

Key Elements in a Research Paper

FACULTY OF
ENGINEERING &
INFORMATION
TECHNOLOGIES

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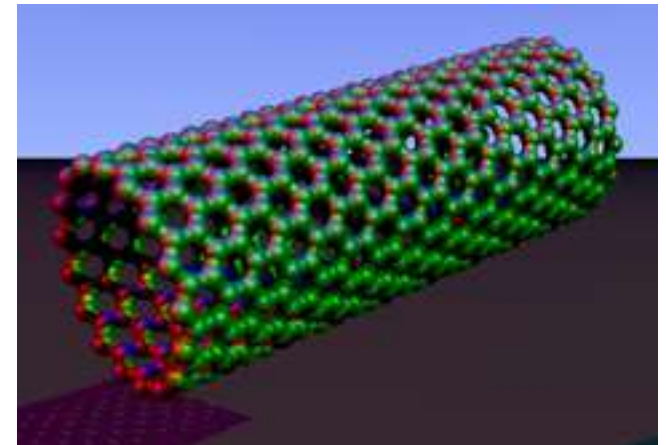
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- › Successful Research Paper
- › Different sections of a research paper
- › Some tips

A Research Paper

- › What is it?
- › What it is not?



[Story about Carbon Nanotubes](#)

- › Imagine you are explaining your idea at a whiteboard
 - Here is a problem
 - Motivation: it is an interesting problem
 - Motivation ... : it is an unsolved problem
 - Here is My Idea
 - My idea works (Details of your solution, experimental results)
 - My idea compares to other's ideas

Standard components

Title	1000 readers
Abstract	100~500 readers
Introduction	1~1.5 page, 100 readers
The Body	5-7 pages, 3~10 readers
Motivation	
Problem Statement	
Approach, Architecture	
Methodology / Solution	
Results and Discussion	2-5 pages, 3~10 readers
Related Work / Background	1-2 pages, 3~10 readers
Conclusion	0.5 pages
References / Bibliography	
Appendix	

General style

Depends on the specific editorial, look at the instructions in general guidelines

e.g.: 10 pages, 12 point Times standard font, A4 (letter), 1 inch margins, single (double) column(s)



How to Write a Technical Paper: Structure and Style of the Epitome of your Research^{1‡}

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Abstract

A major problem that young researchers face is their inability to write good research papers. This document serves as a guideline on how to write a good technical paper. It contains ideas that have been gained through experience; skilled authors will find themselves familiar with these ideas. The document is formatted and structured like a typical journal publication. Each section describes what you should discuss in it.

The abstract is what a person always reads first in a technical paper. Based on the content of the abstract, the reader will decide whether the paper is worthy enough to merit further study. The abstract should classify your research and contribution in the research areas. It should contain the following four parts: a brief introduction describing the discipline that the paper belongs to; a clear and concise statement of your problem; a brief explanation of your solution and its key ideas; a brief description of the results obtained and their impacts. Lastly, provide a short list of index keyword terms.

Keywords: writing guides, writing technical papers, format guides

1 Introduction

The introduction serves a twofold purpose. Firstly, it gives the background on and motivation for your research, establishing its importance. Secondly, it gives a summary and outline of your paper, telling readers what they

should expect to find in it.

When you write the background review, you should consider including technological trends of the area, open problems and recent promising developments. At this point, you can introduce more specific terminology which is not widely known. Provide good motivation for your work, such as explaining its technological, research or economic importance. The motivation should not be elaborate; simply two or three good reasons are enough to make your research important.

The summary should include a problem description, which is slightly more detailed than in the abstract. The summary should also include a description of your solution and some arguments on its impacts. In the description of your solution, include its key concepts and categorize its approach.

Close your introduction with a description of your paper outline, what sections it contains and what the reader will find in each. After completing the introduction, readers will decide if they want to continue.

Your paper should flow smoothly. Readers should never feel as if they are missing information—a technical paper is not a novel. A proper flow is to first set the context, then present your proposal, then provide the verification, and lastly wrap up with conclusions. Figure 1 gives the main sections of a paper. Introduction, related work, system model and problem description set the context, followed by the presentation of your solution. Analysis, simulation and experimentation make up the verification part. Lastly, conclusions and future work make an evaluation of your solution according to the verification results.

2 Related Work

The purpose of the related work section is the most misunderstood by young authors. Therefore, it is important to pay extra attention in writing this section. Similar to the introduction, the purpose of the related work is twofold. First, it gives a list of research works that are

¹The title states the contribution of a paper in one sentence. Though the very first words of a paper, often it is the last to be decided in the authoring process. The most usual format of title is

"A [adjective] [approach] for [problem] in [environment]", although there is no standard to write a title.

[‡]This document was produced on September 14, 2004

- › Understanding your readers/audience
 - Are they professionals who are familiar with your topic/ General audience
 - How much do they know?
 - Do they already understand your problem/question? Generally NO
 - Use plain English (e.g., *relentless* vs *persistent*)
 - Anticipate questions or misunderstandings (self explanatory)
 - Provide enough explanation to avoid any misunderstanding
- › Choose, Define and Narrow your topic
 - Develop questions
 - What is the history of my research topic?
 - Who has made advances in this research topic?
 - What was the significance of those advances?
 - Why were their results important?
 - What is strength/weakness of previous results?

The pre-writing phase ...

- › Make a plan/Narrow down what you plan before the actual writing /
Categorize the points
 - E.g:
 - 2. Understanding the database visualization
 - 2A. What is the database visualization
 - 2AI. How to Visualize data
 - 2AIa. Accessing data
- › CHECKLIST:
 - Clear outline? miss anything? logical sequence?

- › Start writing earlier / make a draft
 - Outline might be changed during the process
- › **Top down design:** Starting with an outline and working out the details
- › Cite the sources correctly
- › Avoid plagiarism.
 - Re-write each piece of information into your own words
- › Learn/use Latex
- › Re-read several rounds / improve the overall quality before submitting as much as possible

- › Communicate clearly what your paper is about
- › Indicate the research problem specifically
- › Avoid common phrases like "novel", "performance evaluation" and "architecture"
- › Use **adjectives** that describe the distinctive features of your work
 - e.g., reliable, scalable, high-performance, robust, low-complexity, or low-cost.
 - long and descriptive
 - *Linear-Time External Multipass Sorting with Approximation Guarantees*
 - short and sweet
 - *Approximate External Sort*
 - middle-of-the-road length, plus a cute name
 - Floosh: *A Linear-Time Algorithm for Approximate External Sort*

- › A concise summary/overview of the overall content of the paper
- › Should introduce & provide
 - the research topic
 - specific research question(s)
 - A statement regarding methodology
 - a general statement about the results and the findings
- › Style:
 - Single paragraph, must be concise (Not more than 250 words)
 - Always written in past tense
 - Should not refer to any other part of the paper such as a figure or table
 - limit background information to a sentence or two, if absolutely necessary
- › Often is written last

- › Avoid use of "in this paper" in the abstract
- › Avoid general motivation in the abstract.
 - You do not have to justify the importance of your work
- › Highlight not just the problem, but also the principal results
- › Abstract will be used by search engines
- › Avoid equations and math

- › Purpose: **acquaint** the reader with the rationale behind the work
- › Should not exceed 1.5~2 pages
 - Stating research question & hypothesis/define & formulate your problem
 - Explain why the research subject was chosen/important
 - Explain the focus of the paper and your specific purpose
 - Should summarize your findings
 - Reveal your plan of organization
- › The **most important** element of any research paper
- › **Opportunity** to convince reviewers/readers to continue reading hungrily
- › Professionals spent 30%-50% of the entire writing time on this
- › Professionals **postpone** writing the introduction **after** writing other sections

- › In essence:
 - What is the main problem which you are conducting a research study?
 - Why is the topic so important?
 - What was the reason it got failed?
 - Why it hasn't been solved yet?
 - What is the main objective of your technical research paper?
- › Avoid cliché phrases such as "recent advances in ..."
- › Introduction must motivate your work and keep readers engage
- › Do not repeat abstract in the introduction

4 - Related work/ Motivation

- › Summarize the state of current literature relevant to the topic
- › You must cite all critical findings to **emphasize** the existing **gap**
- › State how your research problem connect to the literature
- › Summarize, analyse, explain, and evaluate published work rather than merely reporting it
- › Provide an overview/background of the methods used in your research
- › **Avoid** unnecessary background
- › This section can/ recommended to be presented after the results section
- › **Fallacy**: To show my work is good, I have to make others' work look bad

- › Articulate important technical contribution
- › Should start not later than page 3
- › How data & results are collected, organized, & analysed (methodology)
 - Tell a story, story should be linear
 - Keep the reader engaged at every step
 - No significant interruptions in story line (if so move them to Appendix)
- › Should include:
 - Notation and terminology used in the paper in a concise way
 - Problem statement, Algorithms, System/Model descriptions, Analyses, etc
 - A new algorithm should be clear, precise, and written in a way that allows the reader to compare the algorithm to other algorithms
 - A new algorithm should conduct experiments comparing it to **state-of-the-art** algorithms for the same or similar problems
 - Limitations of the algorithm should be described in detail. Interesting cases where an algorithm **fails** are important

6 - Results and Discussion

- › Many conferences/ journals expect experiments
- › Report, analyse, discuss logically the experimental results / proof
- › Overview of experiments: what we do measure, what we don't, why
- › Keep attention of the reader
 - Use tables / graphs, quotations, illustrations, examples, words of emphasis, supporting evidence
- › Avoid crafting experiments to show your work in its best
- › Descriptions of the software and data sufficient to replicate the experiments must be included

Results / Performance Experiments ...

- › What should performance experiments measure?
 - Pure running time
 - Sensitivity to important parameters
 - Scalability in various aspects: data size, problem complexity, ...

- › What should performance experiments show?
 - Absolute performance (i.e., it's acceptable/usable)
 - Relative performance to naive approaches
 - Relative performance to previous approaches
 - Relative performance among different proposed approaches ...

- › Explain the significance of your findings
- › Summarizes the results
- › Do not include any achievements not brought in the results section
- › You can suggest further/future research work

8 - Acknowledgements

- › Should write/thank the names of the people/ funding source who had helped/funded your project
- › Some sources have specific wording requirements and may prefer that the grant number is listed. like "This work was supported by the National ... under grant NN-NNNNN
- › Acknowledge anyone who contributed in any way: through discussions, feedback on drafts, implementation, sometime anonymous reviewers, etc

9 - References/Bibliography

- › Can be sorted alphabetically / as they appear in the paper
- › There are many format styles:
 - American Institute of Physics (AIP style)
 - references are numbered in the text and in the reference list
 - American Mathematical Society (AMS)
 - Brackets with author's initials and year are inserted in the text and at the beginning of the reference [AB90]
 - IEEE style: citation numbers within square brackets and numbers them consecutively
 - APA style: [Fanty et al., 1993]

› Books

- [1] J. K. Author, “Title of chapter in the book,” in Title of His Published Book, xth ed. City of Publisher, Country if not USA: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx.
- NOTE: Use et al. when three or more names are given.

› Conference Articles

- [1] J. K. Author, “Title of paper,” in *Unabbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), year, pp. xxx-xxx.

› Periodicals like Journals/ Magazines/ Letters

- [1] J. K. Author, “Name of paper,” *Abbrev. Title of Periodical*, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year.

› Dissertations/ Theses

- J. K. Author, “Title of dissertation,” Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

- › R. E. Kalman, “New results in linear filtering and prediction theory,” *Basic Eng.*, ser. D, vol. 83, pp. 95-108, Mar. 1961.
- › J. O. Williams, “Narrow-band analyzer,” Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.
- › L. Stein, “Random patterns,” in *Computers and You*, J. S. Brake, Ed. New York: Wiley, 1994, pp. 55-70.
- › E. F. Moore, “Gedanken-experiments on sequential machines,” in *Automata Studies* (Ann. of Mathematical Studies, no. 1), C. E. Shannon and J. McCarthy, Eds. Princeton, NJ: Princeton Univ. Press, 1965, pp. 129-153.
- › J. P. Wilkinson, “Nonlinear resonant circuit devices,” U.S. Patent 3 624 125, July 16, 1990
- › N. M. Amer, “The effects of homogeneous magnetic fields on developments of tribolium confusum,” Ph.D. dissertation, Radiation Lab., Univ. California, Berkeley, Tech. Rep. 16854, 1995.
- › Ye. V. Lavrova, “Geographic distribution of ionospheric disturbances in the F2 layer,” *Tr. IZMIRAN*, vol. 19, no. 29, pp. 31–43, 1961

- › Presents the **non-essential** points of the research paper when absolutely necessary
- › Opportunity to get more detailed extra information
- › A part of proof, raw data & statistics, tables, graphs might be moved to the appendix
- › Ensure to reference appendix appropriately in the main text

- › Tables should be labelled “Table #.” + caption on top of tables
- › Images/charts should be labelled as “Figure # + caption” on the bottom of figures
- › Use a version control system to manage versions (e.g. git)
- › Never use superlatives/Subjective words: Research paper **is not** a fiction/opinion pieces
 - “We felt that st was bad, because we had difficulty ...”
 - Rather “The percentage of st was inversely proportional to the time, suggesting that st was causing difficulty ...”
 - Superlatives include adjectives such as “huge,” “incredible,” “wonderful,” “exciting,”
 - “the result showed an incredibly large increase in...”
 - Rather “ st was five fold greater than st else ..”
- › Use examples to illustrate difficult or unfamiliar theories or concepts
- › Can include a motivation section just before the problem statement section
- › Text in Times Roman, not Arial

- › In every section, the first paragraph should be a summary/overview of the section
- › Huge introductions: if you can not say it in 1.5 page probably it is not clear in your mind / you have the wrong level of abstraction.

Top-10 tips for writing a paper

By **Jim Kurose**

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2006 CoNEXT student workshop panel

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1: Every paper tells a story

› what is the “elevator pitch” of your story?

elevator pitch = summary that is short enough
to give during an elevator ride

❑ the story is *not* what you did, but rather

❖ what you show, new ideas, new insights

❖ why interesting, important?

❑ why is the story of interest to others?

❖ universal truths, hot topic, surprises or unexpected results?

❑ know your story!

2. Write top down

- › computer scientists (and most human beings) think this way!
 - › state broad themes/ideas first, then go into detail
 - context, context, context
 - › even when going into detail ... write top down!
-

3 Introduction: crucial, formulaic

- › if reader not excited by intro, paper is lost
 - › recipe:
 - para. 1: motivation: broadly, what is problem area, why important?
 - para. 2: narrow down: what is problem you specifically consider
 - para. 3: “In the paper, we”: most crucial paragraph, tell your elevator pitch
 - para. 4: how different/better/relates to other work
 - para. 5: “The remainder of this paper is structured as follows”
-

4. Master the basics of organized writing

- › paragraph = ordered set of topically-related sentences
 - › lead sentence
 - sets context for paragraph
 - might tie to previous paragraph
 - › sentences in paragraph should have logical narrative flow, relating to theme/topic
 - › don't mix tenses in descriptive text
 - › one sentence paragraph: warning!
-

5. Put yourself in place of the reader

› less is more:

- “I would have sent you less if I had had time”
- *take the time to write less*

› readers shouldn't have to work

- won't “dig” to get story, understand context, results
- need textual signposts to know where ‘story’ is going, context to know where they are
 - good: “e.g., Having seen that ... let us next develop a model for Let Z be”
 - bad: “Let Z be”

› what does reader know/not know, want/not want?

- write for reader, not for yourself
-

6. Put yourself in place of the reader

- › page upon page of dense text is *no fun* to read
 - avoid cramped feeling of tiny fonts, small margins
 - create openness with white space: figures, lists
 - › enough context/information for reader to understand what you write?
 - no one has as much background/content as you
 - no one can read your mind
 - all terms/notation defined?
-

7. No one (not even your mother) is as interested in this topic as you

- › so you had better be (or appear) interested
 - › tell readers why they should be interested in your “story”
 - › don’t overload reader with 40 graphs:
 - think about main points you want to convey with graphs
 - can’t explore entire parameter space
 - › don’t overload reader with pages of equations
 - put long derivations/proofs in appendix, provide sketch in body of paper
-

8. State the results carefully

- › clearly state assumptions (see overstate/understate your results)
 - › experiment/simulation description: enough info to nearly recreate experiment/description
 - › simulation/measurements:
 - statistical properties of your results (e.g., confidence intervals)
 - › are results presented representative?
 - or just a corner case that makes the point you want to make
-

9. Don't overstate/understate your results

› overstatement mistake:

- “We show that X is prevalent in the Internet”
- “We show that X is better than Y”

when only actually shown for one/small/limited cases

› understatement mistake: fail to consider broader implications of your work

- if your result is small, interest will be small
 - “rock the world”
-

10. Study the art of writing

- › writing well gives you an “unfair advantage”
 - › *writing well matters in getting your work published in top venues*
 - › highly recommended:
 - *The Elements of Style*, W. Strunk, E.B. White, Macmillan Publishing, 1979
 - *Writing for Computer Science: The Art of Effective Communication*, Justin Sobel, Springer 1997.
 - › who do *you* think are the best writers in your area: *study their style*
-

11. Good writing takes times

- › give yourself time to reflect, write, review, refine
 - › give others a chance to read/review and provide feedback
 - get a reader's point of view
 - find a good writer/editor to critique your writing
 - › starting a paper three days before the deadline, while results are still being generated, is a non-starter
-



THANK YOU

Questions?

- › [Common Errors in Student Research Papers](#)
- › [Guide to Grammar and Style](#)
- › [Drafting the Paper in an Academic Style](#)