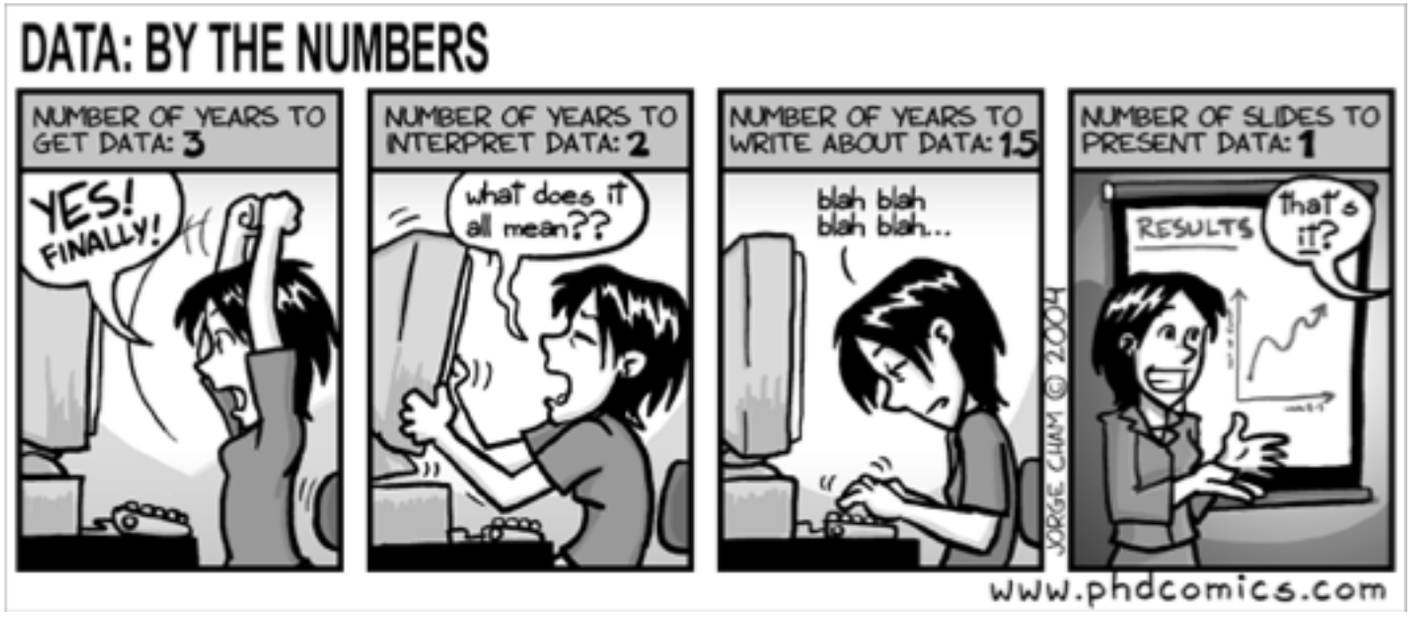
SWEN 6301 Software Construction

Lecture 11: Research in Software Engineering


DATA: BY THE NUMBERS
NUMBER OF YEARS TO GET DATA: 3
YES! FINALLY!
NUMBER OF YEARS TO INTERPRET DATA: 2
what does it all mean??
NUMBER OF YEARS TO WRITE ABOUT DATA: 1.5
blah blah blah blah...
NUMBER OF SLIDES TO PRESENT DATA: 1
RESULTS
that's it?
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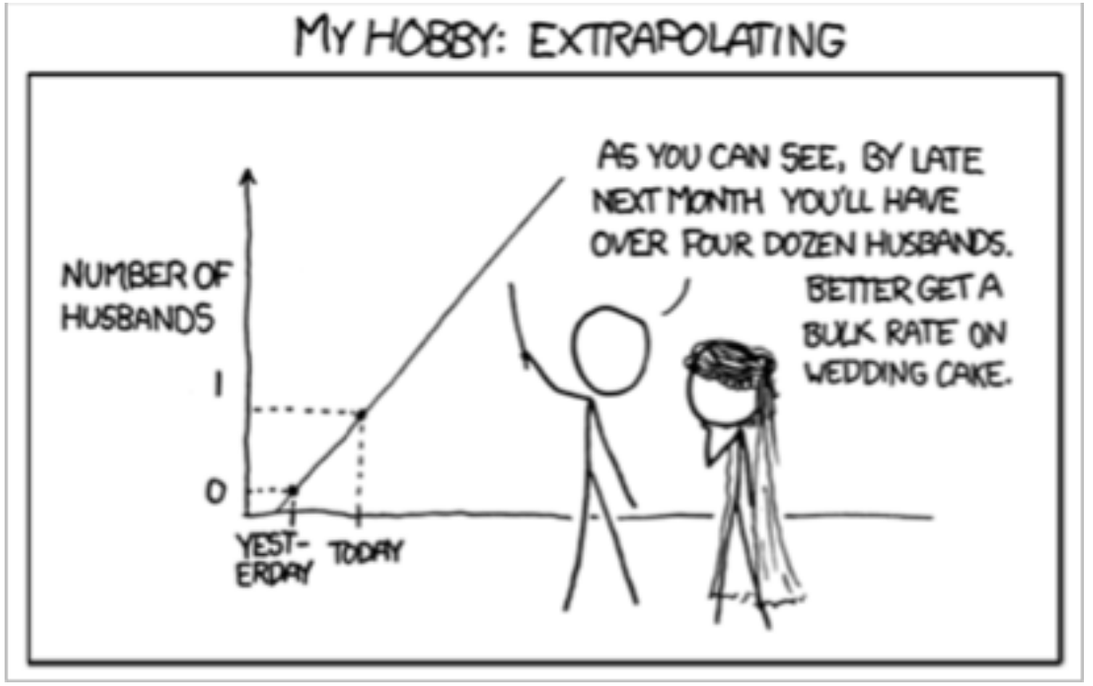
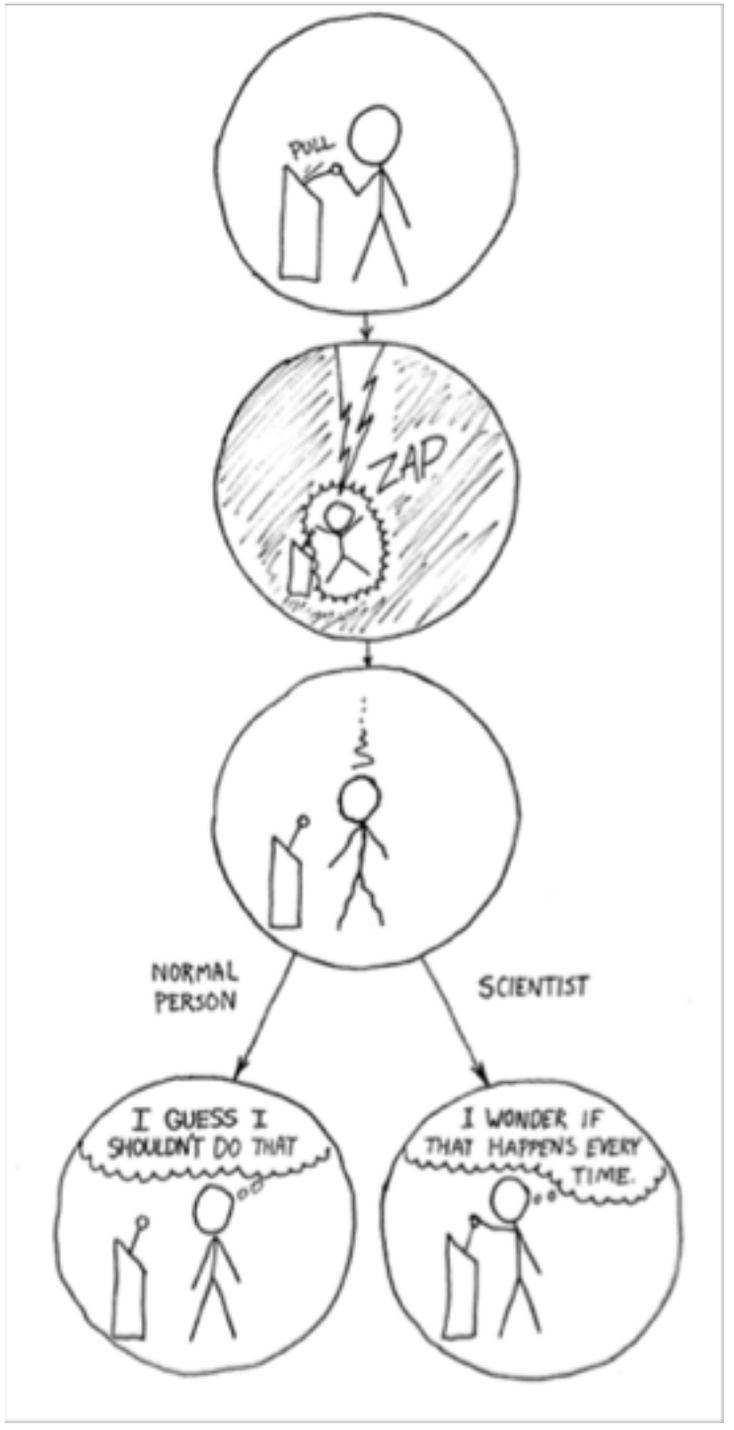

MY HOBBY: EXTRAPOLATING
NUMBER OF HUSBANDS
1
0
YEST-ERDAY
TODAY
AS YOU CAN SEE, BY LATE NEXT MONTH YOU'LL HAVE OVER FOUR DOZEN HUSBANDS.
BETTER GET A BULK RATE ON WEDDING CAKE.


POLL
ZAP
NORMAL PERSON
SCIENTIST
I GUESS I SHOULDN'T DO THAT
I WONDER IF THAT HAPPENS EVERY TIME.

What makes good research?

is it USEFUL?

is it HARD?

is it ELEGANT?

These are all orthogonal and equally respectful

Very little chances that you will excel in all three axes

We are young researchers, don't refuse usefulness, why limit your impact to dusty publications?

http://goo.gl/d1YM9v

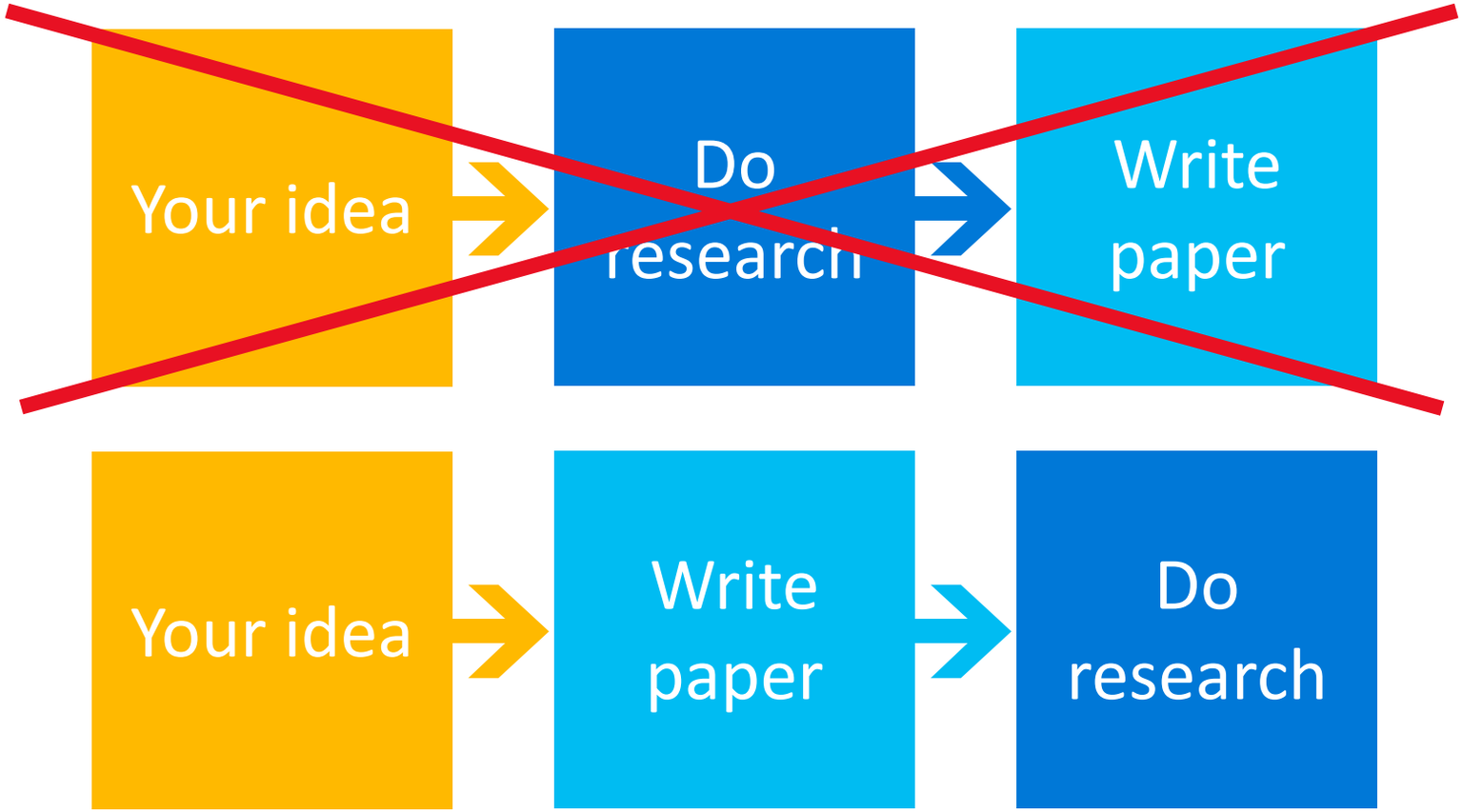
Ten simple, actionable suggestions

that will make your papers better

1. Don’t wait: **write**

Writing papers: *model 1*

Writing papers: *model 2*



Writing papers: *model 2*

- 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: *model 2*

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

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

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

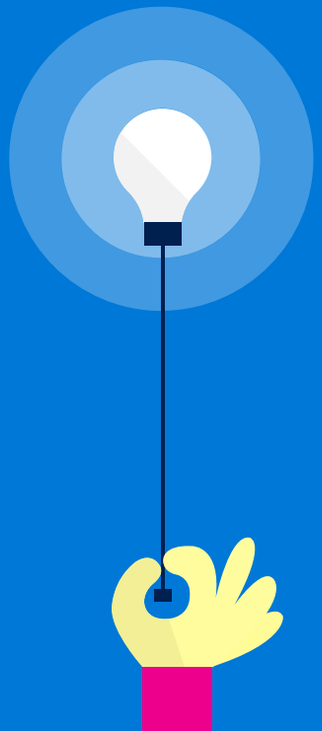
Write a paper, and give a talk, about any idea, no matter how weedy and insignificant it may seem to you

The idea

A re-usable insight, useful to the reader

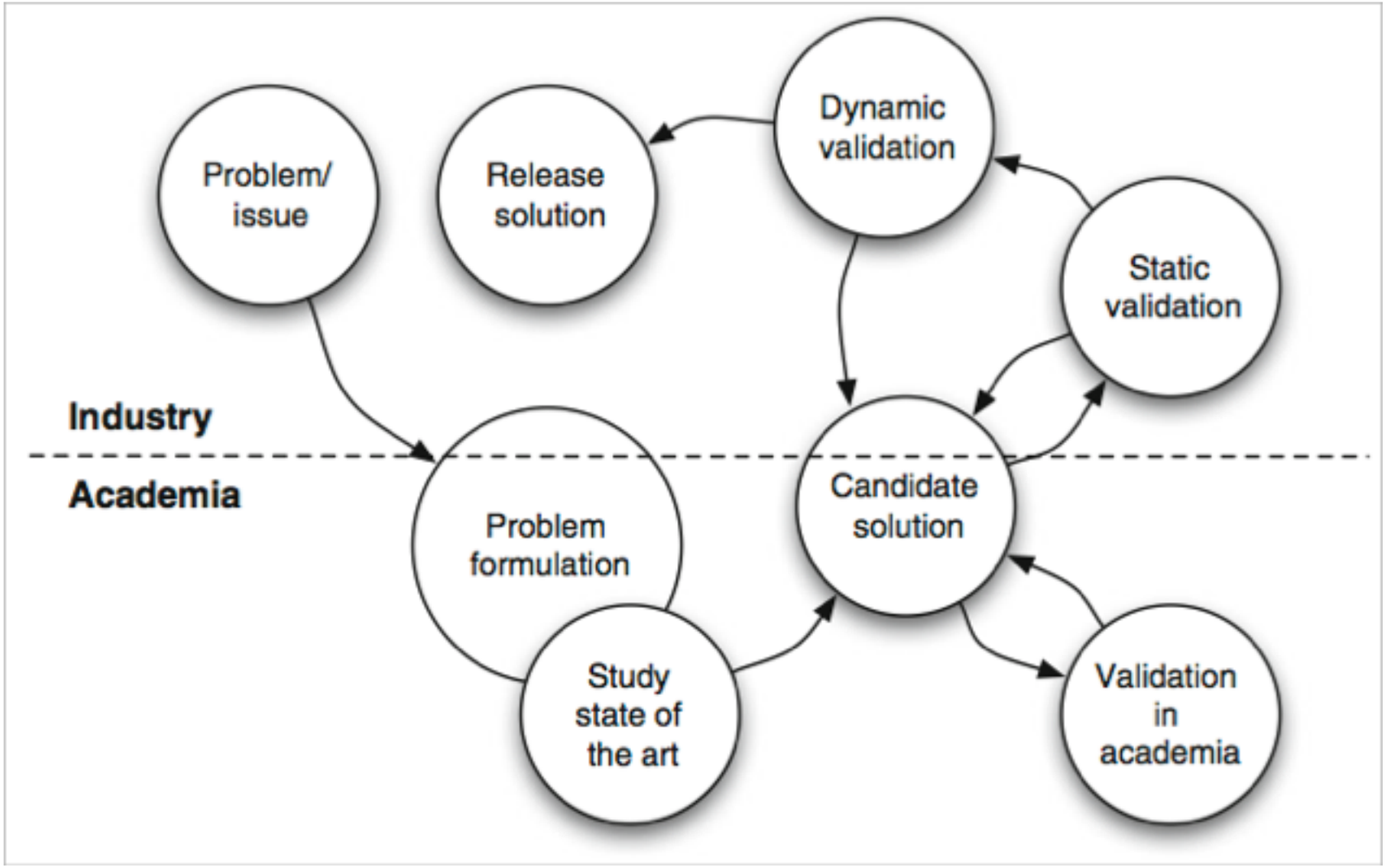
- Your paper should have just one "**ping**": **one clear, sharp idea**
- You may not know exactly what the ping is when you start writing; but you must know when you finish.
- *If you have lots of ideas, write lots of papers*.

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.”

How to have an impact in reality?



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 **Abstract**

Abstract

- People judge papers by their abstracts and read the abstract in order to decide whether to read the whole paper.
- It's important for the abstract to tell the whole story.
- Don't assume, though, that simply adding a sentence about analysis or experience to your abstract is sufficient; the paper must deliver what the abstract promises.

Abstract Example 1

ABSTRACT

How do we know a program does what it claims to do? After clustering Android apps by their description topics, we identify outliers in each cluster with respect to their API usage. A "weather" app that sends messages thus becomes an anomaly; likewise, a "messaging" app would typically not be expected to access the current location. Applied on a set of 22,500+ Android applications, our CHABADA prototype identified several anomalies; additionally, it flagged 56% of novel malware as such, without requiring any known malware patterns.

✓✗	✓	✗	✓
State of the art	Overall contribution	Specific results	Validation

Abstract Example 2

ABSTRACT

Despite the flourishing of languages to describe software architectures, existing Architecture Description Languages (ADLs) are still far away from what it is actually needed. In fact, while they support a traditional perception of a Software Architecture (SA) as a set of constituting elements (such as components, connectors and interfaces), they mostly fail to capture multiple stakeholders concerns and their design decisions that represent a broader view of SA being accepted today. Next generation ADLs must cope with various and ever evolving stakeholder concerns by employing *semantic extension mechanisms*.

In this paper we present a framework, called BYADL – Build Your ADL, for developing a new generation of ADLs. BYADL exploits model-driven techniques that provide the needed technologies to allow a software architect, starting from existing ADLs, to define its own new generation ADL by: i) adding domain specificities, new architectural views, or analysis aspects, ii) integrating ADLs with development processes and methodologies, and iii) customizing ADLs by fine tuning them. The framework is put in practice in different scenarios showing the incremental extension and customization of the Darwin ADL.

State of the art

Overall contribution

Specific results

Validation

5. Nail your **contributions** to the mast

The introduction (1 page)

- Describe the **problem**
- 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 *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:

```
zipWith :: (a->b->c) -> [a] -> [b] -> [c]
zipWith k []     []     = []
zipWith k (x:xs) (y:ys) = k x y : zipWith xs ys
```

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.

Use an example to introduce the problem

Molehills not mountains

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

Bulleted list of contributions

Contributions should be refutable

No!	Yes!
We describe the WizWoz system. It is really cool.	We give the syntax and semantics of a language that supports concurrent processes (Section 3). Its innovative features are...
We study its properties	We prove that the type system is sound, and that type checking is decidable (Section 4)
We have used WizWoz in practice	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.

Types of software engineering research questions

Type of question	Examples
Method or means of development	How can we do/create (or automate doing) X? What is a better way to do/create X?
Method for analysis	How can I evaluate the quality/correctness of X? How do I choose between X and Y?
Design, evaluation, or analysis of a particular instance	What is a (better) design or implementation for application X? What is property X of artifact/method Y? How does X compare to Y? What is the current state of X / practice of Y?
Generalization or characterization	Given X, what will Y (necessarily) be? What, exactly, do we mean by X? What are the important characteristics of X? What is a good formal/empirical model for X? What are the varieties of X, how are they related?
Feasibility	Does X even exist, and if so what is it like? Is it possible to accomplish X at all?

Shaw, Mary. "Writing good software engineering research papers." *25th International Conference on Software Engineering*. IEEE, 2003.

Heilmeier Catechism

George H. Heilmeier, a former DARPA director (1975-1977), crafted a set of questions to help Agency officials think through and evaluate proposed research programs.

- What are you trying to do? Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What is new in your approach and why do you think it will be successful?
- Who cares? If you are successful, what difference will it make?
- What are the risks?
- How much will it cost?
- How long will it take?
- What are the mid-term and final “exams” to check for success?

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.

6. Show your new **results**

Types of software engineering research results

Type of result	Examples
Procedure or technique	New or better way to do some task, such as design, implementation, measurement, evaluation, selection from alternatives, Includes operational techniques for implementation, representation, management, and analysis, but not advice or guidelines
Qualitative or descriptive model	Structure or taxonomy for a problem area; architectural style, framework, or design pattern; non-formal domain analysis Well-grounded checklists, well-argued informal generalizations, guidance for integrating other results,
Empirical model	Empirical predictive model based on observed data
Analytic model	Structural model precise enough to support formal analysis or automatic manipulation
Notation or tool	Formal language to support technique or model (should have a calculus, semantics, or other basis for computing or inference) Implemented tool that embodies a technique
Specific solution	Solution to application problem that shows use of software engineering principles – may be design, rather than implementation Careful analysis of a system or its development Running system that embodies a result; it may be the carrier of the result, or its implementation may illustrate a principle that can be applied elsewhere
Answer or judgment	Result of a specific analysis, evaluation, or comparison
Report	Interesting observations, rules of thumb

Shaw, Mary. "Writing good software engineering research papers." *25th International Conference on Software Engineering*. IEEE, 2003.

Types of software engineering research results validations

Type of validation	Examples
Analysis	I have analyzed my result and find it satisfactory through ...ormal analysis) … rigorous derivation and proof (empirical model) … data on controlled use(controlled … carefully designed statistical experiment) experiment
Experience	My result has been used on real examples by someone other than me, and the evidence of its correctness / usefulness / effectiveness is …alitative model) … narrative(empirical model, … data, usually statistical, on practice (notation, tool) … comparison of this with similar results in technique) actual use
Example	Here's an example of how it works on (toy example) … a toy example, perhaps motivated by reality (slice of life) …a system that I have been developing
Evaluation	Given the stated criteria, my result... (descriptive model) … adequately describes the phenomena of interest … (qualitative model) … accounts for the phenomena of interest… (empirical model) … is able to predict … because …, or … gives results that fit real data … Includes feasibility studies, pilot projects
Persuasion	I thought hard about this, and I believe... (technique) … if you do it the following way, … (system) … a system constructed like this would … (model) … this model seems reasonable Note that if the original question was about feasibility, a working system, even without analysis, can be persuasive
Blatant assertion	No serious attempt to evaluate result

Shaw, Mary. "Writing good software engineering research papers." *25th International Conference on Software Engineering*. IEEE, 2003.

What do program committees look for?

The program committee looks for interesting, novel, exciting results that significantly enhance our ability:

- to develop and maintain software
- to know the quality of the software we develop
- to recognize general principles about software
- or to analyze properties of software

You should explain your result in such a way that someone else could use your ideas

What do program committees look for?

Awful	▼	• I completely and generally solved … (unless you actually did!)
Bad	▼	• I worked on galumphing. (or studied, investigated, sought, explored)
Poor	▼	• I worked on improving galumphing. (or contributed to, participated in, helped with)
Good	▲	• I showed the feasibility of composing blitzing with flitzing. • I significantly improved the accuracy of the standard detector. (or proved, demonstrated, created, established, found, developed)
Better	▲	• I automated the production of flitz tables from specifications. • With a novel application of the blivet transform, I achieved a 10% increase in speed and a 15% improvement in coverage over the standard method.

Shaw, Mary. "Writing good software engineering research papers." *25th International Conference on Software Engineering*. IEEE, 2003.

7. **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)

NO!

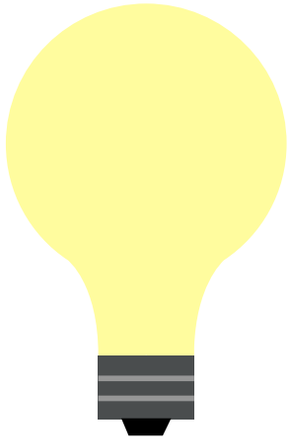
Structure

- **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)

No related work yet!

Your reader

Related work



Your idea

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].

No related work yet!

- **Problem 1**: the reader knows nothing about the problem yet; so your (highly compressed) description of various technical trade-offs is absolutely incomprehensible.
- **Problem 2**: describing alternative approaches gets between the reader and your idea.

Credit

Fallacy

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

The truth: **credit** is not like money

- 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

The truth: **credit** is not like money

Awful	▼	The galumphing problem has attracted much attention [3,8,10,18,26,32,37]
Bad	▼	Smith [36] and Jones [27] worked on galumphing.
Poor	▼	Smith [36] addressed galumphing by blitzing, whereas Jones [27] took a flitzing approach.
Good	▲	Smith's blitzing approach to galumphing [36] achieved 60% coverage [39]. Jones [27] achieved 80% by flitzing, but only for pointer-free cases [16].
Better	▲	Smith's blitzing approach to galumphing [36] achieved 60% coverage [39]. Jones [27] achieved 80% by flitzing, but only for pointer-free cases [16]. We modified the blitzing approach to use the kernel representation of flitzing and achieved 90% coverage while relaxing the restriction so that only cyclic data structures are prohibited.

Shaw, Mary. "Writing good software engineering research papers." *25th International Conference on Software Engineering*. IEEE, 2003.

Related Work

- What existing technology does your research build on?
- What existing technology or prior research does your research provide a superior alternative to?
- What's new here compared to your own previous work?
- What alternatives have other researchers pursued?
- How is your work different or better?

8. 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)

Structure

The idea

Consider a bifircuated 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 $p < p_j . p_i$

- 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

Using examples

The Simon PJ question: *is there any typewriter font?*

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`:

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

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 `Data`[1] The definition of `gsize` refers to the operation `gmapQ`, which is a method of the `Data` class:

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

Example right away

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**.

9. **Listen** to your readers

Getting help

- 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 colleagues as possible

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 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, 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”.
- **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

10. 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

Visual structure

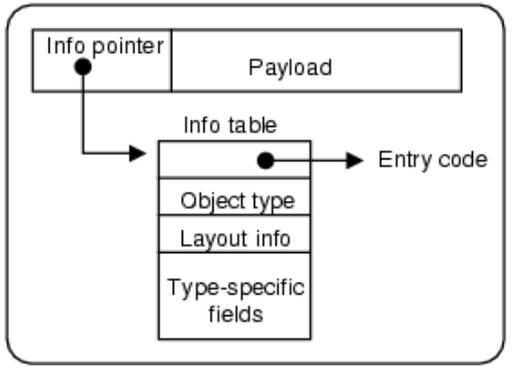


Figure 3. A heap object

The three cases above do not exhaust the possible forms of f. It might also be a *THUNK*, but we have already dealt with that case (rule THUNK). It might be a *CON*, in which case there cannot be any pending arguments on the stack, and rules UPDATE or 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 *FUN* applied to some arguments:

- If there are exactly the right number of arguments, we behave exactly like rule KNOWNCALL, by tail-calling the function. Rule 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 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 $CON(C\ a_1 \ldots a_n)$ 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 *FUN* object has code for the function body.
- An object-type field, which distinguishes the various kinds of objects (*FUN*, *PAP*, *CON* etc) 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 *FUN* object contains its arity; a *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 PAP, 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 FUN object which is always the first field of a PAP. The other 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*

Use the active voice

The passive voice is “respectable” but it deadens your paper. Avoid it at all costs.

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

Use simple, direct language

No!	Yes!
The object under study was displaced horizontally	The ball moved sideways
On an annual basis	Yearly
Endeavour to ascertain	Find out
It could be considered that the speed of storage reclamation left something to be desired	The garbage collector was really slow

What do program committees look for?

- If you claim to improve on prior art, *compare your result objectively to the prior art.*
- If you used an analysis technique, *follow the rules of that analysis technique*.
- If you offer practical experience as evidence for your result, *establish the effect your research has. If at all possible, compare similar situations with and without your result.*
- If you performed a controlled experiment, *explain the experimental design*. What is the hypothesis? What is the treatment? What is being controlled?
- If you performed an empirical study, *explain what you measured, how you analyzed it, and what you concluded.*