How to write a great research paper

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Seven simple, actionable suggestions that will make your papers better.
1. Don’t wait: write
Writing papers: model 1

Your idea → Do research → Write paper
Writing papers: model 2

Your idea → Do research → Write paper

Your idea → Write paper → Do research
Writing papers: model 2

Your 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
Writing papers is a primary mechanism for doing research (not just for reporting it)
2. Identify your key idea
Your goal: to convey a useful and re-usable idea

- You want 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
Fallacy

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

Do not be intimidated

Write a paper, and give a talk, about any idea, no matter how weedy and insignificant it may seem to you.
Do not be intimidated

• 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

Write a paper, and give a talk, about any idea, no matter how weedy and insignificant it may seem to you
Your paper should have just one “ping”: one clear, sharp idea

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

Idea:
A re-usable insight, useful to the reader
Can you hear the “ping”?

• Many papers contain good ideas, but do not distil what they are.

• 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.”

Thanks to Joe Touch for “one ping”
3. Tell a story
Your narrative flow

Imagine you are explaining at a whiteboard
• 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)
4. Nail your contributions to the mast
The introduction (1 page)

• Describe the problem
• State your contributions
...and that is all

ONE PAGE!
1 Introduction

There are two basic ways to implement function application in a higher-order language, when the function is unknown: the push/enter model or the eval/apply model [11]. To illustrate the difference, consider the higher-order function `zipWith`, which zips together two lists, using a function `k` to combine corresponding list elements:

\[
\begin{align*}
\text{zipWith} &: (a\to b\to c) \to [a] \to [b] \to [c] \\
\text{zipWith} &\ k \ [a] \ [b] \ = \ [] \\
\text{zipWith} &\ k \ (x:xs) \ (y:ys) \ = \ k \ x \ y : \text{zipWith} \ xs \ ys
\end{align*}
\]

Here `k` is an unknown function, passed as an argument; global flow analysis aside, the compiler does not know what function `k` is bound to. How should the compiler deal with the call `k x y` in the body of `zipWith`? It can’t blithely apply `k` to two arguments, because `k` might in reality take just one argument and compute for a while before returning a function that consumes the next argument; or `k` might take three arguments, so that the result of the `zipWith` is a list of functions.
Example: “Computer programs often have bugs. It is very important to eliminate these bugs [1,2]. Many researchers have tried [3,4,5,6]. It really is very important.”

Yawn!

Example: “Consider this program, which has an interesting bug. <brief description>. We will show an automatic technique for identifying and removing such bugs”

Cool!
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

Do not leave the reader to guess what your contributions are!

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 strict languages (using call-by-value) have tended to use eval/apply, while those for lazy languages (using call-by-need) have often used push/enter, but this is 90% 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 contrast them in Section 7. There are lots of nitty-gritty 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, eval/apply seems decisively superior, principally because push/enter requires a stack like no other: stack-walking
Contributions should be refutable

No!

We describe the WizWoz system. It is really cool.

We study its properties

We have used WizWoz in practice

Yes!

We give the syntax and semantics of a language that supports concurrent processes (Section 3). Its innovative features are...

We prove that the type system is sound, and that type checking is decidable (Section 4)

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.
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
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.
5. Related work: later
Structure

- Abstract (4 sentences)
- Introduction (1 page)
- Related work
- The problem (1 page)
- My idea (2 pages)
- The details (5 pages)
- Conclusions and further work (0.5 pages)
Structure

- Abstract (4 sentences)
- Introduction (1 page)
- 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 (highly compressed) description of various technical tradeoffs is absolutely incomprehensible

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

To make my work look good, I have to make other people’s work look bad.
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

Giving credit to others does not diminish the credit you get from your paper
6. Put your readers first
Structure

- Abstract (4 sentences)
- Introduction (1 page)
- The problem (1 page)
- My idea (2 pages)
- The details (5 pages)
- Related work (1-2 pages)
- Conclusions and further work (0.5 pages)
3. The idea
Consider a bifurcuated semi-lattice $D$, over a hyper-modulated signature $S$. Suppose $\pi$ is an element of $D$. Then we know for every such $\pi$ there is an epi-modulus $j$, such that $p_j < \pi$.

- Sounds impressive...but
- Sends readers to sleep, and/or makes them feel stupid
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
Conveying the intuition

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

- Remember: explain it as if you were speaking to someone using a whiteboard.
2 Background

To set the scene for this paper, we begin with a brief overview of the Scrap your 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 gsize:

```haskell
gsizer :: Data a -> a -> Int
gsizer x = 1 + sum (gmapQ gsize x)
```

The type for gsize says that it works over any type a, provided a is a data type — that is, that it is an instance of the class Data¹

The definition of gsize refers to the operation gmapQ, which is a method of the Data class:

```haskell
class Typeable a => Data a where
  ...other methods of class Data...
  gmapQ :: (forall b. Data b => b -> r) -> a -> [r]
```

The Simon PJ question: is there any typewriter font?
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.
7. Listen to your readers
• 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”.)

Get your paper read by as many friendly guinea pigs as possible
• 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 important
• Read every criticism as a positive suggestion for something you could explain more clearly
• DO NOT respond “you stupid person, I meant X”.
• INSTEAD: fix the paper so that X is apparent even to the stupidest reader.
• Thank them warmly. They have given up their time for you.
Summary

1. Don’t wait: write
2. Identify your key idea
3. Tell a story
4. Nail your contributions
5. Related work: later
6. Put your readers first (examples)
7. Listen to your readers

More: www.microsoft.com/research/people/simonpj
Language and Style
Basic stuff

• Submit by the deadline
• Keep to the length restrictions
  • Do not narrow the margins
  • Do not ...
  • 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
Visual structure

The three cases above do not exhaust the possible forms of \( f \). It might also be a \texttt{THUNK}, but we have already dealt with that case (rule \texttt{THUNK}). It might be a \texttt{CON}, in which case there cannot be any pending arguments on the stack, and rules \texttt{UPDATE} or \texttt{RET} apply.

4.3 The eval/apply model

The last block of Figure 2 shows how the eval/apply model deals with function application. The first three rules all deal with the case of a \texttt{FUN} applied to some arguments:

- If there are exactly the right number of arguments, we behave exactly like rule \texttt{KNOWNCALL}, by tail-calling the function. Rule \texttt{EXACT} is still necessary — and indeed has a direct counterpart in the implementation — because the function might not be statically known.

- If there are too many arguments, rule \texttt{CALLK} pushes a call remainder of the object is called the payload, and may consist of a mixture of pointers and non-pointers. For example, the object \( \texttt{CON(C a_1 \ldots a_n)} \) would be represented by an object whose info pointer represented the constructor \( C \) and whose payload is the arguments \( a_1 \ldots a_n \).

The info table contains:

- Executable code for the object. For example, a \texttt{FUN} object has code for the function body.
- An object-type field, which distinguishes the various kinds of objects (\texttt{FUN, FAP, CON}) from each other.
- Layout information for garbage collection purposes, which describes the size and layout of the payload. By “layout” we mean which fields contain pointers and which contain non-pointers, information that is essential for accurate garbage collection.
- Type-specific information, which varies depending on the object type. For example, a \texttt{FUN} object contains its arity; a \texttt{CON} object contains its constructor tag, a small integer that distinguishes the different constructors of a data type, and so on.

In the case of a \texttt{FAP}, the size of the object is not fixed by its info table; instead, its size is stored in the object itself. The layout of its fields (e.g., which are pointers) is described by the (initial segment) of an argument descriptor field in the info table of the \texttt{FUN} object which is always the first field of a \texttt{FAP}. The others kinds of heap object all have a size that is statically fixed by their info table.

A very common operation is to jump to the entry code for the object, so GHC uses a slightly-optimised version of the representation in Figure 3. GHC places the info table at the addresses immediately
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
No!  

The object under study was displaced horizontally

On an annual basis

Endeavour to ascertain

It could be considered that the speed of storage reclamation left something to be desired

Yes!

The ball moved sideways

Yearly

Find out

The garbage collector was really slow