"I love nuclear energy. I just want to make sure it stays where God put it -- 93 million miles away, in the sun."
-- William McDonough
How to do Quality Research

A Tutorial
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"And somewhere there are engineers Helping others fly faster than sound. But, where are the engineers Helping those who must live on the ground?"
--- Unknown author
"If we knew what it was we were doing, it would not be called research, would it?"
-- Albert Einstein
This Tutorial: Ingredients of Research

- Read literature
- *Understand (unsolved) problem, innovate*
- Write papers/reports
- Make presentations
- Review others' papers/reports
- Time management
Structure of This Tutorial

- Introduction: 5 min
- How to read a paper? 20 min
- How to write a good paper/report? 20 min
- How to make a good presentation? 20 min
- How to review a paper? 10 min
- Time management (Prof. Anurag Kumar) 20 min
- Q&A: 20-25 min
Papers Used in Examples

- “Practical Network Support for **IP Traceback**”, SIGCOMM 2000
- “Link-level Measurements from an 802.11b Mesh Network”, SIGCOMM 2004 (best paper award, **Roofnet**)
- “Long-Distance 802.11b Links: Performance Measurements and Experience”, MobiCom 2006 (Testbed: **DGP**)
- “**PPR**: Partial Packet Recovery for Wireless Networks”, SIGCOMM 2007
- “**PIP**: A Connection-Oriented, Multi-Hop, Multi-Channel TDMA-based MAC for High Throughput Bulk Transfer”, SenSys 2010
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Reference

  http://portal.acm.org/citation.cfm?id=1273458

- 2-page paper: neat and crisp, but invaluable!
The Three-Pass Approach

- How not to read: start-to-end
- Increasing levels of depth:
  - **First pass, filter pass:** general understanding, context
  - **Second pass, overview pass:** high level idea of contents, but not details
  - **Third pass, detailed pass:** all details
The First Pass, Filter Pass

• Read:
  • Title, abstract, introduction, conclusion
  • Section and sub-section headings (only)
  • Advanced reader: glance over references

• **Purpose** of first pass:
  • Category & context
  • Problem statement, solution contributions
  • Correctness & clarity
  • Use these as filter

• Approximate time: **5-10 min**

• **Note:** when you write a paper, most readers will make only one pass!
The Second Pass, Overview Pass

• Read:
  • Paper more carefully
  • But ignore details: proof, experimental setup, details of idea/architecture
  • Figures, tables, graphs
  • Advanced: mark relevant unread references

• Purpose of second pass; should be able to:
  • **Summarize** paper to someone else: idea, main results, contributions, assumptions, weaknesses
  • Have a **discussion** with someone else
  • Perhaps **compare** with related work at a high level

• Approximate time: **1-2 hours**
The Third Pass, Detailed Pass

- Understand all details
- Virtually **re-implement** the paper
  - How would you have done it? Assumptions, proofs, experiments, results
  - Usually done if paper is closely related to your work
  - Or when doing a review
- Should be able to point out strengths, flaws, missing citations, implicit assumptions, etc.
- Approximate time: **2-6 hours**
Doing a Literature Survey

- **Keywords** on an academic search engine
- Filter pass (first pass) on each paper, read related work section if interesting
- Recent survey paper? Done!
- Browse prominent authors' webpages, where they publish: conferences/journals
- Three passes on decreasing subsets of papers

![Flowchart diagram showing steps of literature survey process](diag.png)

- Summary of literature survey: comparison table
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Overall Goal, Approach

- Paper: written *to be read*
- Overall approach
  - Top-down
  - Continual *refinement*
  - Don't wait for stars to align: put down *whatever* comes to mind
Writing in Multiple Passes

- First pass, **outline** pass:
  - Title (tentative), abstract (tentative)
    - Forces you to think of high level *contributions*
  - Section-level outline, subsection-level outline, paragraph level outline
  - Think of figures, tables, graphs
- Second pass, **rough-draft** pass:
  - Introduction (tentative)
    - Forces you to think of *main contributions*
  - Individual sections: generate text, figures, tables, graphs
- Further passes: **refinements**
Structure of a Paper/Report: 
Guidelines, not Rules

- Title, abstract
- Introduction: includes motivation
- Background: optional
- Related work: can be toward the end
- Technical sections
- Evaluation/results
- Discussion: optional
- Future work: optional
- Conclusion
“Title”, “Abstract”

- Title, abstract: important to write carefully
  - Most read parts of a paper
  - Many search engines index on title/abstract
  - Carefully ==> multiple refinements, not continuous hours

- Title: convey key idea/contribution

- Abstract:
  - Essence of paper
  - Succinctly state: context, contribution, key idea, related work, methodology, eye-catching result
  - 1-3 paragraphs ~ 250 words

- Some examples: IP-traceback, PPR, PIP, Roofnet
“Introduction”

- Also read in first pass, typically
- “Introduction” should typically address most of:
  - What is the context, problem statement?
  - Why is the problem important? (motivation)
  - Is the problem still unsolved? (related work)
  - Why is the problem interesting? (challenges)
  - How have you solved the problem? (approach)
  - Conditions of solution applicability (assumptions)
  - What are the main results? (highlight performance)
  - Summary of contributions (sometimes implicit)
  - Organization of the rest of the report (overview/flow)
- “Introduction” ~ shorter version of paper ~ extended abstract
- Some examples: IP-traceback, PIP, DGP
“Background”

- Optional section
- If paper requires reader to know about:
  - Specific past work
  - Typically your own specific past work
- Even otherwise, it sometimes helps in laying out terminology/context
“Related Work”

- Level of detail of comparison: context specific
- Highly recommended: *table of comparison*
  - Succinctly conveys positioning, contribution of your work
  - Also note: table catches attention in 2nd pass reading
  - Ability to draw this table:
    - Conveys your understanding of existing literature
    - Conveys confidence
- Some examples: IP-traceback, LiT presentation
Technical Sections

- Several sections: depends on paper content
- Section outline: appropriate for “large” sections
- Flow sentences: glue between sections
- Use of *figures, tables*
  - “A picture is worth a thousand words”
  - Quality of figures ~ quality of paper
  - Also: readers catch these in 2\textsuperscript{nd} pass
- Develop, use intuitive *terminology*
- Some examples: PIP, IP-traceback
“Evaluation”, “Results”

- What are you trying to evaluate and why?
- What are the comparison points?
  - Past work, some alternative design, optimal
- What are the comparison metrics?
- Parameters of comparison
- How are you evaluating?
  - Setup: provide all details, explain parameters
- What are the results?
- What are the implications?
Presenting Experimental Results

• Graph:
  • Title, label, axes, units
  • Should be legible in gray-scale print
  • Explain all aspects of graph
  • Also point out unexplainable aspects
  • Consider log-scale

• Table: explain rows, columns

• Seriously consider: summary of results in a table
  • Example: PPR
“Discussion”, “Future Work”, “Conclusion”

- Discussion: additional aspects of your work
  - See example papers...
- Future work: can be merged with conclusion
- Conclusion: read in 1st pass
  - How has your paper changed the world?
Refinements

- Near **perfect paper** $\rightarrow$ underwent **more revisions**!
- Typically, for MTech/PhD students:
  - First two revisions: read yourself and revise
    - At least 2 weeks; comes down with experience
  - Colleagues, fellow students
  - Advisor
  - Outsider: friend in another university/research-lab
- Overall: 2-3 weeks for writing a 12-15 page paper
  - More revisions required for top-rated conferences/journals
Key Things to Remember

- Title, abstract, intro: 1\textsuperscript{st} pass reading
- Figures, tables, graphs: 2\textsuperscript{nd} pass reading
- Refine, refine, refine
  - Until point of diminishing returns
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Overall Goal, Non-Goal

• Goal of presentation:
  • Convey that you have done interesting/useful work
  • Motivate audience to read report/paper
  • Impress audience!

• Important non-goal:
  • Present *everything* you have done
  • Not possible to convey everything!
    - If you try, you will lose audience
Overall Structure

- Flow: similar to report, barring details
- *Figures, figures, figures*
- Presenting **graphs**:  
  - Full slide  
  - Take-away point  
  - Regenerate graphs (jpg/png export from gnuplot)
- Examples: LiT, PIP
Do's and Don'ts: Slide Contents

- **Bullets**, not full sentences
- Text/font, highlight/colours for **keywords**
- Animation: use sparingly
- Meaningful slide titles
- Spelling, grammar, bullet space, capitalization, punctuation
- **Talk outline:** for talks > 20-25 min
- Use equations sparingly; explain intuition
- Backup slides
Do's and Don'ts: Presentation Style

- Don't read off slides
- Gauge audience mood, background
- **Talk length**: skip slides/sections if necessary, never exceed time
- Face the audience, don't block screen
- Don't go back and forth: repeat slides if necessary
Other Guidelines

- *Practice, practice, practice*
- Enthusiasm, energy: don't over-practice
- Understand question and answer
  - But don't give complete control to audience
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Review Guidelines

• Give the paper its due:
  • Read it unhurriedly, mostly 3 passes
  • Write a detailed review
• Identify good ideas: look for reasons to accept paper
• Review papers, not ideas
• Justify your score! And comments too
• Provide adequate references
• Be constructive in your comments
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Resources, References

- http://www.cse.iitb.ac.in/synerg/doku.php?id=public:resources
- “How to give a bad talk”, Rold Riedi, http://www.stat.rice.edu/~riedi/Publ/bad-talk.ppt
- “How to give a good talk”, Arnaud Legout, http://cel.archives-ouvertes.fr/docs/00/52/95/05/ANNEX/HowToGiveATalk.ppt
- Several papers on how to write a review