About Research

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- Main difference between graduate and undergraduate study:

RESEARCH

What is RESEARCH?

Careful, systematic, patient

study and investigation

in some field of knowledge,

undertaken to discover or establish

facts or principles

(Webster's New World Dictionary)

RESEARCH includes

- Find suitable topics
- Decide plausible methods
- Obtain concrete results
- Write technical papers
- Give oral presentations

Find a suitable topic/problem(1/4)

- 提出一個問題往往比解決一個問題更重要

  因為解決一個問題也許僅僅是一個數學上或實驗上的技巧而已

  而提出新的問題 新的可能性 從新的角度去看舊的問題卻需要有創造性的想像力 而且標誌著科學的真正進步

  (愛因斯坦)

Find a suitable topic/problem(2/4)

- Public key cryptography

Find a suitable topic/problem(3/4)

- Well-known problem

  Fermat last theorem, Prime, P=NP?
- Original problem

  Motivations
- From reading papers
- Assigned

  Research projects

Find a suitable topic/problem(4/4)

Topics obtained from reading papers

- Improvement/enhancement
- Generalization
- Specialization
- Combination

Topics obtained from reading papers 1/4

- Improvement/enhancement
  - time/computation cost
  - space
  - bandwidth/message size
  - security/trust
  - power consumption
  - random bits

Topics obtained from reading papers 2/4

- Generalization
  - Secret Sharing
    - access structure
  - Protocols
    - two-party, multiparty
  - Change constants into Variables

Secret Sharing

- A *secret sharing scheme* is a system that is designed to protect a secret piece of information among a group of users in such a way that only certain subsets of users can jointly reconstruct the secret, whereas other subsets of users can ideally not obtain any information about the secret.
- The collection of subsets that can access the secret is called the *access structure* of the secret sharing scheme.

Secret Sharing

- k out of n ((k,n)- *threshold schemes)*
- General *access structure*

secret sharing *with added extras*

1. the ability to disenroll a dishonest user.
2. the ability to change the access structure dynamically
3. protecting against insider cheating.
4. establishing a secret sharing scheme in the absence of a trusted third party.
5. sharing more than one secret.
6. sharing one secret more than once.
7. reconstructing the secret without knowledge of user identities (*anonymous* secret sharing).

Topics obtained from reading papers 3/4

- Specialization
  - Hard problems
    - Discrete logarithm
      - Baby-Step Giant-Step method
      - Pohlig-Hellman method
  - Change variables into constants

Topics obtained from reading papers 4/4

- Combination

  e.g. A *blind*

  RSA-based

  group

  signature scheme

(http://www.cse.ucsd.edu/users/mihir/crypto-topic-generator.html)

How to read

- Efficient reading of papers in science and technology

Reading Research Papers
Some tricks 1/2

- Give up the notion that you must verify the truth of every single line or that you must understand each paragraph before going on to the next.
- Decide what parts of the paper to read carefully and what to skip.
- Get down to details.
- Work through a small section at a time (don't try to understand everything at once).
- Avoid the temptation to go through a section line by line.

Reading Research Papers
Some tricks 2/2

- Make it your own by thinking about how you might approach the problem.
- Don't look things up until you are sure you have to.
- Try to read around those words you don't know.
- Put aside the part you get stuck and try a different part of the paper.
- Ask for help when necessary.

Reading Research Papers
Type of information to look for 1/3

- What is the paper about?

  What problem does the author address?

  Why is the problem interesting?

  What is the history of the problem?

  What are the results?

  Is the problem solved or only partial results given?

  What are the key steps leading to the results?

Reading Research Papers
Type of information to look for 2/3

- What is new, interesting or important here?

What makes the paper worth reading?

- the problem itself
- the final results or solution
- the method used
- some other feature

What are the authors' contributions?

Reading Research Papers
Type of information to look for 3/3

- Which parts are worth spending time on?

Research methods

- Abstraction of the problem
- Model
- Assumptions
- Tools from other fields

Research methods

Abstraction of the problem

- The seven bridges of Konigsberg

  Multigraph model (Euler 1736)

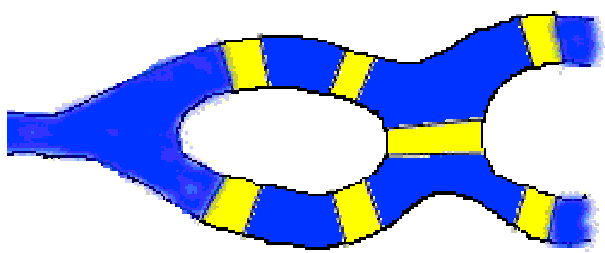
    Euler circuit/path

    Necessary and sufficient conditions for Euler circuits and paths

  Graph theory

The seven bridges of Konigsberg

- In Konigsberg, Germany, a river ran through the city such that in its center was an island, and after passing the island, the river broke into two parts. Seven bridges were built so that the people of the city could get from one part to another. A crude map of the center of Konigsberg might look like this:

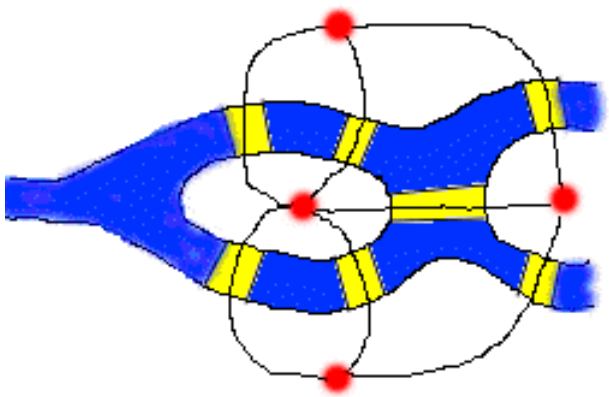


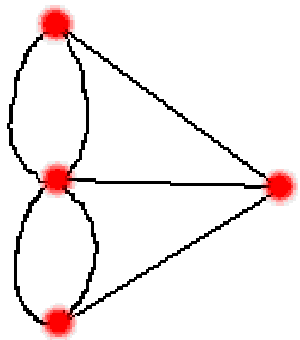
The seven bridges of Konigsberg

- The people wondered whether or not one could walk around the city in a way that would involve crossing each bridge exactly once.

The seven bridges of Konigsberg
Euler's Solution

- Euler realized that all problems of this form could be represented by replacing areas of land by points (he called them *vertices*), and the bridges to and from them by arcs. For Konigsberg, let us represent land with red dots and bridges with black curves:





The seven bridges of Konigsberg
Euler's Solution

- The problem now becomes one of drawing this picture without retracing any line and without picking your pencil up off the paper.

The Generalization to Graph Theory

- Euler generalized this mode of thinking by making the following definitions and proving a theorem:

  Definition: A network is a figure made up of points (vertices) connected by non-intersecting curves (arcs).

  Definition: A vertex is called odd if it has an odd number of arcs leading to it, other wise it is called even.

  Definition: An Euler path is a continuous path that passes through every arc once and only once.

  Theorem: If a network has more than two odd vertices, it does not have an Euler path.

- Euler also proved the converse:

  Theorem: If a network has two or less odd vertices, it has at least one Euler path.

Research methods
Models

- RAM (analysis of algorithms)
- Network security model

Research methods

- Assumptions
- Tools from other fields

  NN, GA

Results and contributions

- Analysis and formal proof

  correctness, security

  algebra, algorithm, complexity theory,

  number theory, probability, …(Math)
- Simulation
- Comparisons

  implemented correctly?

Writing technical papers

- **Helpful Hints for Technical Paper Writing**

http://swig.stanford.edu/~fox/paper_writing.html#hints

Presentations

- **Oral Presentation Advice**
  http://www.cs.wisc.edu/~markhill/conference-talk.html

A Generic Conference Talk Outline

- **Title/author/affiliation** (1 slide)
- **Forecast** (1 slide)
  Give gist of problem attacked and insight found (What is the one idea you want people to leave with? This is the "abstract" of an oral presentation.)
- **Outline** (1 slide)
  Give talk structure. Some speakers prefer to put this at the bottom of their title slide. (Audiences like predictability.)
- **Background**
  - **Motivation and Problem Statement** (1-2 slides)
    (Why should anyone care? Most researchers overestimate how much the audience knows about the problem they are attacking.)
  - **Related Work** (0-1 slides)
    Cover superficially or omit; refer people to your paper.
  - **Methods** (1 slide)
    Cover quickly in short talks; refer people to your paper.
- **Results** (4-6 slides)
- **Summary** (1 slide)
- **Future Work** (0-1 slides)
- **Backup Slides** (0-3 slides)

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  - **Related Work** (0-1 slides)
  - **Methods** (1 slide)
- **Results** (4-6 slides)
  Present key results and key insights. This is main body of the talk. Its internal structure varies greatly as a function of the researcher's contribution. (Do not superficially cover all results; cover key result well. Do not just present numbers; interpret them to give insights. Do not put up large tables of numbers.)
- **Summary** (1 slide)
- **Future Work** (0-1 slides)
  Optionally give problems this research opens up.
- **Backup Slides** (0-3 slides)
  Optionally have a few slides ready (not counted in your talk total) to answer expected questions. (Likely question areas: ideas glossed over, shortcomings of methods or results, and future work.)