



# Research in CS and Research Careers in India

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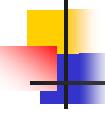
## Agenda

- Research
- Researcher
- Research career



## Research

- What is Research?



## Research

- Answers some general question, whose answer is useful and unknown
  - The question may not be known or articulated before the research/answer
- Creates new knowledge which is interesting/useful



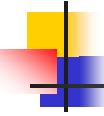
## Science and Engineering Research

- Science research: Focuses on discovery of facts and laws of nature
  - Explains, predicts, defines limits,...
- Engineering is a synthetic discipline; engineering research facilitates creation
  - Creation of new artifacts
  - Or improving existing artifacts



## Computer Science Research

- CS is engineering in that it is synthetic
  - Products are often intellectual only (e.g. algo, software, architecture, process,...)
  - (Some aspects of theory are in the science domain)



## CS Research

- Research (result) must have
  - A new idea (algo, data struct, process,...)
  - Which leads to some improvement
- Newness is necessary but not sufficient!
- A lot of CS research therefore is devoted to finding a better algorithm, methodology, architecture, tool, ...



## Better

- Takes less resources
- Solves a larger class of problems
- Is more general
- Presents a new capability
- New limits
- ...



## Engineering vs. Engineering Research

- A new software is written, which a lot of people use – is it research?
- Is research only if the software embodies some new ideas, and the use of the idea leads to some improvement
- A highly used new product could be good engineering or innovation but need not necessarily be research



## Theoretical and Implementation-oriented research

- Theoretical/conceptual research can be totally in intellectual domain
- Implementation (system) research often has artifacts like prototypes
  - Must still have some new idea
  - Implementation is the best way to express and validate the idea



## Academic and Corporate Research

- Academic research: Knowledge useful for the world, or answer general questions
- Corporate research primarily interested in K that is useful to its business
- Significance (newness and betterment) needed in both
- Often industry research looks at shorter term problems, while academic research may look at longer horizons



## Basic and Applied Research

- Applied research – done to obtain results directly useful in producing something of commercial/practical value
  - Is still research
- Academic research was earlier mostly basic, now is also applied
- Applied areas are generally the focus of corporate research programs



## Evaluating Research

- Two key components
  - The benefits or significance of the new idea
  - Magnitude and significance of the impact, i.e. how many and how deeply other researchers or users are impacted
- Impact is time dependent
  - Can be estimated by measures like no of downloads, uses, readers,...
- Significance is largely determined by the research community



## Necessity of Publication

- Publication, even of research resulting in artifacts, is a way of establishing significance and newness
  - Review and openness used
- An indirect measure of significance is the place where the paper appears
- Publication often necessary for impact (of course not sufficient)



## Researcher



## Researcher

- Researcher: One who creates new knowledge
- What makes a researcher a good one?
- What are the capabilities/skills a competent researcher must have



## Research Process

- Essentially three phases
  - Problem definition
  - Exploring and finding solutions
  - Communicating (and validating) results
- They are not sequential – often writing shows many shortcomings
- Exploring refines problem definition



## Research Process...

- Problem definition perhaps the hardest
  - Requires good breadth; depth in the area; insight in scope/limitations of current work
  - Use insight to define a “doable” problem, which is interesting and whose solution has a potentially wide impact



## Research Process...

- Exploring and solving
  - Apply scientific methods to solve and validate
  - Use of maths/logic, implementation, modeling, ...
- Communicating and validating
  - No real validation without peer evaluation
  - Little value if not communicated
  - Writing also refines and debugs
  - Writing and publishing is a major part of R effort!
- Effort Distr?



## Abilities of a Researcher

- Breadth – helps in all phases
- Expertise and depth in the chosen area – necessary for finding problem, solution approach, goodness,...
- Problem finding ability: Critical reading of literature, abstracting from experience and practice, building perspective; insight
- Solution exploring ability
- Ability to write and present results
- (A good PhD program supports all these)



## Research Careers in CS in India (besides academics)



### Background

- Research activity increasing in India
- Many multinationals are starting labs
  - E.g. IBM, Microsoft, Lucent, Motorola, Intel
  - It is expected many more will open
- Indian companies becoming active
  - E.g. TCS has 3 labs, Infy has R spread
  - As companies get larger, R will become more important to their business



## Research Manpower

- Doing research is a skill, generally developed through PhD
- Hence, primary manpower is PhDs
  - People with research orientation but experience also form this manpower
- All across India, 10-20 PhDs are produced in CS every year



## Demand

- Over next two years, 10 main research labs will require about 200 PhDs
- Plus there will be new labs
- Some of these will be returning expats
- There is already an acute shortage; this shortage will increase in coming years



## Industrial Research Career

- Research does not mean no development but that there is some idea driving it
- Research projects generally are not customer driven
  - Hence deadlines, pressure is different
- Requires engineering, innovation, and researching skills



## Research Career...

- Usually small groups even within a large company engage in research
- The hierarchy is flat, culture different
  - Is more self determining work
- Travel abroad may be frequent, but for shorter durations



## Compensation

- The starting salaries are around Rs 8 to 10 lacs per year
- Increasing every year
- Compensation now better than even that of project people with experience
  - B.Tech + 4 yr will probably make 4-6L



## Doing PhD

- Doing a PhD requires 4 to 5 years after BE/BTech
- Should be undertaken only by the bright ones with commitment
- A lot of growth while doing PhD; can be a lot of fun as well
- Best to do PhD from a good university or institute



## Long Term Research Career

- PhD is just the starting; in the long term, is hard and challenging career
  - You have to continue to be innovative, generate new ideas, ...
  - Primarily self motivating; very easy to become stale/inactive
  - Ladder does not have many steps!



## Summary

- Research is different from engineering – is about creating new knowledge
- A researcher needs different skills
- Research careers are increasing in India, R setup diff even in companies
- Bright and committed students should consider it; do PhD from good places