theory and practice. In 1962 Ken published the now-classic book "A Programming Language", the title of which gave the name APL to his notation. He later went on to develop the programming language - APL.

1980: C Antony R Hoare

C Antony R Hoare, also known as "Tony" Hoare. He received the Turing award for his fundamental contributions to the definition and design of programming languages. While studying Machine Translation with Andrey Kolmogorov, he found the problem of sorting as important, and then thought of the novel sorting algorithm "Quicksort". "An axiomatic basis for computer programming" written by him, is one of the most influential papers on the theory of programming. In this, he developed a logical system, now known Hoare triples, for reasoning about programs using specifications of statement behavior.

1981: Edgar F. Codd

Edgar Codd is considered as father of databases. He revolutionized the way databases were perceived. Several database products did indeed exist at that time; however, they were cumbersome, and difficult to use and rested on no solid theoretical foundation. Codd realized the need for such a foundation and, applying his knowledge of mathematical logic, he was able to provide the relational model of data.

1982: Stephen Arthur Cook

He received the award for his advancement of our understanding of the complexity of computation in a significant and profound way. Cook presented his seminal

paper, "The complexity of theorem proving procedures", that marked the introduction of the theory of NP-completeness, which henceforth occupied a central place in theoretical computer science.

Cook's paper also was the source of the celebrated and still unsolved P versus NP question. The impact of the P versus NP problem has extended beyond the field of computer science.

1983: Dennis M. Ritchie and Kenneth Lane Thompson

They received the award for their development of generic operating systems theory and specifically for the implementation of the UNIX operating system.

Ritchie is best known as the creator of programming language C which was based on an interpretive language called B, created by Ken, which he used to implement the non- kernel parts of Unix. Ritchie added types to the B language, and later created a compiler for the C language.

Thompson wrote the first version of the Unix operating system for a PDP -7 in a month, using a cross-assembler. The PDP-7 he used had only 4K of 18-bit words. He also wrote the then world chess playing champion computer Belle.

Thompson and Ritchie rewrote most of Unix in C in 1973 and also they presented a paper describing Unix. The Unix system presented in the paper was elegant and simple, providing a useful and extensible multi-user programming environment on an affordable machine. Their model of the Unix system has led a generation of software designers to new ways of thinking about programming

1984: Niklaus E. Wirth

He received Turing award for developing a sequence of innovative computer languages, EULER, ALGOL-W, MODULA and PASCAL. He focused on both hardware and software. He seized on the new Field Programmable Gate Array (FPGA), a special chip that can be reprogrammed for a particular application, and developed languages and tools to configure them efficiently from a high level specification.

1985: Richard Manning Karp

He received Turing award for his contributions to the theory of algorithms including the development of efficient algorithms for network flow and other combinatorial optimization problems and most notably, contributions to the theory of NP-completeness. His most recent research has been in computational biology. This work began in the 1990s, as the field began to grow rapidly under the influence of the Human Genome Project. Another major theme in Karp's research has been the use of probability in both the design and analysis of efficient algorithms. He showed that, surprisingly, randomizing the behavior of an algorithm can often significantly reduce its expected running time for any input.

1986: John Hopcroft and Robert Endre Tarjan

Hopcroft received the award for his achievements in the design and analysis of algorithms and data structures. He emphasized the need to focus on "asymptotic complexity", as the size of problems increased with ever increasing computing power. This set a new direction in the analysis of algorithms. He explored efficient structures for storing data in a computer, and created efficient algorithms for solving the problems they could represent. His work on formal languages and the analysis of algorithms has made John Hopcroft one of the pioneering computer scientists who put the discipline on a firm theoretical foundation.

Robert Endre Tarjan received the award for his fundamental achievements in the design and analysis of algorithms and data structures. He emphasized depth-first search as an important algorithmic technique and advocated the use of an adjacency-list representation for sparse graphs, rather than an adjacency matrix. He also developed a linear time algorithm for finding strongly connected components. Tarjan's book "Data Structures and Network Algorithms" is regarded as a "model of precision and clarity". He co-devised the Fibonacci heap data structure with Michael Fredman.

1987: John Cocke

Cocke received the award for his fundamental contributions to the architecture of high performance computers and to the

design of optimizing compilers. His ideas led to an architecture whic has come to be known as the Reduced Instruction Set Computer (RISC). A pioneer in the development of the theoretical foundation for such compilers, Cocke co-developed "interval analysis" with Frances Allen, a program analysis technique based on a control flow graph reduction. Cocke co-invented many of the optimizing transformations underlying today's compilers. He also led the IBM's first supercomputer project called Advanced Computer System (ACS) whose goal was to build a fast computer for scientific applications.

1988: Ivan Sutherland

He received the award for his pioneering and visionary contributions to computer graphics. His doctoral thesis, Sketchpad: A Man-machine Graphical Communications System, described the first computer graphical user interface (GUI). He co-developed the Cohen–Sutherland line clipping algorithm. In 1968, with the help of student Bob Sproull, he created the first virtual reality and augmented reality head-mounted display system, referred to affectionately as the Sword of Damocles because it was suspended from the ceiling above the user's head.

1989: William Morton Kahan

He received the award for his fundamental contributions to numerical analysis, and for his work in creating the IEEE 754 standard for which he has often been called "The Father of Floating Point". Adoption of the standard did a great deal to improve the robustness of floating point arithmetic and improve consistency of results across different computing platforms. He developed "paranoia", a program that tests floating point arithmetic implementations for errors. In recent decades Kahan has continued to articulate and bluntly warn of the shortcomings in the floating point implementations of environments as popular as Java and Matlab.

1990: Fernando Corbato

He received the award for his pioneering work in leading the development of the general-purpose, large-scale, sharing-based computer systems. His work on time sharing and

resource-sharing computer systems, namely, CTSS (Compatible Time-Sharing System) and Multics, made a paradigm shift from conventional batch mode of processing to time sharing computer, which allowed several users to connect to the computer at the same time.

1991: Arthur John Robin Gorell Milner

He received the award for three distinct and complete achievements:

- LCF, the mechanization of Scott's Logic of Computable Functions, probably the first theoretically based yet practical tool for machine assisted proof construction;
- ML, the first language to include polymorphic type inference together with a type-safe exception-handling mechanism, which influenced later languages like Scala, Java and Microsoft C#;
- CCS: Calculus of Communicating Systems, which is a general theory of concurrency.

1992: Butler W Lampson

He received the award for his contributions to the development of distributed, personal computing environments and the technology for their implementation. At Berkeley, Lampson et al designed the CAL time-sharing system for a CDC 6400. This was the first capability-based system to have a real user community. It pioneered the ideas of shadow pages and redo logs. Butler, with Alan Kay designed the byte code machine language scheme used for Smalltalk and Mesa. He also devised the access matrix model for computer security, unifying the ideas of capabilities and access control lists.

1993: Richard Edwin Stearns and Juris Hartmanis

Richard Edwin received the award jointly with Juris Hartmanis, in recognition of their seminal paper which established the foundations for the field of computational complexity theory.

In 1965, in his seminal paper "On the Computational Complexity of Algorithms", Stearns provided a precise definition of the *complexity* of an algorithm, and a *complexity class.* He also showed that there is an infinite sequence of

distinct complexity classes and therefore an infinite sequence of increasingly hard problems. He, along with Philip M. Lewis, showed that a similar hierarchy exists when the complexity is defined in terms of the amount of memory space required to solve the problem on a Turing machine.

Hartmanis and his student Leonard C. Berman showed that all natural NP complete sets are isomorphic (under polynomial time reductions), and further showed that complete sets computable in exponential time cannot be sparse.

1994: Dabbala Rajagopal Reddy and Edward A ("Ed") Feigenbaum

Rajagopal Reddy (Raj Reddy) is the only Indian so far to have received the Turing Award! He received it for pioneering the design and construction of large scale artificial intelligence systems, demonstrating the practical importance and potential commercial impact of artificial intelligence technology. Reddy and his colleagues have also made seminal contributions to other areas of artificial intelligence and computer science, notably to task-oriented architectures, analysis of natural scenes, and autonomous robotic systems. The "blackboard architecture" for coordinating multiple knowledge sources, developed under CMU's speech understanding research program, has been widely adopted. From about 1975 on, Reddy's research interests expanded in several directions. He was one of the major collaborators at CMU with DARPA, and was instrumental in getting DARPA work started on VLSI research, sensor networks, operating systems and user interfaces and workstations. He also experimented with graphics printing. In 2005, Reddy was honored as the first recipient of the "Mozah Bint Nasser Chair" of Computer Science and Robotics. In 2001, Reddy was awarded the Padma Bhushan. He is well known for his efforts to bring digital technology to people on the other side of the "digital divide".

Edward A ("Ed") Feigenbaum received Turing award along with Raj Reddy for similar contributions. Feigenbaum and colleagues developed Heuristic DENDRAL, a computer program that could guess the geometrical structure of complex chemical compounds given their chemical formulae and their mass spectrogram data. Heuristic DENDRAL discovered some

previously unknown structures, and these discoveries were published in a series of papers in the Journal of the American Chemical Society. After their work on chemical structures, Feigenbaum's laboratory went on to develop expert-system programs in medicine (MYCIN, PUFF, ONCOCIN), molecular genetics (MOLGEN), X-ray crystallography (CHRYSALIS), and analysis of pulmonary function (PUFF). It also developed the first transportable general-purpose expert system "shell" (EMYCIN). Feigenbaum co-founded three companies involved in applied artificial intelligence, IntelliCorp, Teknowledge, and Design Power Inc. He continues as an adviser to companies employing AI and related computer technology.

1995: Manuel Blum

He received Turing award in recognition of his contributions to the foundations of computational complexity theory and its application to cryptography and program checking. He developed a machine-independent theory of complexity. In 1997 he provided an algorithm to find median in linear time. In 1984, with his student, Blum gave a good PRNG based on discrete logarithm problem, and finally, in 1986, he gave a public key encryption scheme based on Blum-Blum-Shub generator. In the late 1960s, Blum was convinced that computing the median does indeed require n log n steps, just like sorting. He tried very hard to prove that it does, and in the end his labors were rewarded with a most pleasant surprise: in 1971 he came up with an algorithm that finds the median in linear time. Blum with his student Von Ahn, came up with the idea of a visual challenge, known as "CAPTCHA".

1996: Amir Pnueli

He received the award for his seminal work introducing temporal logic into computing science and for outstanding contributions to program and system verification. Amir's 1977 seminal paper "The Temporal Logic of Programs" revolutionized the way computer programs are analyzed. Amir's paper introduced the notion of reasoning about programs as execution paths, which breathed new life into the field of program verification. In 2000, Amir was awarded the Israel Prize in field of Computer Science, for his breakthrough contributions in the verification of parallel and reactive systems

by the introduction of the specification language of Temporal Logic. He took active part in an Israeli youth movement affiliated with the labour party whose focus was on collaboration between academics and labour.

1997: Douglas Engelbart

He received the award for his inspiring vision of the future of interactive computing and the invention of key technologies to help realize this vision. His numerous technological innovations were crucial to the development of personal computing and the Internet. His work helped to change the way computers work, from specialized machinery that only trained technicians could use, to a medium designed to augment the intelligence of its users and foster their collaboration.

His work on Augmentation of Human Intellect at Stanford Research Institute produced many crucial hardware and software innovations, such as the mouse, integrated email, display editing, windows and cross-file editing.

1998: James Nicholas Gray

He received the award for his seminal contributions to database and transaction processing research and technical leadership in system implementation. He designed end user-oriented performance benchmarks, and helped establish a vendor-neutral organization, the Transaction Processing Performance Council, to oversee their impartial implementation. This led to more than a decade of strong competition between vendors to improve their products. Gray, along with Gordon had set up Microsoft Advanced Laboratory in San Francisco, dedicated to servers and scalability. He played a role in developing TerraServer, which allowed access to satellite imagery with high resolution. His work had a large positive impact on almost everyone involved commercially or academically in the field of online transaction processing.

1999: Frederick Brooks

He received the award for his landmark contributions to computer architecture, operating systems, and software engineering. He helped design the IBM 7090 "Stretch" supercomputer, so called because it was a considerable

"stretch" to the technology and performance of most computers of the time. He is best known for managing the development of IBM's System/360 family of computers and the OS/360 software, and later writing candidly about the process in his seminal book "The Mythical Man-Month". The System /360 was a widely successful project that transformed the face of business computing and reshaped the landscape of the computer companies throughout the world. Brooks coined the term "computer architecture" to mean the structure and behavior of computer processors and associated devices, as separate from the details of any particular hardware implementation.

2000: Andrew Chi-Chih Yao

He received Turing award in recognition of his fundamental contributions to the theory of computation, including the complexity-based theory of pseudorandom number generation, cryptography, and communication complexity. In 1977, Yao introduced the Min-max principle in his paper "Probabilistic computations: toward a unified measure of complexity". Yao's principle has become a fundamental technique for reasoning about randomized algorithms and complexity. In 1981, with Danny Dolev, he introduced a formal model, "Dolev-Yao Model", for symbolic reasoning about security protocols. Later, he worked on the foundations of cryptography. He worked in areas such as decision tree and communication complexity. He also made substantial contributions to the theory of lower bounds for algebraic decision trees.

2001: Ole-Johan Dahl and Kristen Nygaard

They received the award for their ideas fundamental to the emergence of object oriented programming, through their design of the programming languages Simula I and Simula 67. Simula and C influenced C++. In 1957, working in Norwegian Defence Research Establishment (NDRE), Dahl designed and implemented a high-level language for the Mercury, called MAC (Mercury Automatic Coding). These ideas — objects, inheritance, and modularity — are among the major contributions of Dahl and Nygaard to the discipline of programming. Nygaard, with Petter Handlykken and Erik Holbaek-Hansen, developed a system description language

DELTA, which was used to aid in modeling real world systems. When Kristen was a visiting professor in Aarhus University, Denmark, he initiated work on BETA programming language. Like SIMULA, BETA is a language for describing models of the real world, but, in the tradition of SIMULA, it was also to be useful as an implementation language.

2002 : Leonard Max Adleman, Ronald Linn Rivest, and Adi Shamir

These three award winners were instrumental in making modern ecommerce feasible owing to their work in security algorithms. Their RSA is now the most widely used encryption method, with applications throughout the Internet for secure on-line transactions.

Adleman also worked on Fermat's Last Theorem, and in 1986, with colleagues Roger Heath-Brown and Etienne Fouvry, proved that the first case of the theorem holds for infinitely many primes. In the 1980's, with David Wofsy of University of California at San Francisco, he developed a theory of CD4-cell depletion in Acquired Immune Deficiency Syndrome (AIDS) as a homeostatic mechanism failure.

Rivest, in addition to RSA scheme, invented symmetric key encryption algorithms RC2, RC4, RC5 and co-authored RC6. Rivest's interests in security are not limited to encryption. He is a member of the US government technical committee that develops election guidelines. In 2006 he developed a novel three-ballot voting scheme.

Shamir is an internationally recognized cryptographer. Apart from RSA, he has a number of claims to fame. He is the co-inventor of a zero-knowledge proof scheme that allows one individual to show they know certain information without actually divulging it. Shamir invented Shamir's Secret Sharing scheme, in which a number of pieces of the secret are shared between individuals. It requires either some or all of them to collaborate in order to reveal the total secret. Shamir also proposed an identity-based encryption scheme which was of interest because it did not require the user to obtain a public-key to be used in encrypting a message.

2003: Alan Kay

Kay received the award for pioneering many of the ideas fundamental to contemporary object-oriented programming languages, leading the team that developed Smalltalk, and for fundamental contributions to personal computing. Alan Kay envisioned a small computing system in 1970's, long before notebook computers were available and hence some consider him as the "father of personal computers".

2004: Vinton Gray Cerf and Robert Elliot Kahn

Cerf received the award for his pioneering work on internetworking, including the design and implementation of the Internet's basic communications protocols, TCP/IP, and for inspired leadership in networking. In 1982, Cerf became Vice president of Digital Information Services at MCI, where he created MCI Mail, the first commercial email service to use the Internet in 1989. In 1986 Cerf joined CNRI as Vice President. In 1991, recognizing the need for a neutral forum for Internet standards development, Cerf and Kahn founded the Internet Society (ISOC), an international non- profit organization.

In 1972, Kahn organized the first public demonstration of the ARPANET at the October International Computer Communication Conference in Washington, D.C, which encouraged people at the various sites to bring new applications online, making the network more attractive to users. This effort brought the ARPANET to maturity and introduced the network to the larger computer science world.

In the spring of 1973, Kahn approached Cerf with the idea of developing a system for interconnecting networks—eventually called the "Internet." Kahn and Cerf demonstrated farsighted leadership by inviting networking experts from around the world to weigh in on the Internet design at a seminar in June 1973. This move led to more robust protocols, and laid the groundwork for the global spread of the Internet. Cerf and Kahn outlined the resulting Internet architecture in a seminal 1974 paper, "A Protocol for Packet Network Intercommunication".

2005: Peter Naur

He received the Turing award for his fundamental contributions to programming language design and the definition of ALGOL-60, and to compiler design, and also to the art and practice of computer programming. By the age of 12, astronomy became Peter's main passion. By the age of 15, Peter had already written his first scientific paper. In late 1950s, after joining Copenhagen's computing center, Peter participated in the development of the programming language ALGOL. During the rest of the 1960s, Peter played an increasingly important role in establishing computing as an academic field in Denmark. In 1966, he defined the courses he was teaching as datalogi, since he disliked the term computer science. This term, datalogi, has been adopted in Denmark and Sweden.

2006: Frances Elizabeth Allen

Allen, the first woman to win this award in its 40 years of history, made pioneering contributions to the theory and practice of optimizing compiler techniques that laid the foundation for modern optimizing compilers and automatic parallel execution. Allen worked on the Parallel Translator (PTRAN) in IBM, a system for compiling FORTRAN programs not specially written with parallelism in mind. Using her extensive experience with inter-procedural flow analysis, she produced new algorithms for extracting parallelism from sequential code. She introduced the concept of the program dependence graph, a representation now used by many parallelizing compilers.

2007: Edmund Melson Clarke, E. Allen Emerson, and Joseph Sifakis

Edmund Clarke, E Allen Emerson and Joseph Sifakis won the Turing Award in 2007 for their role in developing Model-checking into a highly effective verification technology.

With his student E. Allen Emerson, Edmund Clarke, saw an important possibility in temporal logic: it could be directly checked by machine. This gave birth to the technology of model checking. In 1980s, they invented computation tree logic.

From 1974 to 1977, Sifakis worked on Petri nets and other models for concurrent systems. He obtained original and fundamental results on the structural properties of Petri nets as well as on the performance evaluation of timed Petri nets. These results are extensively used today for scheduling data-flow systems. From 1977 to 1982, he worked on verification of transition systems. He obtained original results on the algorithmic verification of concurrent systems, which was based on a fix-point characterization of the modalities of a branching time temporal logic. These results laid down the foundations of model checking – the most widely used verification method in industry.

2008: Barbara Liskov

She received the award for her contributions to practical and theoretical foundations of programming language and system design, especially related to data abstraction, fault tolerance, and distributed computing. In 1968, she became one of the first women in the United States to be awarded a PhD in computer science. At MIT, she led the design and implementation of the CLU programming language, which emphasized the notions of modular programming, data abstraction, and polymorphism. These concepts are the foundation of object-oriented programming concepts used in modern computer languages such as Java, C++, and C#. Her research has covered many aspects of operating systems and computation.

2009: Charles P. Thacker

He received the award 2009 for the pioneering design and realization of the first modern personal computer - the Alto at Xerox Palo Alto Research Center - and seminal inventions and contributions to local area networks (including the Ethernet), multiprocessor workstations, snooping cache coherence protocols, and tablet personal computers. At Berkeley Computer Corporation, Thacker was responsible for the design of the microprogrammed processor. He also designed equipment for supporting remote users by concentrating their traffic over the fastest available data connection available at the time, 2400 bits per second. By 1980 he started the Dragon project based on LSI. Dragon was a multiprocessor that

employed one of the first cache-coherence protocols. In 1997, he joined Microsoft Research to help establish Microsoft Research Cambridge, in Cambridge, England. In 2010, he designed the Beehive, a simple multiprocessor system running on a Xilinx development board.

2010: Leslie Gabriel Valiant

He received Turing award in 2010 for transformative contributions to the theory of computation, including the theory of probably approximately correct learning, the complexity of enumeration and of algebraic computation, and the theory of parallel and distributed computing. His research has opened new frontiers. Valiant's work includes the study of both natural and artificial phenomena. The natural studies encompass the algorithms used by computing objects such as the human brain while the artificial include computers and their capabilities. In 1990, he proposed bulk synchronous parallel (BSP) model of communication. In this model, the individual processors need not work in lock-step but can each perform computations locally and only communicate the results between them at intervals.

2011: Judea Pearl

Pearl received the award for his fundamental contributions to artificial intelligence through the development of a calculus for probabilistic and causal reasoning. Pearl invented Bayesian Network for defining complex probability models. This work not only revolutionized the field of artificial intelligence but also became an important tool for many other branches of engineering and the natural sciences. He later created a mathematical framework for causal inference that has had significant impact in the social sciences. He created the representational and computational foundation for the processing of information under uncertainty.

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