

# ARC ThinkTank

Algorithms and Randomness  
Center and ThinkTank

Georgia Tech  
2008

# Team

CS

Furst, Lipton  
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Math

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ISYE

Ahmed  
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*and many other affiliated faculty*

# Advisory Board

William Cook

ISYE, GT

Rich DeMillo

CoC, GT

Ravi Kannan

Yale+Microsoft

Richard Karp

UC Berkeley

Richard Lipton

CoC, GT

László Lovász

Eotvos Univ., Hungary

# World-class team

## Awards

- 2 Guggenheim fellows
- 3 Fulkerson prize winners
- 4 Sloan fellows
- Several NSF Career awards

Reputed for **impactful and fundamental discoveries**:

- Planar Separator Theorem
- Permanent Algorithm
- Volume Algorithm
- Unique games Conjecture
- Fast Matrix Algorithms

Several papers at every STOC (ACM) and FOCS (IEEE) since 2006.

# A few *simple* questions:

- How does the brain learn? (from relatively few, but complex examples)
- What is the structure of the internet?  
How to best route on it?
- Can we predict medical risk from patient records?
- How do proteins fold?

# Algorithms and Algorithmic Models

- What is the **inherent complexity** of **computation**?
- Insight into natural processes
- **Computation**, in a general sense, **is universal** (internet, brain, proteins, computers) and so are algorithms.

# Randomness

- A powerful tool to design algorithms
- An abstraction of complexity in modeling real-world problems

# Mission

- To **identify problems** with natural connections to algorithms and randomness.
- To **help solve** these problems and understand related phenomena by suggesting provable algorithms and algorithmic explanations.
- To **formulate general tools** based on the solutions and the insights behind them and thereby extend and solidify the theory of algorithms.
- To **serve as an algorithms and randomness resource** for scientists across campus.

# Activities

- ARC **Colloquium** weekly
- ARC **Research lunch** fortnightly
- RA's/**mentoring** for graduate students
- **Graduate course** on Algorithms and Randomness, yearly.
- **Workshops**, with broad external participation.

# ARC Research Lunch

- Weekly, 12-2pm, by invitation, ARC ThinkTank faculty plus guests.
- Guest gets 10 minutes to present a topic before the session becomes fully interactive.
- **Goal:** identify problems that are theoretically interesting to us and genuinely useful to guest.
- Think about them and provide feedback.
- Present “good” problems to students each semester.

# Example 1: The Internet

- Guests (multiple lunches): Feamster, Dovrolis, Ammar (CoC)
- **Problems**: How to route traffic? How to design/enhance topology?
- **Key insight**: disconnect between theory (of routing algorithms) and practice!

# Internet Routing

- All routing is shortest path based
- Many advantages (small delay, scaleable)
- BUT, not fault-tolerant!  
“#1 problem with the internet”

**Solution: Path Splicing** uses multiple shortest path trees stitched together.

Implemented, tested in simulation, full deployment underway. [HotNets07, SIGCOMM08]

# Example 2: Protein Folding

- Guest: Skolnick (Biology)
- **Problem**: find the native fold of a protein given as a sequence and the pathway by which it gets there.
- **Current method**: Hypothesize energy function and minimize it heuristically.
- **Bottleneck**: only works for proteins whose sequences have a good match with other proteins whose native folds are known.

# Protein Folding

- Potential solution: **Entropic search**
  - Maintains the list of *all* folds satisfying a list of constraints in high dimension.
  - Seems to work well on the small examples we've tried so far, e.g., forms helices.

# motto

If you're looking for an **algorithm** (e.g., to optimize, sample or integrate your favorite function)

OR

If you'd like to find an **algorithmic model** or explanation for a phenomenon you've observed,

Contact ARC.

# What can ARC do for GT?

- GT is **already a leader** in the field of algorithms and complexity.
- Algorithms and complexity might well be the **future of science**.
- With a small investment, ARC can **transform the field** itself and take it into uncharted territory.

# Goals for 08-09

- Increase faculty participation and collaboration
- Hire a complexity theorist
- Solve basic problems (in software testing, spam filtering, wireless routing, computer vision, biology) together with local experts
- Find new insights and tools for the theory of algorithms.