Some remarks on

Research, Design &

Writing a research paper

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Different research targets

• A research question
  – there are some facts you don’t know....
  – .... and want to find out

• A problem
  – you want to find a solution to some problem
  – and need to compare different solutions, or judge the quality

• A theory or description
  – you are searching for a point of view, a mathematical description....
  – …to clearly describe the domain of discourse, unambiguously...
  – ….to understand and explain some part of reality....
  – ….that fits the facts satisfactorily

• A system to be designed
  – you are searching for a good –or the best- design....
  – ….and you need alternatives, and arguments, and comparison

• These are not exclusive! (theory is need in all cases)

• …It’s all about generating knowledge
PDEng: Scientific designers

• What is meant by this?
  – scientifically trained? (having an MSc)
  – or is it apparent in the work and methods itself?

• Build a theoretical framework
  – modeling
  – clarity of communication
  – removal of ambiguity

• Apply and refer to literature, use proven related work, concepts
  – search for and use knowledge that has a scientific underpinning

• Explicit comparison of options
• Motivation of choices
• Verification of assumptions
  – possibly using experiments
Order in research activities

• Put in the right order:
  – research, read literature, write paper, choose topic, state questions, related work
  – choose topic; write paper; research; state questions
    • the paper will structure the research and will help to get the questions clear
  – state questions; read literature
    • the questions will structure and select the literature
  – related work – preference: to the end of your paper
    • so your ideas become first class citizens
    • and you do not discuss issues that cannot be understood yet
    • however, if the related work defines the concepts it goes early
  – be absolutely truthful to existing work
    • put effort in finding, understanding, summarizing and valuing it
    • acknowledge work of others
Method: literature

• journals
  – select *high-impact* journals (for CS: IEEE, ACM)
  – aim for *original* articles (the first ones to set a direction)

• conferences
  – go to IEEE and ACM sites
  – examine relevant proceedings of the last two years
  – this teaches you what is *hot* and *new* in that field
  – you find references to *original* articles

• *know what you want to know* – *so you can skip what you don’t need*
  – e.g., if you want to understand the methods computer scientist use to analyse protocols, you focus on the method section
Method: taxonomy

• Find *criteria* that dissect the domain of discourse
  – independent, if possible
  – hierarchical

• Organize the domain as a (tree) structure of labelled choices

• Investigate where reported (literature!) solutions and systems fit

• Observe empty spots: possibilities for new systems, methods

• Find metrics to discriminate the choices
Example: taxonomy for service registration

- Example: service registration

- Information state
  - stateful
  - stateless

- Caching management
  - soft-state
  - hard-state

- Update timing
  - triggered
  - periodic

- Interaction mode
  - push
  - pull
  - push
Choose at least 2 out of 3

- real world
- model world
- experiment
- simulation
- analytical description

the issue you want to shed light on
Method: experiments

• Use *hypotheses* you want to test
  – e.g. the performance is linearly dependent on the latency
  – e.g. the use of *gnath* makes people more *glub*

• Design experiments accordingly
  – e.g. make it possible to have several different latencies
  – think about what would *refute* your hypothesis

• Fully execute and record the experiment
  – do not change the experiment halfway, do not deviate from the plan
  Only then review the new situation and design new hypotheses

• Try to oversee the whole system; see whether the answer can be given in a much simpler way
  – e.g., a direct argument, an analytical solution

• Make sure you or someone else can *reproduce* experiments
  – describe your experiments truthfully and completely
  – store data and programs

• Cover the parameter space
Tool: metrics

- If you need to quantify outcomes, balance trade-offs...
  - as, e.g., in designs
- ....use metrics to
  - define importance
  - allow comparison
- metric:
  - mapping of a system (property or asset) into the real numbers

- Typically a total cost function (a value function) is given as
  - the inner product of a weight vector and a vector of metrics (‘Weighted Sum Method’)
  - the product of a vector of metrics, each of which has a power parameter

- Balancing several metrics leads to optimization
  - e.g. through Pareto analysis

- Example metrics: latency and throughput, cost (money), energy, response time
Formalization, theoretical framework

• Formalization is the process of making a domain of discourse precise, typically by mathematical modeling
  – domain of discourse: that what you want to study, e.g. a problem domain

• Motivation:
  – obtain focus, make precise, increase understanding
  – remove ambiguity, remove errors from informal understanding
  – make amenable for reasoning, for classification
  – recognize similarities and application of known theory
  – communication

• A formalization gives the vocabulary that is used from that point onwards to reason about the domain. The context of the formalization defines its goals.
Requirements to formalization

• The formalization (models) must be
  – complete with respect to the goals, i.e., all relevant information is there
  – consistent, no internal contradiction
  – correct with respect to the domain of discourse

• The abstraction is such that anything proven or constructed at the formal level translates back to the domain of discourse

• As a result a formalization is an incremental process and also iterative. It is not really possible to do it one-time-right.
Method: modeling

• Find the relevant *concepts* and their *relationships*
  – often, this *is* the problem description

• Motivation: abstract from irrelevant details
  – further: see formalization

• A model has a *goal*, and it must be *adequate* with respect to that goal. It may not be used for aspects not covered by its goal

• A model can be
  – too abstract: relevant details are not in there anymore
  – too detailed: containing irrelevant detail

• Quantitative models: compute or simulate
  – e.g. the simulation of a CSMA protocol

• Validate (and think about that in advance)
  – compare with experiments with the real system
  – find consistency arguments
Method: Interview

• Find experts to obtain their knowledge
  – motivate for yourself the particular choice
    • why do I talk to this guy?
  – write down for yourself what you want to know of him
  – prepare questions!

• Separate facts and viewpoints!
  – try to see this interview as an experiment
Writing about a system

- What’s the difference between
  - a research paper
  - a design document
  - and a manual?
Writing about a system

- research paper, design document
  - the essential choices motivated
    • these last longer than the system
  - the essential concepts and structures explained
    • these last longer than the system

- research paper
  - trying to find quality *metrics* and argue for correctness
  - teaching a longer-lasting principle in relation to the state of knowledge
  - allowing to objectively judge quality, and to compare, reproduce

- a design document
  - satisfaction of requirements (testing, verification, validation)

- a manual?
  - how does the system work?
  - how do I use it?
How to learn?

• Do it!
  – it’s you (and not the teacher) that wants to answer questions, find out facts, solve problems, etc.
  – expose yourself to critique, and improve [blind confirmation serves no-one]

• Get on the internet
  – with the phrase ‘writing a research paper’, or something alike
  – take the advice seriously

• good stuff in e.g.:

• The purpose of a paper or design document is
  – to convey your ideas and findings....
  – .... as clearly as possible ....
  – .... and objectively
Research based articles often include several of the following sections:

Title & Author Information:
briefly summarizes the subject or purpose of the article & documents the author's credentials in the field of study

Abstract:
summarizes the research study and results of the study

Introduction:
states the hypothesis or purpose of the research, motivates it as well

Review of Literature:
summarizes previous research or what has already been written on the subject

Methodology:
describes what kind(s) of research methods were used in this project and how the study or survey were constructed and implemented

Findings/Results:
collates and summarizes the data collected and calculates totals or trends

Conclusions/Discussion:
discusses applications or implications of the findings/results

Further Study:
suggests areas where more complete data or findings are needed and related areas for future research

Works Cited/References:
lists the sources cited by the author(s) of the article

http://www.nwmissouri.edu/library/courses/hes/resart.htm
Connie Ury and Carolyn Johnson
Introduction

• Typical introduction:
  – *broad view* explaining *relevance / context* of paper
  – *narrowing* towards the paper subject while discussing *contributions* by other authors
  – naturally ending in a *explanation of the paper’s subject*
    • hypothesis, problem statement, ....
  – concluding with a *brief overview* of the paper
    • that logically fits the given introduction
    • and touches upon the method used
Style

- Although you may not like it....
  - write as objectively as possible: use ‘we’ rather than ‘I’, avoid addressing the reader and try to let the matter speak for itself. Some people suggest to use passive tense all over.
    - I rewrite this as ...
    - We rewrite this as ...
    - This is rewritten as ...

    - As the reader can observe ...
    - As you can observe ....
    - As can be observed ...

- Avoid superfluous wording

- Check an IEEE style for LateX or Word

- Check reference styles:
  - according to Jan et al.[4], according to [4], [Jan2003]
Conclusion

• Revisit the issue posed in the introduction
  – systematically address it
  – and list your contributions