Research, the doctorate, and the life of researchers

Master 2ème année, spécialité "Réseaux"

Université Pierre et Marie Curie

2013

WHAT IS RESEARCH?

A definition

- "Research is an organized and systematic way of finding answers to questions"

  http://linguistics.byu.edu/faculty/henrichsenl/researchmethods/RM_1_01.html

- In everyday life, this includes
  - Reading a factual book of any sort is a kind of research
  - Surfing the internet or watching the news is also a type of research

From: http://www.experiment-resources.com/definition-of-research.html

In science

- Goal
  - Create knowledge
  - Discovery
- Strict protocols and long established rules
  - Structure
  - Formalism

From: http://www.experiment-resources.com/definition-of-research.html

Why practice CS as science?

- Scientific practice provides a limited type of external verification that grounds our work in something other than mere consensual hallucination

- Scientific practice enables more rapid progress toward things we wish to produce
  - Explanations — *How does that IR system work? Why did the Internet behave in that way?*
  - Guidance — *What should we do if we want our data center to have a higher percentage of uptime?*
  - Technologies — *How can we build a better integrated development environment? What networking protocol offers the highest performance for real P2P networks?*

From: **"Research Methods for Empirical Computer Science"**
Class by David Jensen at University of Massachusetts, Amherst

DOING RESEARCH IN CS

Construct an algorithm or system

- Much of what we think of as "doing computer science" is about building the infrastructure to do computer science
- Examples include building new...
  - Compilers
  - Garbage collectors
  - Networking protocols
  - Machine learning algorithms
- But, of course, this isn't everything we do (or should do)…

From: **"Research Methods for Empirical Computer Science"**
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The kinds of things CS researchers do

- Design an algorithm
- Design an experiment
- Run an experiment
- Gather data
- Identify an existence proof
- Make a conjecture
- Devise a research question
- Construct a theoretical proof
- Find flaws in previous experiment
- Identify an important exception to a theory
- Construct a general theory
- Use a theory to explain an observation
- Compare results from theory and experiment
- Devise a new measurement or technique
- Unify disparate theories
- Establish a relationship between variables

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Identify a research question

- Identify a research question about which a hypothesis can be formulated
- These hypotheses are typically about
  - Algorithms
  - Tasks, or
  - Environments
- Questions about
  - Individual elements (e.g., existence proofs)
  - How changes in one element affect another
  - Comparisons of two more elements holding others constant
- Often iterative and done by multiple researchers

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DO YOU WANT TO DO A DOCTORATE?

What is a doctorate?

- A *long*, *in depth* research exploration of *one* topic
  - Long = three years in France (around 6 years in US)
  - In depth = you will be the world expert or close to it in your particular area
  - One = typically be working on only one narrow problem

From: M. Harchol-Balter, "Applying to Ph.D. Programs in Computer Science"
http://www-2.cs.cmu.edu/~harchol/gradschooltalk.pdf

Very different than taking classes!

In class

- Homeworks have known answers
- Techniques for solving problems introduced in class
- Professor pick problems
- Close guidance: grades, professor tells you what to do next

In research

- Problems may not be solvable
- Invent techniques to solve problems
- You pick problems
- Some help from advisor, but need to be self-motivated and pro-active

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Think about life after doctorate

Academia

- Teaching schools
- Research-1 schools
- Research institutes
  - In France, INRIA, CNRS
- Big vs. small; public vs. private
- Country?
- Do you love (or at least like) to teach? students?

Industry

- Many different types of industry settings
  - Startup
  - "Big industry"
  - Research labs

From: J. Kurose, "10 pieces of advice I wish my PhD advisor had given me"
http://www-net.cs.umass.edu/kurose/talks/

Academia: Research universities/ institutes

- Doing research on anything you like
- Working with graduate students
- Teaching classes
  - Amount of teaching depends on country
- Applying for grants
- Flying around to work with other researchers and to give talks on your research
- Doing service for your department
- Doing service for the community
  - Reviewing papers, organizing conferences

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Academia: Teaching schools

- Teaching lots of classes
- Doing service for your department
- Occasionally advising undergraduates on undergraduate research, or doing a little of your own research

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Industry: Research labs

- Doing research
  - Always need to be useful for company
- Working with other people in the company
  - Could also have students as interns
- Traveling around a little to give talks and work with others
- Doing service for the community
  - Reviewing papers, organizing conferences

Importance of each of these tasks depends on the company (more R or more D)

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Should you get a doctorate?

- Evaluate
  - What type of career do you want?
  - Do you have the elements (personality, drive, passion) to succeed?
  - Is this the best use of your time?
- If not, it is OK to leave
  - At any time
- If so, optimize your decisions (life, career, research choices) around making the most of it
  - If you're going to "half ass" it, why bother?

From: N. Feamster, A. Gray, "What is a Ph.D.?"
http://www.gtnoise.net/classes/cs7001/fall_2008/syllabus.html#Schedule

If you decide to get a doctorate…

- A successful career
  - Ability to have real impact
  - A lifetime of learning and advancement of knowledge
  - A job you love
  - Freedom: much less structure than other jobs
  - Many people are not so lucky

- High-quality research
  - You will be evaluated on your publication record and contributions to science, not on your dissertation
  - You have an opportunity to fundamentally change the world we live in. Dissertation is a minimal requirement…think BIG!

From: N. Feamster, A. Gray, "What is a Ph.D.?"
http://www.gtnoise.net/classes/cs7001/fall_2008/syllabus.html#Schedule

HOW TO DO GOOD RESEARCH?

"A successful person isn't necessarily better than her less successful peers at solving problems; her pattern-recognition facilities have just learned what problems are worth solving."

– *Ray Kurzweil*

Factors to consider

- Importance
  - How important is the research topic within the larger research and application community?
- State of knowledge
  - What do we know already? What is the position of the research with respect to "the frontier"?
- Unique competence
  - Are you uniquely qualified to address this research? What is your "secret weapon"?
- Interest
  - How much does this research problem interest you personally? Do you have a passion for this problem?

From: **"Research Methods for Empirical Computer Science"**
Class by David Jensen at University of Massachusetts, Amherst

Assessing importance

- Audience
  - Who will care about the answer?
- Impact
  - Will different answers change...
    - ...what research gets done next?
    - ...what is done by practitioners?
- Longevity
  - How long will the answer be relevant and important?

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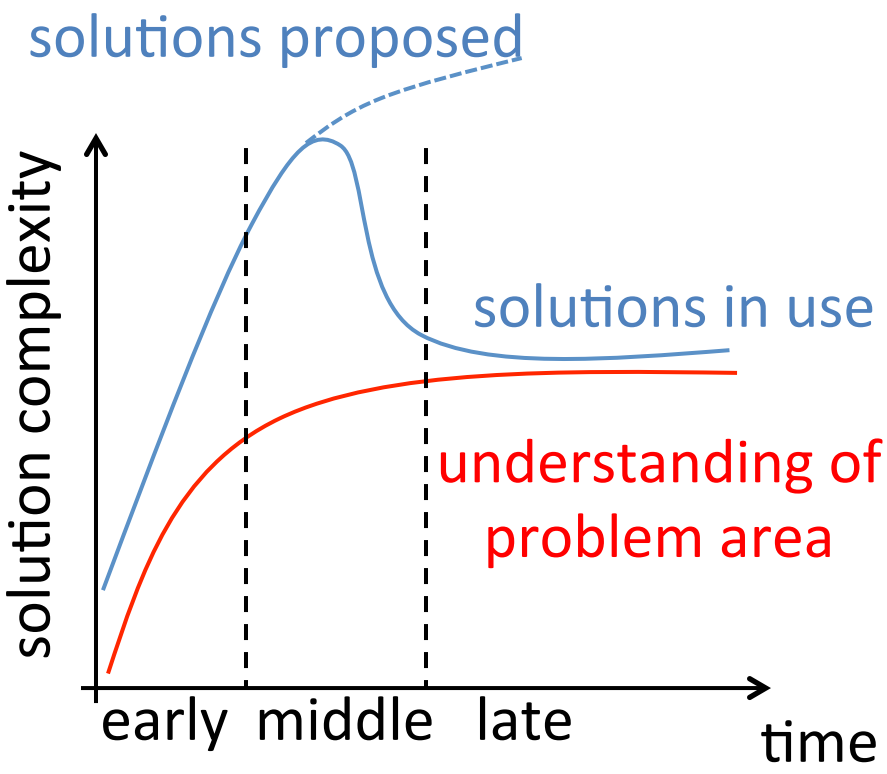
Choosing a research problem

- Pick your problems carefully!
  - what's the fundamental issue you're solving?
  - will the problem be of interest five, ten years from now?
  - focus on fundamentals in a world with an increasingly short attention span
- Avoid crowded areas
  - unless you have a unique talent, viewpoint
  - low-hanging fruit has been picked
  - researchers working on "next big thing" are not in the crowd

From: J. Kurose, "10 pieces of advice I wish my PhD advisor had given me"
http://www-net.cs.umass.edu/kurose/talks/

Complexity of solutions



- complexity, sophistication are themselves not of interest (except to purist)
  - means, not an end
  - how is the "story" changed in the end?

From: J. Kurose, "10 pieces of advice I wish my PhD advisor had given me"
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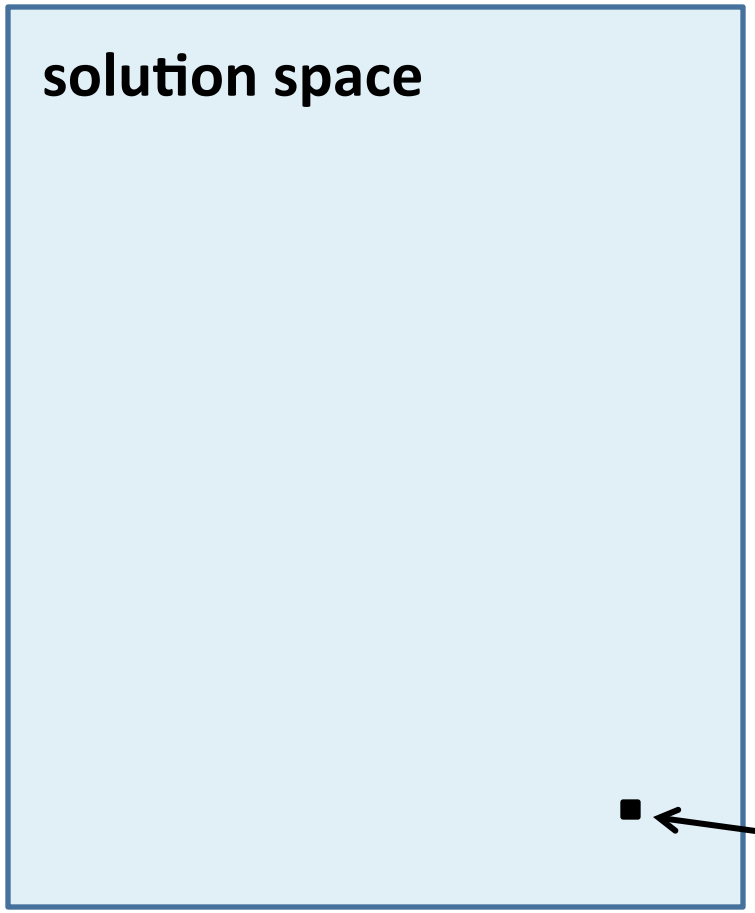
Avoid point solutions



- Insights that cut across solution space vs. point solution
- what broader conclusions can be drawn from your work?

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Be thorough

- Always begin with a literature survey
- Start with the smallest non-trivial instance
- Learn as you go
- Prepare to change
- Crystallize solutions
- Keep an eye open for the unexpected
- Carry a notebook

From: S. Kehav, “Hints on doing research”
http://blizzard.cs.uwaterloo.ca/keshav/mediawiki-1.4.7/index.php/Hints_on_doing_research

Be part of a community of scholars

- Meet people, listen, collaborate
  - Good students, colleagues, friends
- Approach, talk with people
- Interactions with peer students
  - research discussions
  - paper presentations
  - practice talks
  - ….

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Homework

- Select one paper from a conference/journal
  - This paper should guide your selection of your project's topic
  - List of conferences in networking with some statistics
    - http://www.cs.ucsb.edu/~almeroth/conf/stats/
- One-page write up with two parts
  1. How did you select this paper and why?
     - Detail your process for selecting paper
     - Explain why you find it interesting
     - How this paper inspire your project topic
  2. Short description of your project topic
- Submit your homework at
  - https://tibre.lip6.fr/hotcrp/metho13-1

Recommended reading

- Loehle, C. (1990). A guide to increasing creativity in research - inspiration or perspiration? *Bioscience* 40:123-9
  - http://limnology.wisc.edu/courses/zoo955/Fall2005/publications/Wk04_Research/Loehle_1990_Guide_to_Creativity.pdf

Reading for the next weeks

- V. Paxson, "End-to-End Routing Behavior in the Internet." *IEEE/ACM Transactions on Networking*, Vol.5, No.5, pp. 601-615, October 1997.
  - http://conferences.sigcomm.org/sigcomm/1996/papers/paxson.pdf

If you want to learn more…

- Oliver, J. (1991). *The Incomplete Guide to the Art of Discovery*. Columbia University Press. 0-231-07620-7.
  - PDF available at: http://kdl.cs.umass.edu/courses/rmcs/index.html

- D. Patterson, "How to Have a Bad Career In Research/Academia"
  - Slides available at: http://www.cs.berkeley.edu/~pattrsn/talks/nontech.html