Welcome!
Outline of Today's Session

• Introduction

• Glimpse of Research conducted at CSE, IIT Delhi

• Interaction session by Recent PhD graduates

• Faculty Student Interaction
Why PhD/MSR or Research in General?
Our PhD Graduates

- DeepMind Inc
- UT Austin (Research fellow)
- Georgia Tech University
- IIIT Delhi
- Hong Kong University
- Adobe (Principal Scientist)
- University of Toronto (post doc)
- IBM Research
- Google Labs
- Hasso Plattner Institute (Researcher)
- Microsoft Research
- BITS Pilani
- Ecom Express (Vice President)
- CompilerAI Labs (Co-Founder)
- TIFR
Research areas we work in

- Algorithms and Complexity Theory
- Cryptography
- Quantum computing
- Computational social choice
- Game theory
- Artificial Intelligence (AI)
- Machine Learning (ML)
- Natural Language Processing (NLP)
- Databases and Data Analytics
- Architecture and Embedded Systems
- Graphics and Computer Vision

- Networks and Distributed Systems
- Programming Languages, Semantics and Verification
- Operating Systems
- High Performance Computing and Systems Software
- Information and Communication Technologies for Development
- Neuro-informatics and Medical informatics
- Cyber Security and Secure Information Systems
Our Industry Collaborations

- IBM Research
- Foundation for Ecological Security
- Huawei
- Domino’s
- Flipkart
- Bill and Melinda Gates Foundation
- Swiggy
- Freescale Semiconductors
- Google
- Qualcomm
- Microsoft Research
- NetApp
- Gram Vaani Community Media
- VMware
Top Venues We Publish at

- WSDM
- FOCS
- NeurIPS
- IJCAI
- LICS
- ICLR
- AAAI
- TCC
- ICALP
- WSDM
- STOC
- ICML
- SIGMOD
- OOPSLA
- SODA
- CGO
- WWW
- NeurIPS
- SOSP
- ICALP
- WSDM
- STOC
- TCC
- ASPLOS
- PLDI
- KDD
- FSTTCS
- CCS
- NDSS
- VLDB
- ICTD
- COMPASS
- PLDI
- CCS
Some of Perks of PhD/MSR Life

- Independent researcher
- Collaborations
- Visit Conferences, present your research
Applying for PhD/MSR
PhD / MSR Application Process

• Step 1: Apply through the IIT Delhi portal
  • https://home.iitd.ac.in/pg-admissions.php

• Step 2: Wait to hear from us if you get shortlisted
  • Last Cycle: http://phd.cse.iitd.ac.in/phd_selection/dec22.html

• Step 3: Online exam testing your basics

• Step 4: Verbal interviews (typically conducted through Microsoft Teams)
Preparing for the Interviews

• Online exams
  • Three sections: Programming, Basic math and probabilities, Comprehension
  • Cut-offs will be announced before the exam takes place
    • Typically, >20% in each section and >30% in total

• Verbal interviews
  • Basic CS (Data structures, algorithms, basics of probabilities, math and linear algebra)
    • If you choose a certain area of research, basics of that area.

• How do you prepare?
  • PhD Programme@CSE/SIT (iitd.ac.in)
Fellowships and Travel Support

• 1.5 lakhs of travel support to every PhD student from the institute

• An additional 2.5 lakhs from the department to present paper in conferences
  • Must be a top-tier conference (A*)

• Many students from the department are supported by external fellowships that allow a top-up salary of up to 40k INR and additional travel support
  • Google
  • Qualcomm
  • PMRF
  • TCS
  • Etc.
Further queries?

• Website: http://phd.cse.iitd.ac.in/

• Email: icphd@cse.iitd.ac.in
Glimpse of Research @ CSE
Theory Group: Introduction

Amit Kumar  Amitabha Bagchi  Ashish Chiplunkar  Keerti Choudhary  Naveen Garg

Nikhil Balaji  Ragesh Jaiswal  Rohit Vaish  Venkata Koppula

https://cstheory.iitd.ac.in/
(Dynamic) Graph Algorithms

Should ‘shortest-path’ after each update be recomputed?
Approximation Algorithms

I find shortest tours.

I find close-to-shortest tours.
And I'm fast!

Amit Kumar

Naveen Garg
Online Algorithms
Randomized algorithms
(Quantum) Cryptography

Hard Computational Problem $\Rightarrow$ Provable Security?

- Signatures
- Zero knowledge proofs
- Code Obfuscation
- Pseudorandom Functions
- Encryption

Venkata Koppula
Ragesh Jaiswal
Algorithms + Economics/AI

Computational Social Choice
Algorithmic Game Theory
Fairness in AI

Rohit Vaish
Ashish Chiplunkar
Theory Group: Preparation, Pre-requisites

**Relevant courses:**
- Linear algebra
- Probability
- Discrete mathematics
- Data structures
- Algorithms
Compilers / OS / Formal Methods

Abhilash Jindal  S. Arun Kumar  Kolin Paul  Kumar Madhukar
Rijurekha Sen  Sanjiva Prasad  Subodh Sharma  Sorav Bansal
Increasing Complexity of Compilers
Current Compilers

Problem (program spec) → Compiler Algorithms Carefully Developed by Expert Programmers → Solution (optimized assembly impl.)
Superoptimization-based Compiler

Problem (program spec) → Inductive Synthesis → Candidate Solution → Equivalence Checker → Solution (optimized assembly impl.) → Counter-example
Equivalence Checker

End-to-End, support for loops, aliasing information, function calls, …
No false-positives (sound)
Minimize false-negatives
Compiler Validation

Source Code → Compiler → Machine Code

Compiling

Front-end

Optimizations

Back-end

Equivalent?

Yes, Proof

No
Find several bugs in popular compilers and libraries

Found over 20 Bugs found in GCC, ICC, Qemu, Linux Kernel, NetBSD, Newlib, Dietlibc, …
(some had escaped over 20 years of testing and use)
What you need to apply for a PhD in these areas?

- Basic knowledge and Interest in Software Systems
- Theory of Computation, Operating Systems, Programming Languages
- Strong desire to become an expert in deep areas of computer science, and the required patience and perseverance

What have people done after doing a PhD from IIT Delhi in these areas?

- Faculty (IIITD, TIFR), Principal Scientist at a Reputed Industrial Research Lab, Techno-Corporate Leadership Roles (VP), Deep-Tech Startup Founders, Senior Engineering Leadership Roles all over the world
Data Science & Information Retrieval

Amitabha Bagchi
Sayan Ranu
Srikanta Bedathur
Maya Ramanath
Abhijnan Chakraborty

https://dsire.iitd.ac.in
Recent Explosion of Data
Data and Knowledge Bases

How to efficiently store and retrieve such huge amount of data?
Graph Neural Networks

How to efficiently perform inference on large graphs?
Search and Recommendations

How to retrieve information a user wants?
How to ensure equitable performance across different user groups?
Data Science Group: Pre-requisites

Relevant courses:

- Linear algebra
- Probability
- Data structures and Algorithms
- AI/Machine Learning
Annual LULC maps on intra-annual patterns of land-use

Pan-India micro-watershed diagnosis on water stress

Participatory tools to assist communities in scientific and equitable natural resource management and crop planning

AI-based tools for community-based forest governance and monitoring to assess the impact of community forest rights regulation
Infer socio-economic development using satellite data, at fine spatial-temporal scales

Low-cost systems for community radio automation, deployed at scale in the wild

Automated question-answering for agriculture, using speech recognition and machine learning

Price forecasting of agricultural commodities to recommend to farmer coops the right time to sell their produce, to maximize income
Cyber Security Group

Huzur Saran  Smruti Sarangi  Kolin Paul  Sanjiva Prasad  Subodh Sharma

Vireshwar Kumar  Venkata Koppula  Sorav Bansal  Ragesh Jaiswal
Area Overview

Smart City

Smart Home

Smart Transportation

Smart Robot

Cyber Attacks

Ukraine power cut ‘was cyber-attack’

Mirai botnet: How CCTV cameras almost brought down the internet

Hackers remotely kill a Jeep on the highway

‘I’m in your baby’s room’: A hacker took over a baby monitor

Discover and mitigate security and privacy vulnerabilities
Some Interesting Projects

Car Security

Bluetooth Security

5G Security
Cyber Security + Machine Learning

Network Intrusion Detection System

Remote Attestation
Secure, low-power, smart, networked systems

• Secure CAN, LIN, and Flexray buses (protocol redundancy)
• Black-box recorders: secure persistent memory
• 5G processors for vehicles

Smart Vehicles

Drones

Smart glasses

5G stack

1. Secure augmented reality
2. Ultra-low power Transformers (language translation)
3. Software-based 5G testbed
2. Approximate communication using polar codes
3. 5G OS design

Computation offloading
CPU-GPU performance prediction
Architectures for flight-path processing: power efficient stereo vision
Secure Web Browsers and Operating Systems

We are creating a secure version of Chrome and the Javascript V8 engine

Zero-client system

Make it safe and secure
Session by our Senior / Recent PhD Students
Speakers

Shubhani Gupta
(IIT Delhi, CompilerAI Labs)

Nikhil Kumar
(Hasso Plattner Institute)
Informal Interaction Session
Thank you!