# REVISED SYLLABUS

*Academic Year 2018-2019*


## Department of Computer Science

### School of Mathematics, Statistics and Computational Sciences

## Central University of Rajasthan

*NH-8 Jaipur- Ajmer Highway, Bandarsindri*
*Kishangarh -305802*
*District-Ajmer, Rajasthan*
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# M.Tech in Computer Science (Cyber Physical System)

## Scheme and Detail Syllabus: 2018-19

| S No | Subject Code | Title Of the Course | Credits | Contact Hours /Week | | |
|---|---|---|---|---|---|---|
| | | | | L | T | P |
| **Sem I** | | | | | | |
| 1 | MTC-411 | Probability Theory and Distributions | 4 | 3 | 1 | 0 |
| 2 | MTC-412 | Algorithm and Complexity | 4 | 3 | 0 | 2 |
| 3 | MTC-413 | Advanced Computer Networks | 4 | 3 | 0 | 2 |
| 4 | MTC-414 | Program Elective –I | 4 | 3 | 0 | 2 |
| 5 | MTC-415 | Open Elective-I | 4 | 3 | 0 | 2 |
| 6 | MTC-416 | System Design Lab | 4 | 0 | 2 | 3 |
| | | **Total** | **24** | | | |
| **SemII** | | | | | | |
| 1 | MTC-421 | WSN and IOT | 4 | 3 | 0 | 2 |
| 2 | MTC-422 | System Programming | 4 | 3 | 0 | 2 |
| 3 | MTC-423 | Program Elective-II | 4 | 3 | 0 | 2 |
| 4 | MTC-424 | Program Elective-III | 4 | 4 | 0 | 0 |
| 5 | MTC-425 | Minor Project | 4 | 0 | 0 | 8 |
| 6 | MTC-426 | Open Elective-II | 4 | 3 | 0 | 2 |
| | | **Total** | **24** | | | |
| **SemIII** | | | | | | |
| 1 | MTC-511 | Dissertation-I | 24 | 0 | 24 | 24 |
| | | **Total** | **24** | | | |
| **SemIV** | | | | | | |
| 1 | MTC-521 | Dissertation-II | 24 | 0 | 24 | 24 |
| | | **Total** | **24** | | | |

*L=Lecture P=Practical T=Tutorial*

## MTC-411 Probability Theory and Distributions

### Course Objectives

- To provide students with a formal treatment of probability theory.
- To equip students with essential tools for statistical analyses.
- To foster understanding through real-world statistical applications.

### Learning Outcomes

At the end of the course students can be able to:

- Develop problem-solving techniques needed to accurately calculate probabilities.
- Apply problem-solving techniques to solving real-world events.
- Apply selected probability distributions to solve problems.
- Present the analysis of derived statistics to all audiences.

### Syllabus

**Probability Theorem:** Properties of probability, Conditional probability, Independence, Bayes theorem.
**Discrete Distributions:** Probability distribution functions and cumulative distribution functions.
**Continuous Distributions:** Probability density functions and cumulative distribution functions, joint and marginal probability density functions.
**Mean and variance:** moment -generating functions, Marginal and conditional probability distributions, some specific discrete distributions.
**Functions of Random Variables:** Distribution function technique, Transformation technique, Moment-generating function techniques.

### Text/References:


1. DeGroot, Morris H., and Mark J. Schervish. Probability and Statistics. Addison-Wesley.
2. Feller, William. An Introduction to Probability Theory and Its Applications, Wiley.
3. Freund, W.J., Mathematical Statistics, Prentice-Hall..
4. Hoel, P.G., Mathematical Statistics, John Wiley & Sons.
5. Hogg, R.V., & Craig, A.T., Introduction to Mathematical Statistics, Prentice-Hall, Inc.
6. Mood, A.M., Graybill, F.A., Boes, D.C., Introduction to the Theory of Statistics, Mc Graw Hill.
7. Papoulis: Probability, Random Variables and Stochastic Processes, McGraw Hill.

## MTC-412 Algorithms and Complexity

**Course Objectives**

- To teach various problem solving strategies.
- To teach mathematical background for algorithm analysis and implementation of various advanced data structures like Tree, graph and heaps.
- To teach different pattern matching algorithms.

**Learning Outcomes**

At the end of the course students can be able to:

- Calculate time complexity and space complexity of an algorithm.
- Identify, implement, and use various data structures as appropriate for a given problem.
- Identify, formulate, and solve engineering problems.
- Apply design and development principles in the construction of software systems of varying complexity.

**Syllabus**

**Analysis:** RAM model – Notations, Recurrence analysis - Master's theorem and its proof - Amortized analysis.
**Advanced Data Structures:** B- Trees, AVL trees, Dictionaries and tries, Binomial Heaps, Fibonacci Heaps, Disjoint Sets, Union by Rank and Path Compression.
**Graph Algorithms and complexity:** Topological sorting, Articulation point, All-Pairs Shortest Paths, Spanning Tree, Maximum Flow and Bipartite Matching.
**Randomized Algorithms:** Finger Printing, Pattern Matching, Graph Problems, Algebraic Methods, Probabilistic Primality Testing, De-Randomization
**Approximation algorithms:** Polynomial Time Approximation Schemes.
**Complexity:** - NP-Hard and NP-complete Problems - Cook's theorem, NP completeness reductions.

**Text/References:**

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, Introduction to Algorithms, Prentice Hall.
2. Aho, Hopcraft, Ullman, Design and Analysis of Computer Algorithms, Addison Wesley.
3. R. Motwani and P. Raghavan, Randomized Algorithms, Cambrdige University Press.
4. C. H. Papadimitriou, Computational Complexity, Addison Wesley.
5. S. Basse, Computer Algorithms: Introduction to Design and Analysis, Addison Wesley.

## MTC-413 Advanced Computer Networks

**Course Objectives:**

1. To teach functionalities of various layers in OSI and TCP architecture.
2. To discuss the basics of network simulations and modeling.
3. To teach basics of modern networks like sensor networks, body area networks etc,.
4. To teach basics of enterprise networks.

**Course Outcomes:**

At the end of the course students can be able to:

1. Understand networking hardware elements like router, switch, bridge etc,.
2. Understand various network and transport layer protocols for wireless networks.
3. Understand characteristics, challenges, and applications of modern networks
4. Understand the servers and data centres.

**Syllabus**

**Unit I: Introduction**

Introduction to Layered architecture, Networking hardware and software stacks.

**Unit II: Network Performance**

Network Simulation and Modelling, Performance issues in networks, Protocol case studies (e.g. HTTP, HTTPS, SSL, DHCP, DNS, Transport protocols and Routing protocols in wired and wireless networks and their performance).

**Unit III: Modern Networks**
Mobile Networks, Sensor Networks, Vehicular Networks, Underwater Networks and Body Area networks and related performance issues.

**Unit IV: Enterprise Networks**

Enterprise network infrastructure planning and design. Capacity planning of servers and data centres.

**Text/ References:**

1. Top-Down Network Design- Networking Technology, Author Priscilla Oppenheimer, Publisher- Pearson Education, 2010.
2. Computer Networking: A Top-Down Approach (6th Edition), J Kurose and KW Ross, Pearson, 2012.

## MTC-421 Wireless Sensors Networks and Internet of Things (IoT)

**Course Objectives**

1. To teach state of art of wireless sensor networks
2. To discuss importance of communication protocols.
3. To teach challenges in routing protocol and overview of transport layer protocols.
4. To teach basics of Internet of Things.

**Learning Outcomes**

At the end of the course students can be able to:

1. Understand technological background of sensor networks.
2. Able to design applications using Raspberry Pi.
3. Design and apply various existing routing protocols of sensor networks.
4. Design the architecture and reference model of IoT.

**Syllabus**

## Unit I: Introduction

Overview of Wireless Sensor Networks – Characteristics, Applications, Design objectives, challenges. Technological Background – MEMS Technology, Hardware and Software Platforms, Wireless Sensor Network Standards. Sensor network architectures and protocol stack.

## Unit II: Medium Access Control

Fundamental MAC protocols, Objectives of MAC design, Energy efficiency in MAC design, MAC protocols for wireless sensor networks – Contention based protocols, Contention free protocols, Hybrid protocols.

## Unit III: Network and Transport Layer

Fundamentals and Challenges of Routing protocol, Overview of Routing protocols: Location-aided protocols, Layered and In-network processing based protocols, Data centric and multipath Protocols. Data aggregation mechanisms. Traditional transport protocols, Transport protocols for sensor networks

## Unit IV: Basics on Internet of Things

Introduction, Reference Model and architecture, IoT reference Model. IoT Reference Architecture-Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

**Text/References:**


1. Jun Zheng, Abbas, " Wireless sensor networks A networking perspective", WILEY, 2009.
2. Kazem Sohraby, Daniel Minoli, & Taieb Znati, ―Wireless Sensor Networks-Technology, Protocols, And Applications‖, John Wiley, 2007
3. Thomas Haenselmann, ―Wireless Sensor Networks: Design Principles for Scattered Systems‖, Oldenbourg Verlag, 2011
4. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
5. E. H. Callaway, Jr. E. H. Callaway, Wireless Sensor Networks Architecture and Protocols: CRC Press

6. F. Zhao and L. Guibas, Wireless Sensor Network: Information Processing Approach, Elsevier.
7. A. Hac, Wireless Sensor Network Designs, John Wiley & Sons
8. Francis daCosta, **"Rethinking the Internet of Things: A Scalable Approach to Connecting Everything",** 1st Edition, Apress Publications, 2013

**Internet of Things (IoT) Using MOOCs for the academic Year 2018-19 Even Semester**

**Syllabus**

**Unit I:**

Introduction to IoT: Part I, Part II, Sensing, Actuation, Basics of Networking: Part-I

Basics of Networking: Part-II, Part III, Part IV

**Unit II:**

Communication Protocols: Part I, Part II, Part III, Part IV, Part V, Sensor Networks: Part I, Part II, Sensor Networks: Part III, Part IV, Part V, Part VI, Machine-to-Machine Communications

**Unit III:**

Interoperability in IoT, Introduction to Arduino Programming: Part I, Part II, Integration of Sensors and Actuators with Arduino: Part I, Part II
Introduction to Python programming: Part I, Part II, Introduction to Raspberry Pi: Part I, Part II, Implementation of IoT with Raspberry Pi: Part I
Implementation of IoT with Raspberry Pi: Part II, Part III, Introduction to SDN: Part I, Part II, SDN for IoT: Part I, SDN for IoT: Part II, Data Handling and Analytics: Part I, Part II, Cloud Computing: Part I, Part II

**Unit IV:**

Cloud Computing: Part III, Part IV, Part V, Sensor-Cloud: Part I, Part II
Fog Computing: Part I, Part II, Smart Cities and Smart Homes: Part I, Part II, Part III
Connected Vehicles: Part I, Part II, Smart Grid: Part 1, Part II, Industrial IoT: Part I
Industrial IoT: Part I, Case Study: Agriculture, Healthcare, Activity Monitoring: Part I, Part II

**Text/ References:**

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)

2. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press)

3. Research papers

## MTC-422: System Programming

**Course Objectives**

1. Enumerate and explain the function of the common operating system kernel routines that are provided by an operating system and accessible from a systems programming language
2. Design, write, and test moderately complicated low-level programs using a systems programming language.
3. Proficiently use a pre-processor to implement code that is portable between different computing platforms.
4. Implement routines that read and write structured binary files such as word processing documents, index systems, or serialized hierarchical data
5. Use operating system kernel calls from within a programming language to allocate/free virtual memory, initiate and synchronize multiple threads/processes, interact with the file system, set and respond to timers/interrupts.

**Learning Outcomes**

After learning the course the students can be able to:

1. To understand the basics of system programs like editors, compiler, assembler, linker, loader, interpreter and debugger.
2. Describe the various concepts of assemblers and macro-processors.
3. To understand the various phases of compiler and compare its working with assembler.
4. To understand how linker and loader create an executable program from an object module created by assembler and compiler.
5. To know various editors and debugging techniques.

**Syllabus**

**Unit I**

Overview of System Software: Introduction, Software, Software Hierarchy, Systems Programming, Machine Structure, Interfaces, Address Space, Computer Languages, Tools, Life Cycle of a Source Program, Different Views on the Meaning of a Program, System Software Development, Recent Trends in Software Development, Levels of System Software.

Overview of Language Processors: Programming Languages and Language Processors, Language Processing Activities, Program Execution, Fundamental of Language Processing, Symbol Tables Data Structures for Language Processing: Search Data structures, Allocation Data Structures.

**Unit II**

Assemblers: Elements of Assembly Language Programming, Design of the Assembler, Assembler Design Criteria, Types of Assemblers, Two-Pass Assemblers, One-Pass Assemblers, Single pass Assembler for Intel x86 , Algorithm of Single Pass Assembler, Multi-Pass Assemblers, Advanced Assembly Process, Variants of Assemblers Design of two pass assembler

**Unit III**

Introduction, Relocation of Linking Concept, Design of a Linker, Self Relocating Programs, Linking in MSDOS, Linking of Overlay Structured Programs, Dynamic Linking, Loaders, Different Loading Schemes, Sequential and Direct Loaders, Compile-and-Go Loaders,

General Loader Schemes, Absolute Loaders, Relocating Loaders, Practical Relocating Loaders, Linking Loaders, Relocating Linking Loaders, Linkers v/s Loaders

**Unit IV**

Scanning and Parsing Programming Language Grammars, Classification of Grammar, Ambiguity in Grammatic Specification, Scanning, Parsing, Top Down Parsing, Bottom up Parsing, Language Processor Development Tools, LEX, YACC. Compilers Causes of Large Semantic Gap, Binding and Binding Times, Data Structure used in Compiling, Scope Rules, Memory Allocation, Compilation of Expression, Compilation of Control Structure, Code Optimization.

**Text/References:**


1. System Programming by D M Dhamdhere McGraw Hill Publication
2. System Programming by Srimanta Pal OXFORD Publication.
3. System Programming and Compiler Construction by R.K. Maurya& A. Godbole.
4. System Software – An Introduction to Systems Programming by Leland L. Beck, 3rd Edition, Pearson Education Asia, 2000
5. System Software by Santanu Chattopadhyay, Prentice-Hall India, 2007.
6. Compilers Principles, Techniques and Tools, By Aho Setti Ullman.

| **List of Electives (Program / Open Electives)**<br>Following list will be used for offering program elective/open elective and additional electives can be added as and when required after taking departmental approval. | |
|---|---|
| 1 | Compiler Design |
| 2 | Theory of Computation |
| 3 | Image Processing and Pattern Recognition. |
| 4 | Foundation of Data Science |
| 5 | Soft Computing |
| 6 | Machine Learning |
| 7 | High Performance Computing |
| 8 | Information Retrieval System |
| 9 | Mobile Computing |
| 10 | Information Theory and Coding |
| 11 | High Speed Networks |
| 12 | Advance Computer Architecture |
| 13 | Cyber Law & Security Polices |
| 14 | Intrusion Detection and Prevention Systems |
| 15 | Software Define Networking |
| 16 | Grid Computing |
| 17 | Ad-Hoc Networks |
| 18 | Meta Heuristics |
| 19 | Privacy and Forensics for Communication Network |
| 20 | Digital Forensics and Investigations |
| 21 | Data mining for evidence trace in Networks |
| 22 | Simulation and Modeling |
| 23 | Programming Abstraction |
| 24 | Advanced Software Engineering. |
| 25 | Cryptography and Network Security. |
| 26 | Embedded Systems |
| 27 | Information Theory and Coding |
| 28 | SCADA Systems and Security |

| | |
|---|---|
| 29 | Critical Infrastructure Management |
| 30 | Feedback Control Systems |
| 31 | Cloud Computing |
| 32 | Sensor and Actuator Networks |
| 33 | Real-Time Operating Systems and Fault-tolerant system |
| 34 | Hybrid system Modeling and Analysis using UPPAL and Statistical Model checking |
| 35 | Computing for Data Science |

Note: More to be added.

## Soft Computing

**Unit I: Artificial intelligence systems**

Neural networks, fuzzy logic, genetic algorithms. Artificial neural networks: Biological neural networks, model of an artificial neuron, Activation functions, architectures, characteristics learning methods, brief history of ANN, ANN architectures.

**Unit II: Back propagation networks**

BP architecture, multilayer perceptron, back propagation learning input layer, hidden layer, output layer computations, calculation of error, training of ANN, BP algorithm, momentum and learning rate, Selection of various parameters in BP networks. Variations in standard BP algorithms- Adaptive learning rate BP, resilient BP, Levenberg-Marquardt, and conjugate gradient BP algorithms, Applications of ANN.

**Unit III: Fuzzy Logic**

Crisp and fuzzy sets, fuzzy conditional statements, fuzzy rules, fuzzy algorithm. Fuzzy logic controller, fuzzification, interface knowledge base decision making, logic defuzzification, interface design of fuzzy logic controller, case studies.

**Unit IV: Genetic algorithms**

Basic concepts, encoding, fitness function, reproduction-Roulette wheel, Boltzmann, tournament, rank, and steady state selections, Elitism. Inheritance operators, Crossover-different types, Mutation, Bit-wise operators, Generational cycle, Convergence of GA, Applications of GA case studies. Basics of genetic programming.

**Text/References:**


1. R. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, Prentice Hall of India, New Delhi, 2003
2. L. Fausett, Fundamentals of Neural Networks, Prentice Hall, Upper Saddle River, N.J, 1994.
3. D. E. Goldberg, Genetic Algorithms in Search, Optimisation, and Machine Learning, Addison-Wesley, Reading, MA, 1989
4. M. T. Hagan, H. B. Demuth, and M. H. Beale, Neural Network Design, PWS Publishing, Boston, MA, 1996.
5. T. Ross,Fuzzy Logic with Engineering Applications, Tata McGraw Hill, New Delhi, 1995

6. J. R. Koza, Genetic Programming: On the Programming of Computers by Natural Selection, MIT Press, Cambridge, 1992.
7. B. Yegnanarayana, Artificial Neural Networks. Prentice Hall of India, New Delhi, 1999.

## Information Retrieval System

**Unit I: Introduction**

Definition, Objectives, Functional Overview, Relationship to DBMS, Digital libraries and Data Warehouses, Information Retrieval System Capabilities - Search, Browse.

**Unit II: Cataloging and Indexing**

Objectives, Indexing Process, Automatic Indexing, Information Extraction, Data Structures: Introduction, Stemming Algorithms, Inverted file structures, N-gram data structure, PAT data structure, Signature file structure, Hypertext data structure, Automatic Indexing: Classes of automatic indexing, Statistical indexing, Natural language, Concept indexing, Hypertext linkages.

**Unit III: Document and Term Clustering**

Introduction, Thesaurus generation, Item clustering, Hierarchy of clusters – User Search Techniques: Search statements and binding, Similarity measures and ranking, Relevance feedback, Selective dissemination of information search, weighted searches of Boolean systems, Searching the Internet and hypertext -Information Visualization: Introduction, Cognition and perception, Information visualization technologies.

**Unit IV: Text Search Algorithms**

Introduction, Software text search algorithms, Hardware text search systems. Information System Evaluation: Introduction, Measures used in system evaluation, Measurement example-TREC results. Multimedia Information Retrieval, Models and Languages, Data Modeling, Query Languages, Indexing and Searching, Libraries and Bibliographical Systems.

**Text/References:**

1. Information Storage and Retrieval Systems: Theory and Implementation By Kowalski, Gerald, Mark T Maybury Kluwer Academic Press, 2000.
2. Modern Information Retrieval by Ricardo Baeza-Yates, Pearson Education, 2007.
3. Information Retrieval: Algorithms and Heuristics by David A Grossman and Ophir Frieder, 2nd Edition, Springer International Edition, 2004.
4. Information Retrieval Data Structures and Algorithms By William B Frakes, Ricardo Baeza-Yates, Pearson Education, 1992.
5. Information Storage & Retrieval by Robert Korfhage – John Wiley & Sons.
6. Introduction to Information Retrieval by Christopher D. Manning and Prabhakar Raghavan, Cambridge University Press, 2008

## Mobile Computing

**Unit I**

Introduction, Applications, A short history of wireless Communication, A market for Mobile Communications, Some open research topics, A Simple Reference Model. Overview , Wireless Transmission, Frequency for radio transmission, Regulations, Signals, Antennas, Signal Propagation, Path Loss of radio Signals, Additional signal Propagation effects, Multi-path Propagation. Multiplexing, Modulation, Spread Spectrum.

**Unit II**

Medium Accesses Control, Motivation for Specialization MAC, Hidden and exposed terminals, near and Far Terminals, SDMA, FDMA, TDMA, CDMA.

**Unit III**

Wireless LAN, IEEE 802.11: System Architecture, Protocol architecture, Physical Layer, MAC Control Layer, MAC Management, 802.11b, 80.11a,HIPERLAN: , Bluetooth : User Scenario, Architecture, Radio Layer, Link Manager Protocol, L2CAP, SDP, IEEE 802.15.

**Unit IV**

Mobile Network Layer, Mobile IP, Dynamic Host Configuration Protocol, Mobile Ad-Hoc Networks, Mobile Transport Layer, Classical TCP Improvements.

**Text/References:**


1. Mobile Communications by Jochen H.Schiller.
2. Mobile Computing, Technology Applications and Service Creation by Asoke K Talukder and Roopa R Yavagal.
3. Stojmenovic and Cacute**,** "Handbook of Wireless Networks and Mobile Computing", *Wiley*, 2002, ISBN0471419028.
4. Reza Behravanfar, "Mobile Computing Principles: Designing and Developing Mobile Applications with UML and XML", ISBN: 0521817331, Cambridge University Press, October 2004,
5. Adelstein, Frank, Gupta, Sandeep KS, Richard III, Golden , Schwiebert, Loren, "Fundamentals of Mobile and Pervasive Computing", ISBN: 0071412379, McGraw-Hill Professional, 2005.

## Software Defined Networks

**Unit I**

Introduction, Centralized and Distributed Control and Data Planes, Introduction What Do They Do? Distributed Control Planes, Centralized Control Planes, Conclusions

Open Flow: Introduction, Hybrid Approaches, Conclusions, SDN Controllers Introduction General Concepts, Layer 3 Centric Plexxi Cisco One PK Conclusions

**Unit II**

Network Programmability: Introduction, the Management Interface the Application-Network Divide Modern Programmatic Interfaces, I2RSModern Orchestration

Data Center Concepts and Constructs

**Introduction:** The Multitenant Data Center Virtualized Multitenant Data Center SDN Solutions for the Data Center Network VLANsEVPN, VxLan,NVGRE, Conclusions, Network Function Virtualization Introduction Virtualization and Data Plane I/O Services Engineered Path, Service Locations and Chaining, NFV at ETSI, Non-ETSI NFV Work, Conclusions.

**Unit III**

Network Topology and Topological Information Abstraction Introduction, Network Topology, Traditional Methods, LLDP,BGP-TE/LS,ALTO,I2RS Topology Building an SDN Framework, Introduction, Build Code First; Ask Questions Later, The Juniper SDN Framework, IETF SDN Framework(s),Open Daylight Controller/Framework, Policy, Conclusions.

**Unit IV**

Use Cases for Bandwidth Scheduling, Manipulation, and Calendaring, Introduction, Bandwidth Calendaring, Big Data and Application Hyper-Virtualization for Instant CSPF, Expanding Topology, Conclusion, Use Cases for Data Center Overlays, Big Data, and Network Function Virtualization, Introduction, Data Center Orchestration, Puppet (DevOps Solution),Network Function Virtualization (NFV),Optimized Big Data, Conclusions

**Text/References:**


1. SDN: Software Defined Networks An Authoritative Review of Network Programmability Technologies By Thomas D. Nadeau, Ken Gray Publisher: O'Reilly Media Final Release Date: August 2013 Pages: 384.
2. Software Defined Networks: A Comprehensive Approach Paperback – Import, 30 Jun 2014by Paul Goransson (Author), Chuck Black (Author)

3. Software Defined Networking with Open Flow by Siamak Azodolmolky (Author)

## High Performance Computing

**Unit I**

Single-processor Computing , The Von Neumann architecture, Modern processors , Memory Hierarchies, Multi core architectures, Locality and data reuse, Programming strategies for high performance ,Power consumption ,Review questions.

**Unit II**

Parallel Computing , Introduction ,Quantifying parallelism, Parallel Computers Architectures , Different types of memory access ,Granularity of parallelism ,Parallel programming , Topologies ,Multi-threaded architectures ,Co-processors ,Remaining topics , Computer Arithmetic , Integers , Real numbers , Round-off error analysis ,Compilers and round-off , More about floating point arithmetic , Conclusions. Numerical treatment of differential equations , Initial value problems, Boundary value problems , Initial boundary value problem ,Numerical linear algebra ,Elimination of unknowns ,Linear algebra in computer arithmetic , LU factorization ,Sparse matrices, Iterative methods ,Further Reading .

**Unit III**

High performance linear algebra, Collective operations, Parallel dense matrix-vector product ,LU factorization in parallel, Matrix-matrix product, Sparse matrix-vector product , Parallelism in solving linear systems from Partial Diffential Equations (PDEs),Computational aspects of iterative methods , Parallel preconditioners ,Ordering strategies and parallelism ,Operator splitting , Parallelism and implicit operations ,Grid updates ,Block algorithms on multi core architectures.

**Unit IV**

Applications ,Molecular dynamics ,Force Computation ,Parallel Decompositions ,Parallel Fast Fourier Transform , Integration for Molecular Dynamics , Sorting ,Brief introduction to sorting Odd-even transposition sort ,Quicksort ,Bitonic sort ,Graph analytics ,Traditional graph algorithms, Real world' graphs ,Hypertext algorithms ,Large-scale computational graph theory, N-body problems ,The Barnes-Hut algorithm ,The Fast Multipole Method ,Full computation, Implementation Monte Carlo Methods, Parallel Random Number Generation, Examples, Computational biology Dynamic programming approaches, Suffix tree.

**Text/References:**

1. Introduction to High Performance Scientific Computing Evolving Copy - open for comments Victor Eijkhout, Edmond Chow, Robert van de Geijn.
2. High Performance Computing (RISC Architectures, Optimization & Benchmarks), Charles Severance, Kevin Dowd, Oreilly.
3. High Performance Computing (RISC Architectures, Optimization & Benchmarks), Georg Hager, Gerhard Wellein, CRC Press.
4. Introduction to High-Performance Scientific Computing (Scientific and Engineering Computation), Lloyd D. Fosdick, Elizabeth R. Jessup

## Meta Heuristics

**Unit I**

Scatter Search and Path Relinking: Advances and Applications, Fred Glover, Manuel Laguna and Rafael Marti, An Introduction to Tabu Search, Michel Gendreau, Genetic Algorithms ,Colin Reeves Genetic Programming: Automatic Synthesis of Topologies and Numerical Parameters ,John R. Koza

**Unit II**

Graph Algorithms: Definitions and Representation, Minimum Spanning Tree: Prim's Algorithm, Single Source Shortest Paths: Dijkstra's Algorithm, All-Pairs Shortest Paths, Transitive Closure, Vertex Covering, Vertex Coloring - Randomized Algorithms.

**Unit III**

Introduction, Overview, and Notation, Basic Methodologies and Applications, Restriction Methods, Greedy Methods, Recursive Greedy Methods Linear Programming LP Rounding and Extensions. On Analyzing Semi Definite Programming Relaxations of Complex Quadratic Optimization Problems Polynomial-Time Approximation Schemes.

**Unit IV**

Rounding Interval Partitioning and Separation Asymptotic Polynomial-Time Approximation Schemes Randomized Approximation Techniques Distributed Approximation via LP-Duality and Randomization Empirical Analysis of Randomized Algorithms Reductions that Preserve Approximability Differential Ratio Approximation Hardness of Approximation.

**Text/References:**

1. Handbook of Approximation Algorithms and Meta heuristics by TeofiloF.Gonzalez.
   S. Rajasekaran and G.A.V. Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI, 2003.
2. R. Eberhart, P.Simpson and R. Dobbins, “Computational Intelligence-Pc Tools”, AP Professional, Boston, 1996.
3. T.H.Cormen, C.E.Leiserson, R.L.Rivest and C. Stein, "Introduction to algorithms", 3rd edition, MIT Press, 2009.

## Ad-Hoc Networks

### Unit I: Introduction

Fundamentals of Wireless Communication Technology – The Electromagnetic Spectrum, Radio propagation Mechanisms, Characteristics of the Wireless Channel, Mobile ad hoc networks (MANETs) and Vehicular ad hoc networks (VANETs):concepts and architectures. Applications and Design Challenges of MANETs and VANETs.

### Unit II: Mac Protocols

Issues in designing a MAC Protocol, Classification of MAC Protocols: Contention based protocols-Contention based protocols with Reservation Mechanisms- Contention based protocols with Scheduling Mechanisms – Multi channel MAC-IEEE 802.11. IEEE Standards: 802.11a, 802.11b etc,. 802.15, HIPERLAN

### Unit III: Routing Protocols

Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Power Aware Routing Protocols. Multi cast routing in Ad Hoc Wireless Networks: Issues in Designing a Multicast Routing Protocol, Classifications of Multicast Routing Protocols. Energy Efficient Multicasting, Multicasting with Quality of Service Guarantees, Application Dependent Multicast Routing.

### Unit IV: Energy Management

Energy Management in AdHoc Wireless Networks: Classification of Energy Management Schemes, Transmission Power Management Schemes, System Power Management Schemes. Special topics in Ad Hoc and wireless networks.

### Text/ References

1. C S. Ram Murthy, B. S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall of India, 2nd ed. 2005.

2. R. Hekmat, Ad hoc Networks: Fundamental Properties and Network Topologies, Springer, 1st ed. 2006.
3. B. Tavli and W. Heinzelman, Mobile Ad Hoc Networks: Energy Efficient Real Time Data Communications, Springer, 1st ed. 2006.
4. Carlos De MoraisCordeiro, Dharma Prakash Agrawal "Ad Hoc & Sensor Networks: Theory and Applications", World Scientific Publishing Company, 2006.
5. G. Anastasi, E. Ancillotti, R. Bernasconi, and E. S.Biagioni, Multi Hop Ad Hoc Networks from Theory to Reality, Nova Science Publishers, 2008

# Grid Computing

## Unit I: Introduction

Evolution of Distributed computing: Scalable computing over the Internet – Technologies for network based systems – clusters of cooperative computers – Grid computing Infrastructures – cloud computing – service oriented architecture – Introduction to Grid architecture and standards – Elements of Grid – Overview of Grid architecture.

## Unit II: Grid Services

Introduction to Open Grid Services Architecture (OGSA) – Motivation – Functionality Requirements – Practical & Detailed view of OGSA/OGSI – Data intensive grid service models – OGSA services.

## Unit III: Virtualization

Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software – Pros and Cons of cloud computing – Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – Virtual clusters and Resource Management – Virtual for data center automation.

### Unit IV: Programming Model

Open source grid middleware packages – Globus Toolkit (GT4) Architecture, Configuration – Usage of Globus – Main components and Programming model – Introduction to Hadoop Framework – Map reduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job – Design of Hadoop file system, HDFS concepts, command line and java interface, dataflow of File read & File write.

### Text/ References

1. Ahmar Abbas, "Grid Computing: A Practical Guide to Technology and Application", Charles River Media, 2005.
2. Kai Hwang, Geoffery C. Fox and Jack J. Dongarra, "Distributed and Cloud Computing: Clusters, Grids, Clouds and the Future of Internet", First Edition, Morgan Kaufman Publisher, an Imprint of Elsevier, 2012.
3. Bart Jacob, " Introduction to Grid Computing", IBM Red Books, Vervante, 2005.
4. Tom White, " Hadoop The Definitive Guide", First Edition. O"Reilly, 2009.
5. Joshy Joseph and Craig Fellenstein, "G rid Com puting", Pearson Education, 2003.
6. Ian Foster and Carl Kesselm an, "The Grid2: Blueprint for a New Computing Infrastructure", Morgan Kaufman, 2004.

## Advanced Computer Architecture

**Unit I: Introduction**

Overview of Parallel Processing and Pipelining Processing, Study and comparison of Uni-processors and Parallel processors. Necessity of high performance, Constraints of conventional architecture, Parallelism in Uni-processor system, Evolution of parallel processors, future trends, Architectural Classification, Instruction level Parallelism and Thread Level Parallelism. Performance Metrics and Measures, Speedup Performance Laws.

**Unit II: Pipelining Processing**

Principles and implementation of Pipelining, Classification of pipelining processors, Pipeline Architecture, Study and comparison of processors with and without pipelining. General pipelining reservation table, Design aspect of Arithmetic and Instruction pipelining, Pipelining hazards and resolving techniques, Data buffering techniques, Job sequencing and Collision, Advanced pipelining techniques: loop unrolling techniques, out of order execution, software scheduling, trace scheduling. Advances in pipeline architectures. Implementation issues of programs on any pipelined processor and their analysis.

**Unit III: SIMD Computer Organization And Parallel Algorithms For Array Processors**

Study and comparison of Vector and Array processors, Basic vector architecture, Issues in Vector Processing, Vector performance modelling, vectorizers and optimizers, Case study: Cray Arch. Masking and Data network mechanism, Inter PE Communication, Interconnection networks of SIMD, Static Vs Dynamic network, cube hyper cube and Mesh Interconnection network. Matrix Multiplication. Sorting, SIMD computer organization. Implementation issues of Matrix multiplication and sorting on array processor and their analysis.

**Unit IV: Multiprocessor**

Microprocessor Architectures, Study and comparison of Loosely and Tightly coupled multiprocessors. Loosely and Tightly coupled multiprocessors, Processor characteristics of multiprocessors, Inter Processor communication network, Time shared bus, Crossbar switch, Multiport Memory Model, Memory contention and arbitration techniques, Cache coherency and bus snooping, Massively Parallel Processors (MPP), Cow's and NOW's Cluster and Network of Work Stations), Chip Multiprocessing (CMP). Implementation issues of a program on multiprocessor system

**Text/ References**

1. Kai Hwang, Faye A. Briggs, "Computer Architecture and Parallel Processing" McGraw Hill international Edition.

2. Kai Hwang, "Advanced Computer Architecture", Tata McGraw-Hill.
3. Rajaraman, L Sivaram Murthy, "Parallel Computers", PHI.
4. William Stallings, "Computer Organization and Architecture, Designing for performance" Prentice Hall, Sixth edition.
5. Kai Hwang, Scalable Parallel Computing.
6. Harrold Stone, High performance computer Architecture.
7. Richard Y. Kain, Advanced Computer Architecture
8. http://www.intel.com/products/processor (for Intel Itanium Processor).

## Cloud Computing

**Unit I: Introduction**

Overview of Computing Paradigm: Recent trends in Computing - Grid Computing, Cluster Computing, Distributed Computing, Utility Computing, Cloud Computing.

Introduction to Cloud Computing: Evolution of Cloud Computing, Cloud Computing (NIST Model), Cloud Service Providers. Properties, Characteristics & Disadvantages of Cloud Computing.

Cloud Computing Architecture: Cloud Computing Stack: Working of Cloud Computing, Role of Networks in Cloud computing, Protocols, Role of Web services. Service Models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Deployment Models: Public, Private, Community, and Hybrid Clouds.

**Unit II: Data Center Servers and Virtualization**

Data Center Design: DC Topology, Scale and Management. Data Center Server: Server Building Blocks, Server Availability, Server Security.
Data Center Virtualization: Data Center Virtualization Overview, Virtualization Availability, Virtualization Server Hierarchy, Functions and Benefits, Virtualization Performance. Data Center Storage Hierarchy

**Unit III: Data Center Networking**

Data Center Networking: Requirements, Architecture, Design Factors for Data Center Networks, Virtual Ethernet, Data Center Routing, Addressing, Transport layer protocols.
Network Virtualization: Virtualization Technologies for the Data Center Network: Switching techniques, Traffic patterns, Network Node virtualization, Virtual Network Services. Server virtualization software: VMware VSphere, Features and Components of VMware VSphere, VSphere e Solutions to Data Center Challenges. Virtual Network Security.

**Unit IV: Virtual Machine Management**

Virtual Machine Management: Configuration, Placement and Resource Allocation. Creating and Configuring Hyper-V Network Virtualization, Overview of Backup and Restore Options for Virtual Machines, Protecting Virtualization Infrastructure by Using Data Protection Manager. Power efficiency in Virtual Data centers, Fault Tolerance in Virtual Data Centers, Resource Scheduling, Performance. ACE Virtual Contexts and Case Studies.

**Text/ References**


1. Cloud Computing: Concepts, Technology & Architecture, Thomas Erl, Ricardo Puttini, Zaigham Mahmood, Prentice Hall, 2013

2. IT Infrastructure and Its Management: Phalguni Gupta and Surya Prakash,Tata McGraw-Hill, 2009.
3. Cloud Computing for Dummies by Judith Hurwitz, R. Bloor, M.Kanfman, F.Halper (Wiley India Edition).

4. IBM Data Center Networking: Planning for Virtualization and Cloud Computing, 1st Edition (May 2011).
5. Data Center Networks: Topologies, Architectures and Fault-Tolerance Characteristics, By Yang Liu, Jogesh K Muppala, Malathi Veeraraghavan, Dong Lin, Mounir Hamdi, Springer.
6. Mastering in Cloud Computing: R. Buyya, Christian Vecchiola, and Thamarai Selvi , Tata McGraw Hill Education Private Limited, India, ISBN-13: 978-1-25-902995-0
7. Cloud Computing Bible by Barrie Sosinsky, Wiley India.


## Computing for Data Science

**Unit I: Computer Package**
Installation of RStudio and understanding the basic framework, Basic computational structures – Iterations and Recursions, Sequences and Arrays in R – Search and Sort Algorithms, Vectors and Matrices in R – Solving systems of linear equations, Functions in R – Plotting (2D, Contour, 3D), Differentiation, Root finding, Linear Models in R – Gradient descent, linear regression, Eigenvalue/vector computation and SVD in R ,Handling sparse matrices in R – Basic operations on sparse matrices, Probability Distributions and Random Sampling in R, Monte-Carlo Simulation in R – Implementation of case studies

**Unit II: Concept of Computations**
Algorithms – Search and Sort, Divide and Conquer, Greedy Algorithms - motivating example from set cover for large data sets. Computational Complexity – Growth of functions, Order notation, Computational Complexity -- Convergence, Error Estimation, Sparse Matrix – Store, Search and Basic operations, Binary Trees and Graphs as Computational Models

**Unit III: Numerical Methods**
Solving system of linear equations – Gauss-Jordan (concept of pivoting), Solving non-linear equations – Newton-Raphson, Steepest Descent, Optimizing cost functions – Gradient descent, least square regression, Iterative methods in Linear Algebra – Power iteration, Eigenvalues, SVD

**Unit IV: Computing Methodologies**
Monte-Carlo Simulation – Case studies, Sparse Matrix – Store, Search and Basic operations Pruning and Sampling algorithms, streaming data, External sorting

### Text/References:


1. Software for Data Analysis – Programming with R : John M. Chambers, Springer

2. Elementary Numerical Analysis – An Algorithmic Approach: Samuel Conte and Carl de Boor (McGraw-Hill Education)

3. Introduction to Algorithms: Cormen, Leiserson, Rivest and Stein, The MT Press (Third Edition)