TATA CONSULTANCY SERVICES
Experience certainty.

Mathematics in Industry – *Prospects and Opportunities*

Dr. Sharadha Ramanan

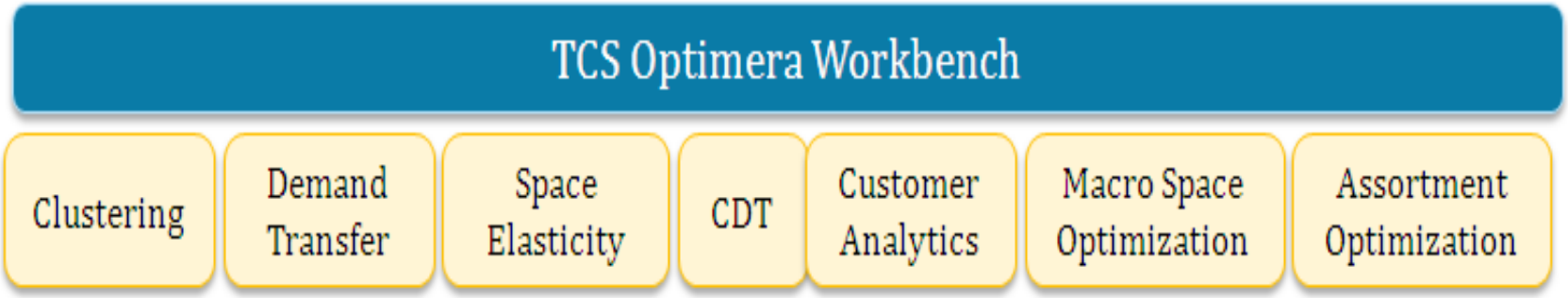
Head, *Computational Intelligence Group*

My Mathematical Experience in TCS

- Companies consuming my mathematical models are several Fortune 500 companies across different verticals like airlines, retail and manufacturing
- Core engine of TCS Product Optimera is based on the mathematical work done by me and my team
- Gartner/ AMR Research reviewed this product, with other competing products, and positioned TCS as World Leaders in Assortment Planning, Feb 2010
- Patent on 'Assortment Planning and Optimization' filed in 2011
- Mathematical Modeling and Simulation to Identify and Solve Clients' business problems through multiple iterations
- Areas/Problems I have worked on: System Dynamics model for TCS Software Engineering projects, Software Error Prediction, Productivity Improvement Model, Flight Crew Training Planner, Assortment Optimization, Macro Space Optimization
- This is a representative sample of the work that I have done in my 14 years at TCS

My Mathematical Experience in TCS

- Representative sample of Consulting Projects
  - **Macro Space Optimization**
    - **(2010-11) – Leading Arts & Crafts retailer in USA**
  - **Optimera Workbench**
    - **(2010-11) – Leading Arts & Crafts retailer in USA**
  - **Statistical Variability Engagement**
    - **(2010-11) – Leading Pharmacy chain in USA**
  - **Assortment Planning and Optimization**
    - **(2009-10) – Leading retail and Pharmacy chain in USA**
  - **Flight Crew Manpower Planning (Proto)**
    - **(2008-09) – Leading European Airline**



How Mathematics is consumed in the Real World

- Industry Sampler – Finance, Stock markets, Risk analysis, Algorithmic Trading, Data Mining, CFD, Bio-Informatics, Operations Research, Economics, SCM, Telecom
- TCS has Research and Development centers and Innovation Labs across the world. We are involved right from conceptualization, implementation and execution
- This century will be about making sense of data, really large data, and data across disciplines. Not enough theories analyzing and explaining the data
- Mathematicians should not miss this wave relating to algorithms and Computation
- Indians have a natural flair for problem solving, algorithms and computation. Examples are Bhaskara, R.C. Bose, C.R. Rao, Karmakar, Agarwal
- Our current Academic Mathematical Programs inexplicably shun computation and algorithms. Mathematics programs focus on theories, and not on examples, problem solving, algorithms, computations and applications
- Engineering programs focus on only on applications and computations, and the engineers produced are blissfully unaware of the underlying mathematics, theories and imagination which led to these applications
- This provides opportunities for mathematicians who venture out of their comfort zones to other disciplines

Qualities expected of Mathematicians in Industry

- Problem Solving capability
  - Computation and Programming experience
  - Understanding of basic concepts and methods
  - Applying mathematical concepts using Matlab, R Project
  - Mathematical maturity and elbow grease
  - Willingness to learn
  - Real competition is from the engineers who are good in programming and computation. You have mathematics education as your edge. Learn and do a bit of computation. Their edge is programming and their deficit is lack of rigorous mathematical education and insight
  - With a mathematics education, programming and computation can be learnt easily
  - Currently, there are more engineers than mathematicians = More opportunities for mathematicians now
  - Your true strengths will be to use common sense to problem solving, ability to apply concepts and ability to generalize
  - Making sense of data and data chasing theories. This is the mathematical pulse of applied work

What is expected from young mathematicians in industry

- A bit of computation, linear algebra, differential equations, mathematical and statistical skills
- Basic communication skills
- Basic computational skills
- Be willing to learn and correct on the go
- Basic knowledge of concepts in mathematics and statistics
- Being able to cope with a steep learning curve and ability to learn new things fast. This is not an exam oriented learning but knowledge oriented learning
- Stick to a style you are comfortable with, instead of busy conforming to what you think is required of you
- Acquire computation skills. Unless you are open in mind with respect to computation, these opportunities will not come to you
- I am looking for bright people who can do both mathematical modeling and computation. Contact me if you think you qualify and are interested

Computation skills needed in Industry

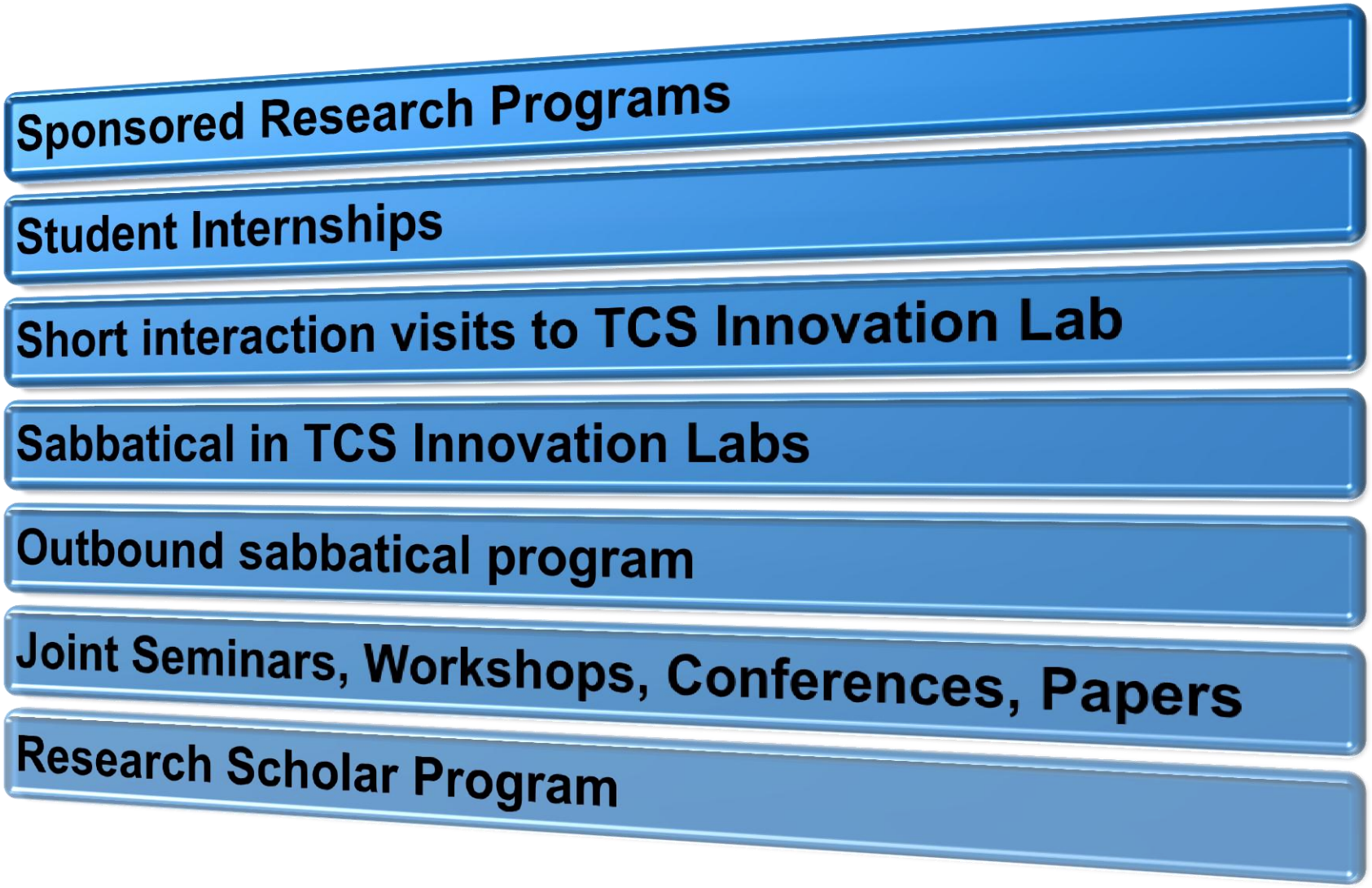
- Handle high level tools like SAS, SPSS, R project, WEKA. R is the biggest trend now. There are plenty of opportunities available if you learn R
- Any customer data with a number of variables are represented as vectors, for e.g., speech language and image signals. Linear algebra, Probability models and Computation skills are very useful in solving these real world problems
- Learn Java and Python. Learn Map Reduce and Hadoop. Good computer programming gives you good opportunity to practice mathematics
- Cryptography, Coding Theory, Computational fluid dynamics, Image, Video, Speech, Natural Language Processing among others

TCS & Women

- 30% of TCS workforce are women. This beats the academic rates by a huge margin
- 7-10 % of TCS Senior management are women
- TCS is a most women friendly organization and has a very accommodating culture for women
- TCS has HR policies for women such as:

- Opportunity to pursue higher studies taking up to 2 years leave. Support and sponsorship for higher studies based on approval
- Women are given up to 1 year leave with Loss of Pay if their spouse is going overseas. They are even given opportunities to work there
- If they have children less than 6 years, they can avail leave without pay for up to 1 to 1 1/2 years
- Women can take a break for a year if their children are writing board exams
- Flexibility for working from home because of geographical spread of TCS offices across the world. Based on the kind of role and ability of role to work remote, one can work from home
- Post maternity women can work from the closest office near to their home
- One can choose a different career role different from what one is currently doing
- Many women working in tight schedule projects shift to Quality, HR, Process Excellence
- DAWN - Diversity and Women's Network, an initiative to sharpen focus and heighten sensitivity on the diversity mandate across the various geographies

TCS Academic COIN™ - Models of Collaboration



TCS Research Scholarship Program

Vision

- Enhance our nation's talent base of research in Computing Sciences

The Program

- Support 200 PhD researchers in CS and related disciplines from Institutes across India – starting 2010.
- Holistic model including interactions with TCS Innovation Labs and financial support for the scholar, guide and institution

Goals

- Support High quality and Impact sustaining research.
- Possible exposure to the complexities of the real world data and situations during Interaction with TCS researchers.
- Encourage Institutes to find and admit more students
- Provide an attractive environment for both the student and Institute to do research in computer science

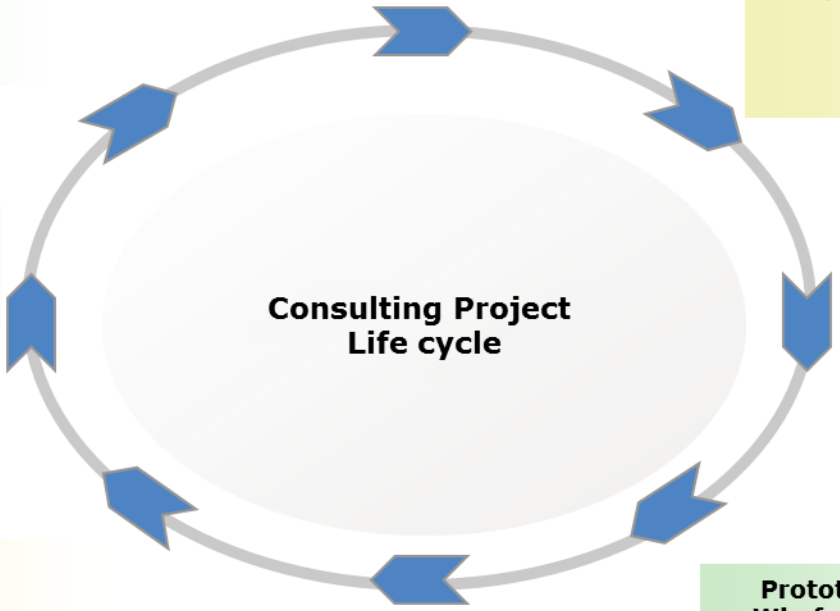
Sample Research Areas

- Machine translation
- Wearable computing
- Machine learning for computer vision
- Secure multi-party computation
- Microphone array speech processing
- Cooperative control of multiple mobile robots
- Multimedia data transmission over future wireless networks
- Intrusion detection techniques
- Text mining and social network analysis
- Scalable video streaming over internet
- Security and reliability on the Cloud
- Data- mining- based intrusion detection
- Self-healing networks

Problem Solving in Industry: Focus and Constraints

- Gap between Academics and Industry
  - various tools and techniques are available but cannot be applied directly
  - industry factors not considered in the academic model
  - real world constraints and scenarios are missing
- In Industry
  - focus is on Client problems, relating to their context
  - issues leading to the problem are well understood
  - how to formulate a problem is the key
  - how to solve it and what methods to use
  - the problem is not easily categorized as geometrical, algebraic or stochastic problem
  - time constraints, 12 - 16 weeks for a Proof of Concept (PoC)
  - to deal with real data and all its complexities (noise)
  - first obtain an approximate solution, then iterate again by adding relevant factors to improve it and obtain a good solution

Typical Consulting Project Life Cycle diagram



Understand Client's issues
Formulate the Problem
Explore relevant area, do prior art search
Identify relevant mathematical/ statistical methods & techniques
Select a small prototype problem

Win prototype project

Rapid Prototype building by leveraging continuing research

Prototype evaluation
Win full project award

Support to ISU delivery with
- Risk management
- Design
- Testing & acceptance

Support to ISU for asset based GTM

- Improve & consolidate offering for replication

Continuing academic & industrial research

Case Study – Assortment Optimization Tool

Customer Profile
- One of the largest pharmacy chain in USA
- Over 7,000 stores in USA

Challenges
- To optimize the overall product sales gross margins while satisfying the space and integrality constraints and taking into account all the relevant costs

TCS Solution
- Use category wise historical data for sales, price, cost, replenishment frequency, product size, fixture type and size, maximum number of facings, regular and promotion
- Include assortment breadth and depth, performance, customer insights and rules/ strategies
- Consider ranking, space elasticity, SKU demand transfer, choice sets, markdown of existing SKUs
- Objective is to maximize overall gross margins and minimize the costs
- Analyze various reports & compare scenarios

R&D role
- Acquire project, research, analysis, develop prototype, implementation and testing in real-life environment

Technology & Product
- R, Optimization Solver
- Optimera - Assortment Planning Tool

Expected Business Benefits

Reduction in Inventory costs up to 40%.

Localized customer centric assortment , reduced number of SKUs without significant impact on sales , reduced complexities

Reduce stock outs for all SKUs and higher availability for critical SKUs, with option to analyze the cost of increased availability

Case pack – Inner pack recommendations to optimize the pack size delivered to the store

Reduced backroom costs and wastages

Gartner evaluates TCS as World Leaders!

(AMR Research. Feb 2010)

Contact

Dr. Sharadha Ramanan,

Head, Computational Intelligence Group (CompInt)

sharadha.ramanan@tcs.com

TATA Consultancy Services
17, Cathedral Road,
Tamil Nadu,
Chennai - 600 086
India.