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 valueing 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

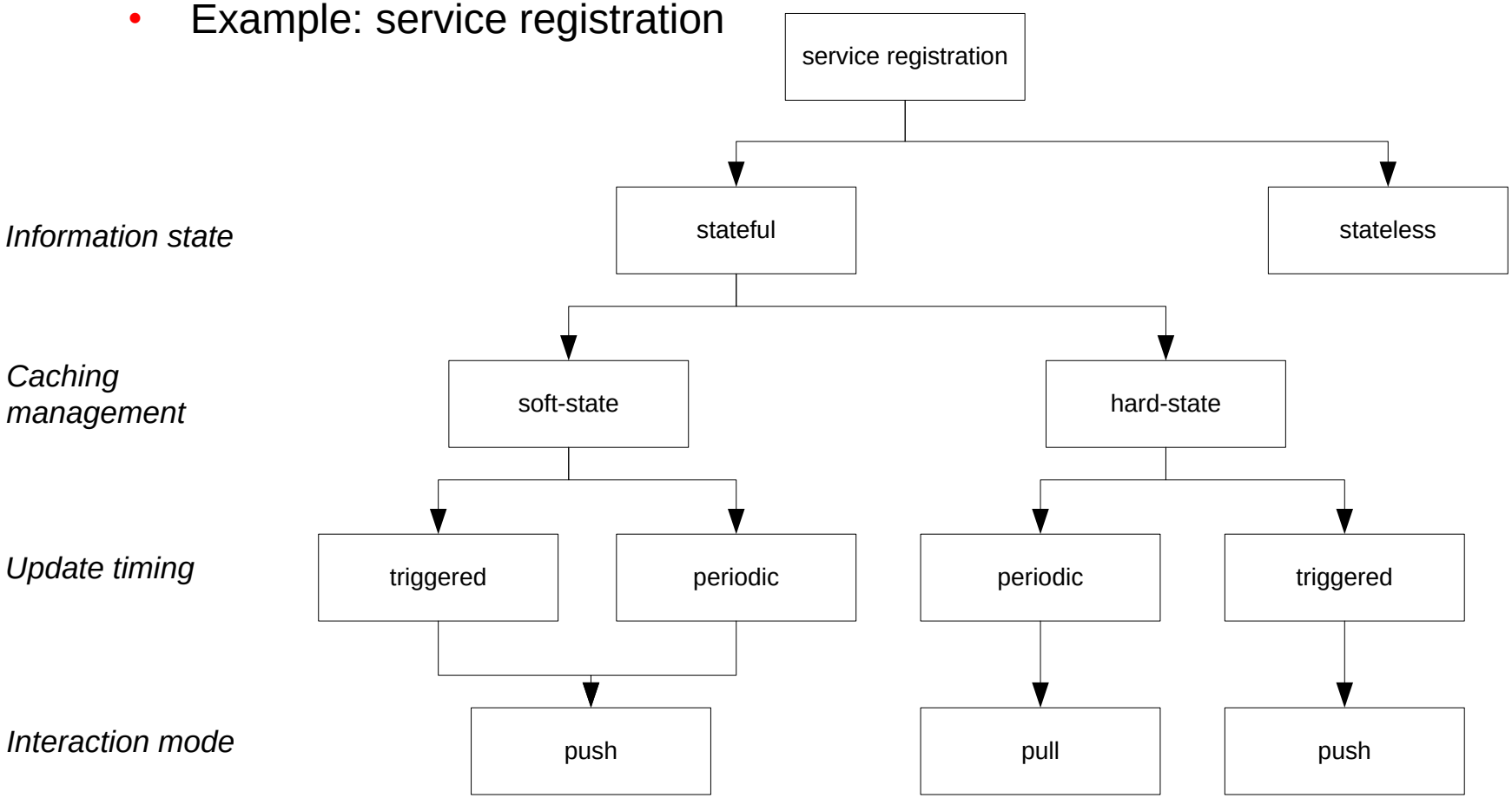
- *know what you want to know – so you can skip what you don't need*
  - e.g., if you want to understand the methods computer scientist use to analyse protocols, you focus on the method section

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

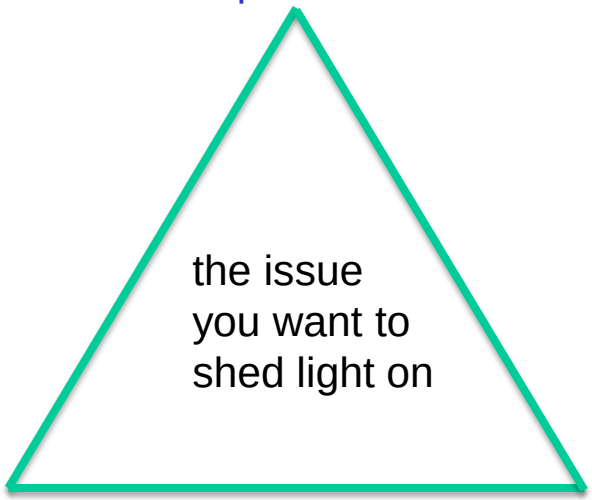
- Example: service registration



Choose at least 2 out of 3

real world

model world



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.:
  - http://research.microsoft.com/~simonpj/papers/giving-a-talk/writing-a-paper-slides.pdf

- The purpose of a paper or design document is
  - to convey your ideas and findings....
  - .... as clearly as possible ....
  - .... and objectively

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