How to write a great research paper

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Writing papers is a skill

- Many papers are badly written
- Good writing is a skill you can learn
- It’s a skill that is worth learning:
  - You will get more brownie points (more papers accepted etc)
  - Your ideas will have more impact
  - You will have better ideas

Increasing importance

Writing papers: model 1

Idea → Do research → Write paper

Writing papers: model 2

Idea → Write paper → Do research

- Forces us to be clear, focused
- Crystallises what we don’t understand
- Opens the way to dialogue with others: reality check, critique, and collaboration
Do not be intimidated

Fallacy  You need to have a fantastic idea before you can write a paper. (Everyone else seems to.)

Write a paper, and give a talk, about any idea, no matter how weedy and insignificant it may seem to you.

The purpose of your paper

Why bother?

Fallacy  We write papers and give talks mainly to impress others, gain recognition, and get promoted.

Fallacy  Writing the paper is how you develop the idea in the first place.

It usually turns out to be more interesting and challenging that it seemed at first.

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Papers communicate ideas

- Your goal: to infect the mind of your reader with your idea, like a virus
- Papers are far more durable than programs (think Mozart)

The greatest ideas are (literally) worthless if you keep them to yourself

The Idea

A re-usable insight, useful to the reader

- Figure out what your idea is
- Make certain that the reader is in no doubt what the idea is. Be 100% explicit:
  - “The main idea of this paper is....”
  - “In this section we present the main contributions of the paper.”
- Many papers contain good ideas, but do not distil what they are.

One ping

- Your paper should have just one “ping”: one clear, sharp idea
- Read your paper again: can you hear the “ping”?
- You may not know exactly what the ping is when you start writing; but you must know when you finish
- If you have lots of ideas, write lots of papers

The purpose of your paper is not...

To describe the WizWoz system

- Your reader does not have a WizWoz
- She is primarily interested in re-usable brain-stuff, not executable artefacts

Thanks to Joe Touch for “one ping”
Your narrative flow

- Here is a problem
- It’s an interesting problem
- It’s an unsolved problem
- **Here is my idea**
  - My idea works (details, data)
  - Here’s how my idea compares to other people’s approaches

Structure (conference paper)

- Title (1000 readers)
- Abstract (4 sentences, 100 readers)
- Introduction (1 page, 100 readers)
- The problem (1 page, 10 readers)
- My idea (2 pages, 10 readers)
- The details (5 pages, 3 readers)
- Related work (1-2 pages, 10 readers)
- Conclusions and further work (0.5 pages)

The abstract

- I usually write the abstract last
- Used by program committee members to decide which papers to read
- Four sentences [Kent Beck]
  1. State the problem
  2. Say why it’s an interesting problem
  3. Say what your solution achieves
  4. Say what follows from your solution

Example

1. Many papers are badly written and hard to understand
2. This is a pity, because their good ideas may go unappreciated
3. Following simple guidelines can dramatically improve the quality of your papers
4. Your work will be used more, and the feedback you get from others will in turn improve your research
The introduction (1 page)

1. Describe the problem
2. State your contributions

...and that is all

ONE PAGE!

Describe the problem

1. Introduction

There are two basic ways to implement function application in a higher-order language, when the function is unknown: the \textit{pushdown} model or the \textit{eval/apply} model \cite{1}. To illustrate the difference, consider the higher-order function \texttt{zipWith}, which zips together two lists, using a function \texttt{k} to combine corresponding list elements:

\[
\texttt{zipWith} \mathbin{::} (\texttt{a} \rightarrow \texttt{b} \rightarrow \texttt{c}) \rightarrow \texttt{[a]} \rightarrow \texttt{[b]} \rightarrow \texttt{[c]}
\]

\[
\texttt{zipWith} \; \texttt{k} \; \texttt{[]} \; \texttt{[]} = \texttt{[]}
\]

\[
\texttt{zipWith} \; \texttt{k} \; \texttt{x} : \texttt{xs} \; \texttt{y} : \texttt{ys} = \texttt{k} \; \texttt{x} \; \texttt{y} : \texttt{zipWith} \; \texttt{k} \; \texttt{xs} \; \texttt{ys}
\]

Here \texttt{k} is an \textit{unknown function}, passed as an argument; global flow analysis aside, the compiler does not know what function \texttt{k} is bound to. How should the compiler deal with the call \texttt{k x y} in the body of \texttt{zipWith}? It can’t blindly apply \texttt{k} to two arguments, because \texttt{k} might in reality take just one argument and compute for a while before returning a function that consumes the next argument; or \texttt{k} might take three arguments, so that the result of the \texttt{zipWith} is a list of functions.

State your contributions

- Write the list of contributions first
- The list of contributions drives the entire paper: the paper substantiates the claims you have made
- Reader thinks “gosh, if they can really deliver this, that’s be exciting; I’d better read on”
State your contributions

Which of the two is best in practice? The trouble is that the evaluation model has a pervasive effect on the implementation, so it is too much work to implement both and pick the best. Historically, compilers for safer languages (using call-by-value) have tended to use evalscript while those for safer languages (using call-by-need) have not used it at all. But this is a historical accident — either approach will work in both settings. In practice, implementors choose one of the two approaches based on a qualitative assessment of the trade-offs. In this paper we put the choice on a firmer basis:

- We explain precisely what the two models are, in a common notational framework (Section 4). Surprisingly, this has not been done before.
- The choice of evaluation model affects many other design choices in subtle but pervasive ways. We identify and discuss these effects in Sections 5 and 6, and commit them in Section 7. There are lots of interesting details here, for which we make no apology — they were far from obvious to us, and articulating these details is one of our main contributions.

In terms of its impact on compiler and run-time system complexity, evalscript seems decisively superior, principally because push/enter requires a stack like no other: stack-walking.

Contributions should be refutable

<table>
<thead>
<tr>
<th>NO!</th>
<th>YES!</th>
</tr>
</thead>
<tbody>
<tr>
<td>We describe the WizWoz system. It is really cool.</td>
<td>We give the syntax and semantics of a language that supports concurrent processes (Section 3). Its innovative features are...</td>
</tr>
<tr>
<td>We study its properties</td>
<td>We prove that the type system is sound, and that type checking is decidable (Section 4)</td>
</tr>
<tr>
<td>We have used WizWoz in practice</td>
<td>We have built a GUI toolkit in WizWoz, and used it to implement a text editor (Section 5). The result is half the length of the Java version.</td>
</tr>
</tbody>
</table>

No “rest of this paper is...”

- Not: "The rest of this paper is structured as follows. Section 2 introduces the problem. Section 3 ... Finally, Section 8 concludes".

- Instead, use forward references from the narrative in the introduction. The introduction (including the contributions) should survey the whole paper, and therefore forward reference every important part.

Structure

- Abstract (4 sentences)
- Introduction (1 page)
- Related work
  - The problem (1 page)
  - My idea (2 pages)
  - The details (5 pages)
  - Related work (1-2 pages)
- Conclusions and further work (0.5 pages)
We adopt the notion of transaction from Brown [1], as modified for distributed systems by White [2], using the four-phase interpolation algorithm of Green [3]. Our work differs from White in our advanced revocation protocol, which deals with the case of priority inversion as described by Yellow [4].

Problem 1: the reader knows nothing about the problem yet; so your (carefully trimmed) description of various technical tradeoffs is absolutely incomprehensible.

Problem 2: describing alternative approaches gets between the reader and your idea.

In a paper you MUST provide the details, but FIRST convey the idea.

3. The idea
Consider a bifurcated semi-lattice $D$, over a hyper-modulated signature $S$. Suppose $p_i$ is an element of $D$. Then we know for every such $p_i$, there is an epi-modulus $j$, such that $p_j < p_i$.

Sounds impressive... but

Sends readers to sleep

In a paper you MUST provide the details, but FIRST convey the idea.
Presenting the idea

- Explain it as if you were speaking to someone using a whiteboard
- **Conveying the intuition is primary**, not secondary
- Once your reader has the intuition, she can follow the details (but not vice versa)
- Even if she skips the details, she still takes away something valuable

Putting the reader first

- **Do not** recapitulate your personal journey of discovery. This route may be soaked with your blood, but that is not interesting to the reader.
- Instead, choose the most direct route to the idea.

The payload of your paper

**Introduce the problem, and your idea, using EXAMPLES** and only then present the general case

Using examples

2 Background

To set the scene for this paper, we begin with a brief overview of the *Scrappy* boilerplate approach to generic programming. Suppose that we want to write a function that computes the size of an arbitrary data structure. The basic algorithm is “for each node, add the sizes of the children, and add 1 for the node itself”. Here is the entire code for `gsizest`

```hs
gsizest :: Data a => a -> Int
gsizest t = 1 + sum (gmapQ gsizest t)
```

The type for `gsizest` says that it works over any type `a`, provided `a` is a `Data` type — that is, that it is an instance of the class `Data`. The definition of `gsizest` refers to the operation `gmapQ`, which is a method of the `Data` class:

```hs
class Typeable a => Data a where
  ...other methods of class Data...

  gmapQ :: (forall r. Data b => b -> r) -> a -> r
```

Example right away

The Simon PJ question: is there any typewriter font?
The details: evidence

- Your introduction makes claims
- The body of the paper provides **evidence to support each claim**
- Check each claim in the introduction, identify the evidence, and forward-reference it from the claim
- Evidence can be: analysis and comparison, theorems, measurements, case studies

Related work

**Fallacy** To make my work look good, I have to make other people's work look bad

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The truth: credit is not like money

**Giving credit to others does not diminish the credit you get from your paper**

- Warmly acknowledge people who have helped you
- Be generous to the competition. “In his inspiring paper [Foo98] Foogle shows... We develop his foundation in the following ways...”
- Acknowledge weaknesses in your approach
Credit is not like money

Failing to give credit to others can kill your paper

If you imply that an idea is yours, and the referee knows it is not, then either

- You don’t know that it’s an old idea (bad)
- You do know, but are pretending it’s yours (very bad)

Conclusions and further work

- Be brief.

Structure

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The process of writing
The process

- Start early. Very early.
  - Hastily-written papers get rejected.
  - Papers are like wine: they need time to mature
- Collaborate
- Use CVS to support collaboration

Getting help

Get your paper read by as many friendly guinea pigs as possible

- Experts are good
- Non-experts are also very good
- Each reader can only read your paper for the first time once! So use them carefully
- Explain carefully what you want ("I got lost here" is much more important than "Jarva is mis-spelt").

Getting expert help

- A good plan: when you think you are done, send the draft to the competition saying "could you help me ensure that I describe your work fairly?"
- Often they will respond with helpful critique (they are interested in the area)
- They are likely to be your referees anyway, so getting their comments or criticism up front is Jolly Good.

Listening to your reviewers

Treat every review like gold dust

Be (truly) grateful for criticism as well as praise

This is really, really, really hard

But it’s really, really, really, really, really, really, really, really important
Listening to your reviewers

- Read every criticism as a positive suggestion for something you could explain more clearly
- DO NOT respond “you stupid person, I meant X”. Fix the paper so that X is apparent even to the stupidest reader.
- Thank them warmly. They have given up their time for you.

Language and style

Basic stuff

- Submit by the deadline
- Keep to the length restrictions
  - Do not narrow the margins
  - Do not use 6pt font
- On occasion, supply supporting evidence (e.g. experimental data, or a written-out proof) in an appendix
- Always use a spell checker

Visual structure

- Give strong visual structure to your paper using
  - sections and sub-sections
  - bullets
  - italics
  - laid-out code
- Find out how to draw pictures, and use them
Use the active voice

The passive voice is "respectable" but it DEADENS your paper. Avoid it at all costs.

**NO**
- It can be seen that...
- 34 tests were run
- These properties were thought desirable
- It might be thought that this would be a type error
- YES
- We can see that...
- We ran 34 tests
- We wanted to retain these properties
- You might think this would be a type error

**We** = you and the reader
**We** = the authors
**You** = the reader

Summary

If you remember nothing else:
- Identify your key idea
- Make your contributions explicit
- Use examples

A good starting point:
- [Advice on Research and Writing](http://www-2.cs.cmu.edu/afs/cs.cmu.edu/user/mleone/web/how-to.html)