Introduction to Software Evolution

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MSE | MASTER OF SCIENCE IN ENGINEERING

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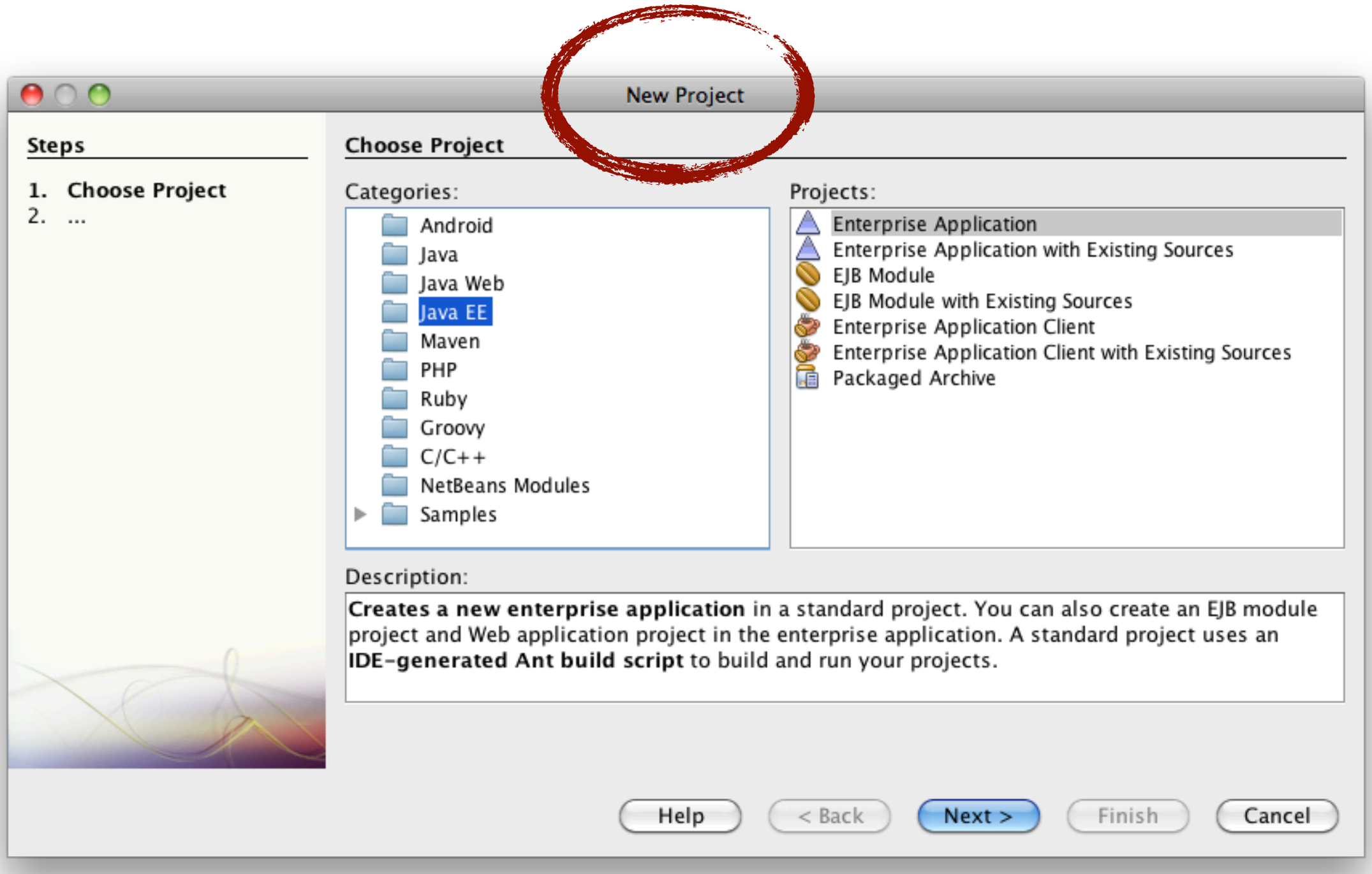
RE-Planning

Date		Theory	Practice
20.09.12	agile	Introduction to agile & scrum	
27.09.12	agile	Agile development tools	Agile development tools
04.10.12	agile	User Stories	Guest speaker (Lotaris)
11.10.12	agile	The Product Owner	Presentations Agile Development Tools
18.10.12	agile	Guest speaker (Octo)	Guest speaker (Octo)
01.11.12	agile	**Continuous Delivery**	**Lab**
08.11.12	architecture	Behavior Driven Development (BDD)	BDD lab
15.11.12	architecture	Development in and for the Cloud	Guest speaker (Cloudbees)
22.11.12	architecture	BDD lab	BDD lab
29.11.12	evolution	Software Evolution	Guest speaker (SonarSource)
06.12.12	evolution	BDD lab	BDD lab
13.12.12	evolution	OO Reengineering	BDD lab
20.12.12	architecture	Design of (REST) APIs	BDD lab
10.01.13	architecture	BDD Presentations	BDD Presentations
17.01.13			
24.01.13			


New Project
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Java Web
Java EE
Maven
PHP
Ruby
Groovy
C/C++
NetBeans Modules
Samples
Projects:
Enterprise Application
Enterprise Application with Existing Sources
EJB Module
EJB Module with Existing Sources
Enterprise Application Client
Enterprise Application Client with Existing Sources
Packaged Archive
Description:
Creates a new enterprise application in a standard project. You can also create an EJB module project and Web application project in the enterprise application. A standard project uses an IDE-generated Ant build script to build and run your projects.
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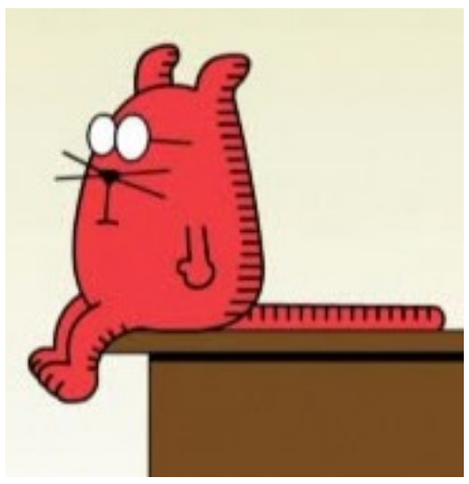
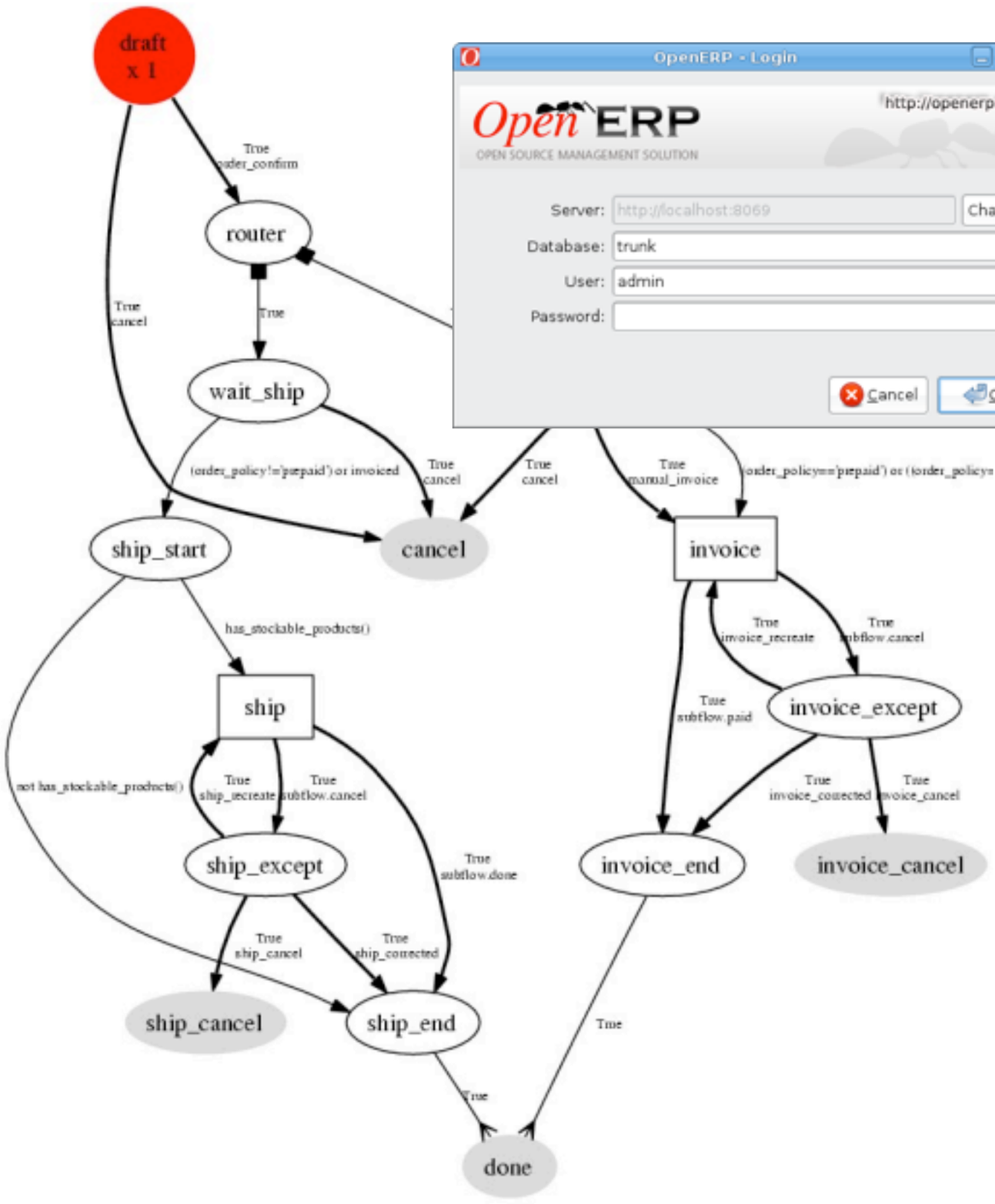
I want to be able to send e-invoices to mobile phone users!



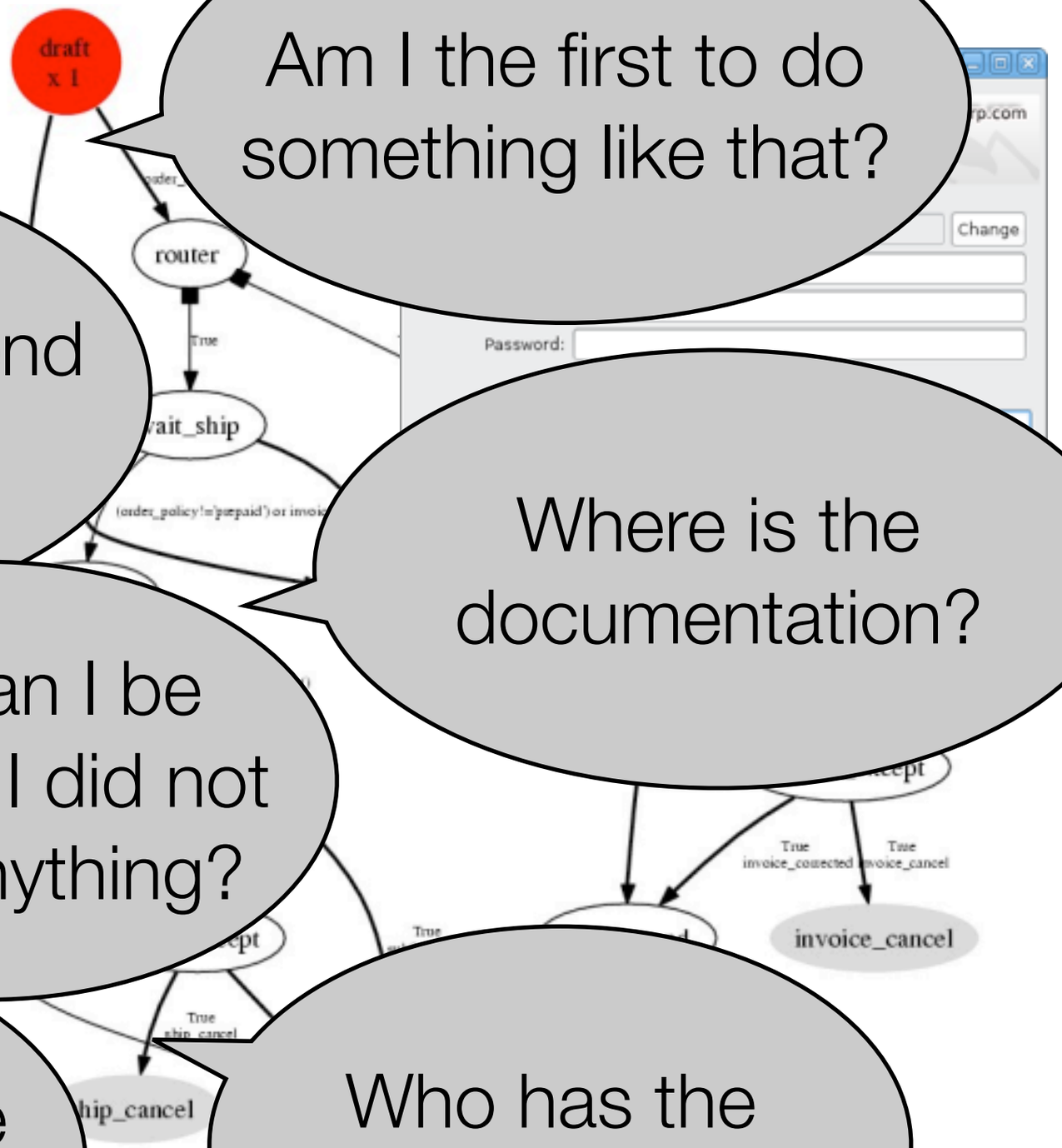


http://doc.openerp.com/developer/2_4_module_development/4_1_module_structure.html

How was the ERP system designed?

How can I extend the ERP?

Am I the first to do something like that?



How can I be sure that I did not break anything?

Where is the documentation?

How do I release my new feature?

Who has the knowledge?

http://doc.openerp.com/developer/2_4_module_development/4_1_module_structure.html

Agenda

- **Introduction**
  - The scientific and engineering fields of software evolution
- **Foundations**
  - Laws of Software Evolution
  - Software Aging
  - Roadmap
- **Methods & Tools**
  - Dealing with Legacy Systems
  - Re-engineering

Introduction

Research on Software Evolution

Google scholar | software evolution | Search | Advanced Scholar Search | Scholar Preferences

Scholar | Articles and patents | anytime | include citations | Results **1 - 10** of about **2,080,000**. (**0.15** sec)

Architecture-based runtime software evolution — psu.edu [PDF]
P Oreizy, N Medvidovic, RN Taylor - ... conference on **Software** ..., 1998 - portal.acm.org
ABSTRACT Continuous availability is a critical requirement for an important class of **software** systems. For these systems, runtime system **evolution** can mitigate the costs and risks associated with shutting down and restarting the system for an update. We present an architecture- ...
Cited by ... - Related articles - BL Direct - All 19 versions - Import into BibTeX

[PDF] **Programs, life cycles, and laws of software evolution** — bth.se [PDF]
MM Lehman... - Proceedings of the IEEE, 1980 - ipd.bth.se
PROCEEDINGS OF THE IEEE, VOL. 68, NO. 9, SEPTEMBER 1980 Programs, Life Cycles, and Laws of **Software Evolution** MEIR M. LEHMAN, senior member, ieee Abstract—By classifying programs according to their relationship to the environment in which they are executed ...
Cited by 540 - Related articles - All 2 versions - Import into BibTeX

[PDF] **Evolution** in the ... software ... — psu.edu [PDF]
MW Godfrey, Q Tu - 16th IEEE International Conference on **Software** ..., 2000 - Citeseer
Most studies of **software evolution** have been performed on systems developed within a single company using tradi- tional management techniques. With the widespread avail- ability of several large **software** systems that have been de- veloped using an "open source" development ...
Cited by 335 - Related articles - View as HTML - All 47 versions - Import into BibTeX

Metrics and laws of software evolution-the nineties view — psu.edu [PDF]
... , JF Ramil, PD Wernick, DE Perry, ... - ... **Software** Metrics ..., 1997 - doi.ieeecomputersociety.org
Imperial College of Science, Technology and Medicine London SW7 2BZ tel: +44 (0)171 594 8214 fax: +44 (0) 17 1 594 82 15 e-mail: (mml,jcfl,pdw)@doc.ic.ac.uk URL:http:Nwww-dse.doc.ic.ac.uk/-mml/feast1 ... M Turski Institute of Informatics Warsaw University Warsaw ...
Cited by ... - Related articles - All 36 versions - Import into BibTeX

Software maintenance and evolution: a roadmap — psu.edu [PDF]
KH Bennett, VT Rajlich - ... of the conference on The future of **Software** ..., 2000 - portal.acm.org
Keith Bennett has been a full Professor since 1986, and a former Chair, both within the Department of Computer Science at the University of Durham. For the past fourteen years he has worked on methods and tools for program comprehension and reverse engineering, based on ...
Cited by 263 - Related articles - All 22 versions - Import into BibTeX

Laws of software ... invited — psu.edu [PDF]
MM Lehman - Lecture Notes in Computer Science, 1996 - Springer
Abstract. Data obtained during a 1968 study of the **software** process [8] led to an investigation of the **evolution** of OS/360 [13] and and, over a period of twenty years, to formulation of eight Laws o] So]tware Evo- lution. The FEAST project recently initiated (see sections 4 - 6 ...
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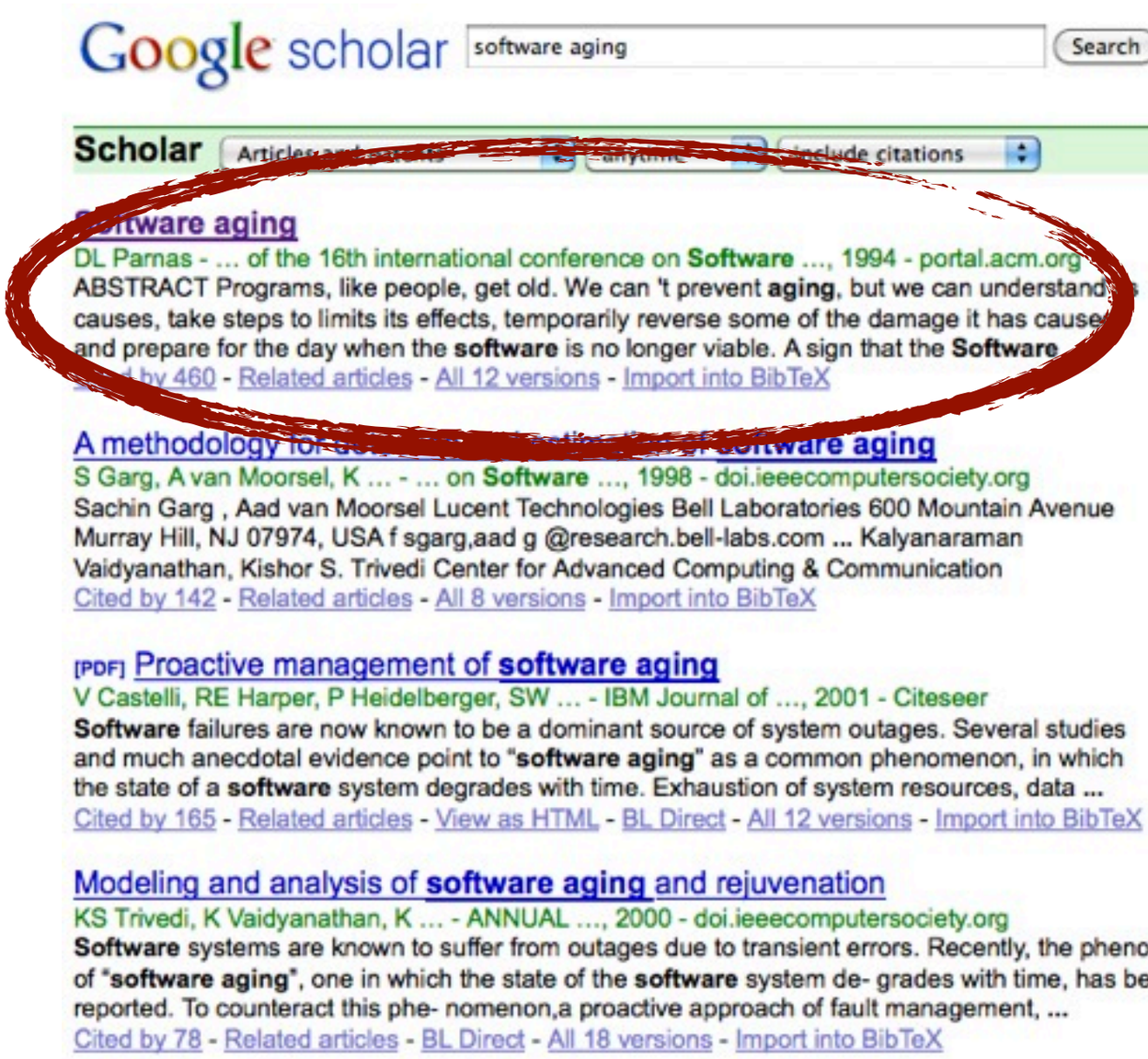
Research on Software Evolution


Google scholar software aging Search Advanced Scholar Search Scholar Preferences

Scholar Articles and patents anytime include citations Results 1 - 10 of about 1,230,000. (0.15 sec)

Software aging
DL Parnas - ... of the 16th international conference on **Software** ..., 1994 - portal.acm.org
ABSTRACT Programs, like people, get old. We can 't prevent **aging**, but we can understand its causes, take steps to limits its effects, temporarily reverse some of the damage it has caused and prepare for the day when the **software** is no longer viable. A sign that the **Software**
Cited by 460 - Related articles - All 12 versions - Import into BibTeX

A methodology for detection and estimation of **software aging** ncsu.edu [PS]
S Garg, A van Moorsel, K ... - ... on **Software** ..., 1998 - doi.ieeecomputersociety.org
Sachin Garg , Aad van Moorsel Lucent Technologies Bell Laboratories 600 Mountain Avenue Murray Hill, NJ 07974, USA f sgarg,aad g @research.bell-labs.com ... Kalyanaraman Vaidyanathan, Kishor S. Trivedi Center for Advanced Computing & Communication
Cited by 142 - Related articles - All 8 versions - Import into BibTeX

[PDF] Proactive management of **software aging** psu.edu [PDF]
V Castelli, RE Harper, P Heidelberger, SW ... - IBM Journal of ..., 2001 - Citeseer
Software failures are now known to be a dominant source of system outages. Several studies and much anecdotal evidence point to "**software aging**" as a common phenomenon, in which the state of a **software** system degrades with time. Exhaustion of system resources, data ...
Cited by 165 - Related articles - View as HTML - BL Direct - All 12 versions - Import into BibTeX

Modeling and analysis of **software aging** and rejuvenation psu.edu [PDF]
KS Trivedi, K Vaidyanathan, K ... - ANNUAL ..., 2000 - doi.ieeecomputersociety.org
Software systems are known to suffer from outages due to transient errors. Recently, the phenomenon of "**software aging**", one in which the state of the **software** system de- grades with time, has been reported. To counteract this phe- nomenon,a proactive approach of fault management, ...
Cited by 78 - Related articles - BL Direct - All 18 versions - Import into BibTeX

Concepts

Legacy Systems

Agile processes

Life Cycle

Maintenance

Software Aging

Software Evolution

Reverse Engineering

Program Comprehension

Re-engineering

Program Transformation

Mining Software Repositories

Metrics

Research dimensions

Empirical studies and validation

Basic research

How do we model a software system and its evolution?

Industrial, large scale systems

Software Evolution

Methods and tools-oriented research

How do we support program comprehension and program transformation?

Research on Software Evolution

- **Pioneers:**
  - Keith H. Bennett
  - Meir M. Lehman
  - Bennet P. Lientz, Lientz
  - David Lorge Parnas
  - Vaclav T. Raijlich
  - E. Burton Swanson Swanson
- **Some of the people in the community:**
  - Serge Demeyer, Universiteit Antwerpen (Belgium)
  - Stephane Ducasse, INRIA (France)
  - Harald C. Gall, Software Evolution and Architecture lab, University of Zürich (Switzerland)
  - Tudor Girba, did his Ph.D. at the Software Composition Group at University of Bern (Switzerland)
  - Michele Lanza, University of Lugano (Switzerland)
  - Tom Mens, Software Engineering Lab, Université de Mons (Belgium)
  - Oscar Nierstrasz, Software Composition Group, University of Bern.

Publish Date: March 10, 2008
Print ISBN: 3540764399

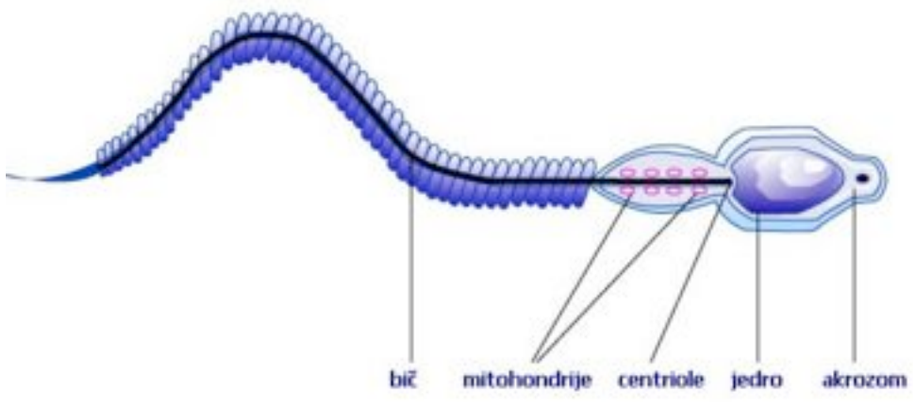
History and Challenges of Software Evolution

- **1968**: first conference on Software Engineering, organized by the NATO Science Committee, with the goal to establish **sound engineering principles** in order to obtain reliable, efficient and economically viable software.
- **1970**: Royce proposes the **waterfall life-cycle process** for software development. Maintenance is seen as the final phase of the software lifecycle (with only bug fixes and minor adjustments). The model had a strong and long influence on the industrial practice of software development.
- **Late 1970's**: first attempt towards a more evolutionary process model. Identification of new activities, such as impact analysis and change propagation. In the same period, formulation of "**Laws of software evolution**" by Lehman.
- **1990's**: widespread acceptance of software evolution, formalization of evolutionary processes (Gilb's evolutionary development, Boehm's spiral model, Bennet and Rajich's staged model).
- **Software evolution is a crucial ingredient of agile software development (iterative and incremental development, embracing change!)**

Tom Mens, Introduction and Roadmap: History and Challenges of Software Evolution, Software Evolution, ISBN 978-3-540-76439-7

History and Challenges of Software Evolution

- **Two dimensions of Software evolution**
  - **What and Why?** Software evolution as a **scientific discipline**, which studies the nature of the software evolution **phenomenon**, and seeks to understand its driving factor, its impact.
  - **How?** Software engineering as an **engineering discipline**, which studies more **pragmatic aspects** that aid software developers and project managers in their day-to-day tasks. Focus on **technology**, **methods**, **tools** and activities that provide a means to direct, implement and control software evolution.



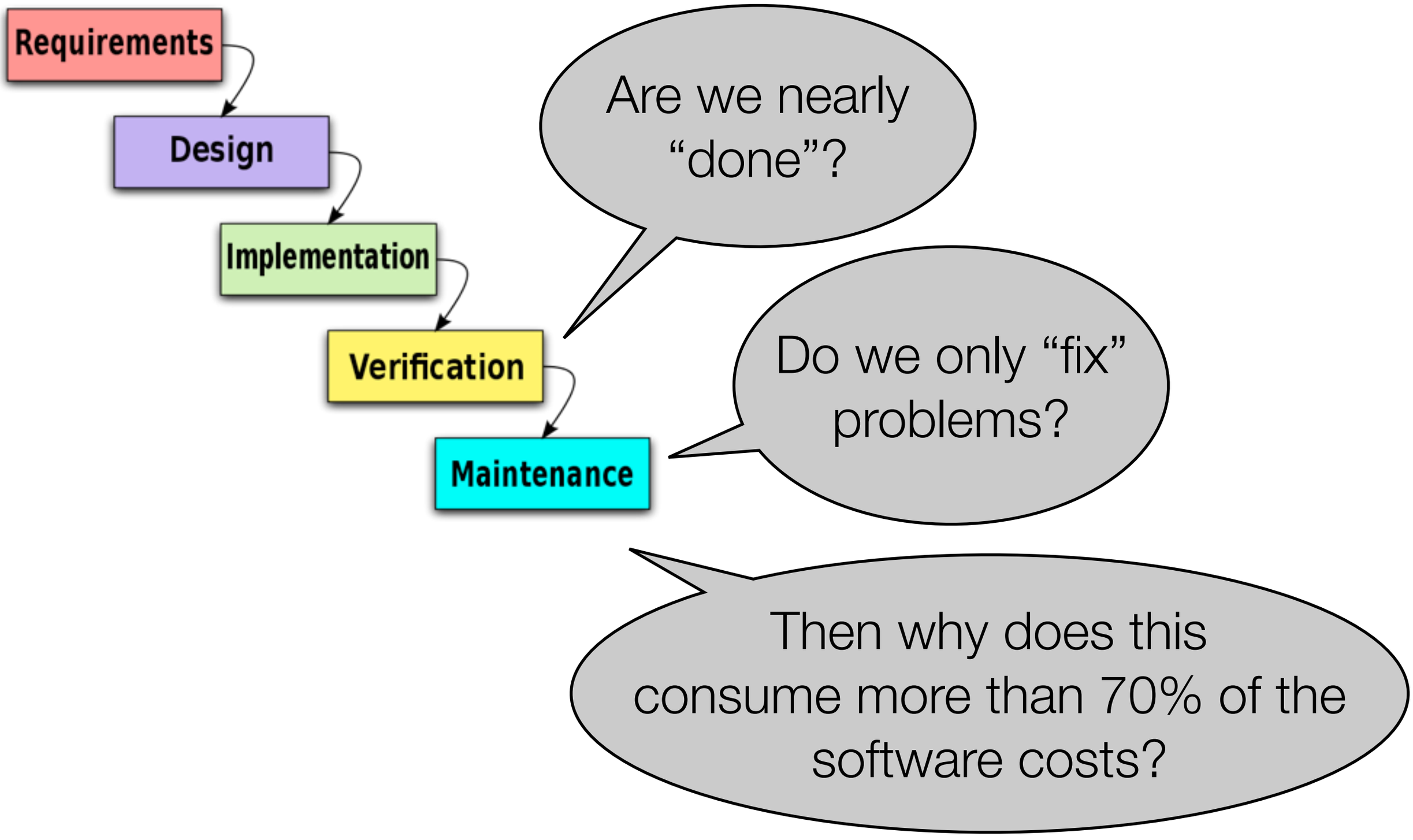
Software Maintenance

- In many engineering disciplines, **physical products** are designed, built and delivered to users.
- Think about a **bridge**, a **building**, a **car** or a **vacuum cleaner**.
- Maintenance is about making sure that the product **stays operational** over the years.
- Since we are talking about physical products, we are thinking about fixing defects, changing **worn-out components**, do some cleaning, adding oil, etc.
- When we talk about maintenance, the **functionality of the product stays the same**.

http://www.flickr.com/photos/laenulfean/474217855/sizes/m/#cc_license

Is software maintenance only about fixing defects?

What does it mean to “maintain” software?



Software Maintenance

- Maintenance is **costly** - between 70% to 80% of the software costs are spent on maintenance.
- Classification of software maintenance activities:
  - **Corrective**: errors need to be fixed.
  - **Preventive**: prevent problems in the future (fix design issues).
  - **Adaptive**: something has changed in the environment.
  - **Perfective**: improve system qualities, e.g. performance.

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Management Applications
H. Morgan Editor

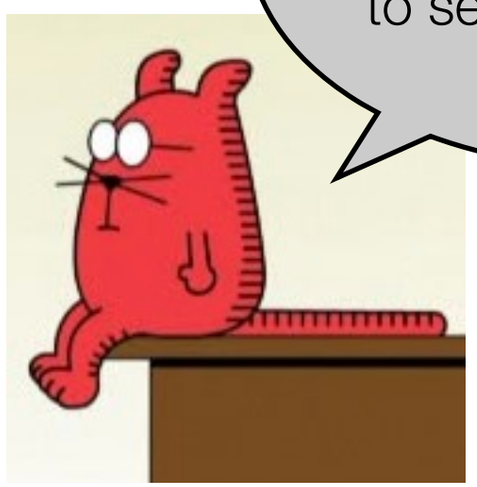
Characteristics of Application Software Maintenance

B. P. Lientz, E. B. Swanson,
and G. E. Tompkins
University of California at Los Angeles

Maintenance and enhancement of application software consume a major portion of the total life cycle cost of a system. Rough estimates of the total systems and programming resources consumed range as high as 75–80 percent in each category. However, the area has been given little attention in the literature. To analyze the problems in this area a questionnaire was developed and pretested. It was then submitted to 120 organizations. Respondents totaled 69. Responses were analyzed with the SPSS statistical package. The results of the analysis indicate that: (1) maintenance and enhancement do consume much of the total resources of systems and programming groups; (2) maintenance and enhancement tend to be viewed by management as at least somewhat more important than new application software development; (3) in maintenance and enhancement, problems of a management orientation tend to be more significant than those of a technical orientation; and (4) user demands for enhancements and extension constitute the most important management problem area.

Communications of the ACM
June 1978 Volume 21 Number 6

Software Maintenance



Software Maintenance

Corrective

Preventive

Adaptive

Perfective

Lehman's "Laws" of Evolution

- Propose a **theoretical model** to reason about software systems and their interaction with the socio-economic **environment**.
- Maintenance is costly, but maintenance is not only about bug fixing!
- Propose a classification of software: S-Programs, P-Programs and **E-Programs**.
- Conduct **quantitative studies** on large scale industrial projects, (collect metrics)
- Derive "**Laws of Evolution**" that are generally applicable.

THE TOTAL U.S. expenditure on programming in 1977 is estimated to have exceeded $50 billion, and may have been as high as $100 billion. This figure, which represents more than 3 percent of the U.S. GNP for that year, is already an awesome figure. It has increased ever since in real terms and will continue to do so as the microprocessor finds ever wider application. Programming effectiveness is clearly a significant component of national economic health. Even small percentage improvements in productivity can make significant financial impact. The potential for saving is large.

Economic considerations are, however, not necessarily the main cause of widespread concern. As computers play an ever larger role in society and the life of the individual, it becomes more and more critical to be able to create and maintain effective, cost-effective, and timely software. For more than two decades, however, the programming fraternity, and through them the computer-user community, has faced serious problems in achieving this [1]. As the application of microprocessors extends ever deeper into the fabric of society the problems will be compounded unless very basic solutions are found and developed.

"Programs, Life Cycles, and Laws of Software Evolution", Proceedings of the IEEE, Vol. 68, No. 9, September 1980.

Different Types of Software Systems

- **S-Programs**. Programs that can be completely and formally specified.
    - e.g. a program that sorts an array.
- **P-Programs**. Programs that can be completely specified, but which makes an approximation of the real world.
    - e.g. a program that plays chess against a human player.
- **E-Programs**. Programs that mechanize a human or societal activity. The program becomes a part of the world it models!
    - e.g. an ERP system.

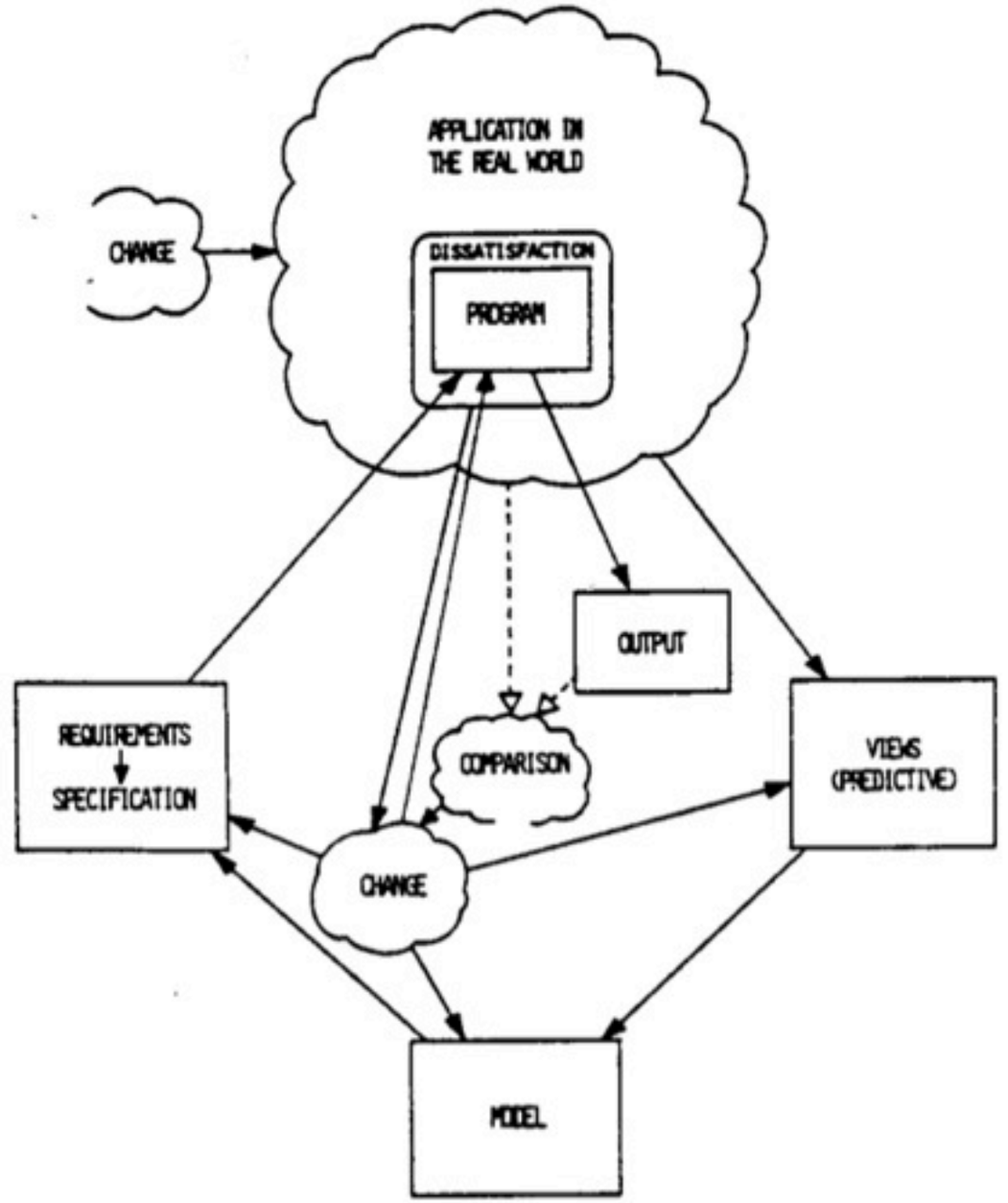
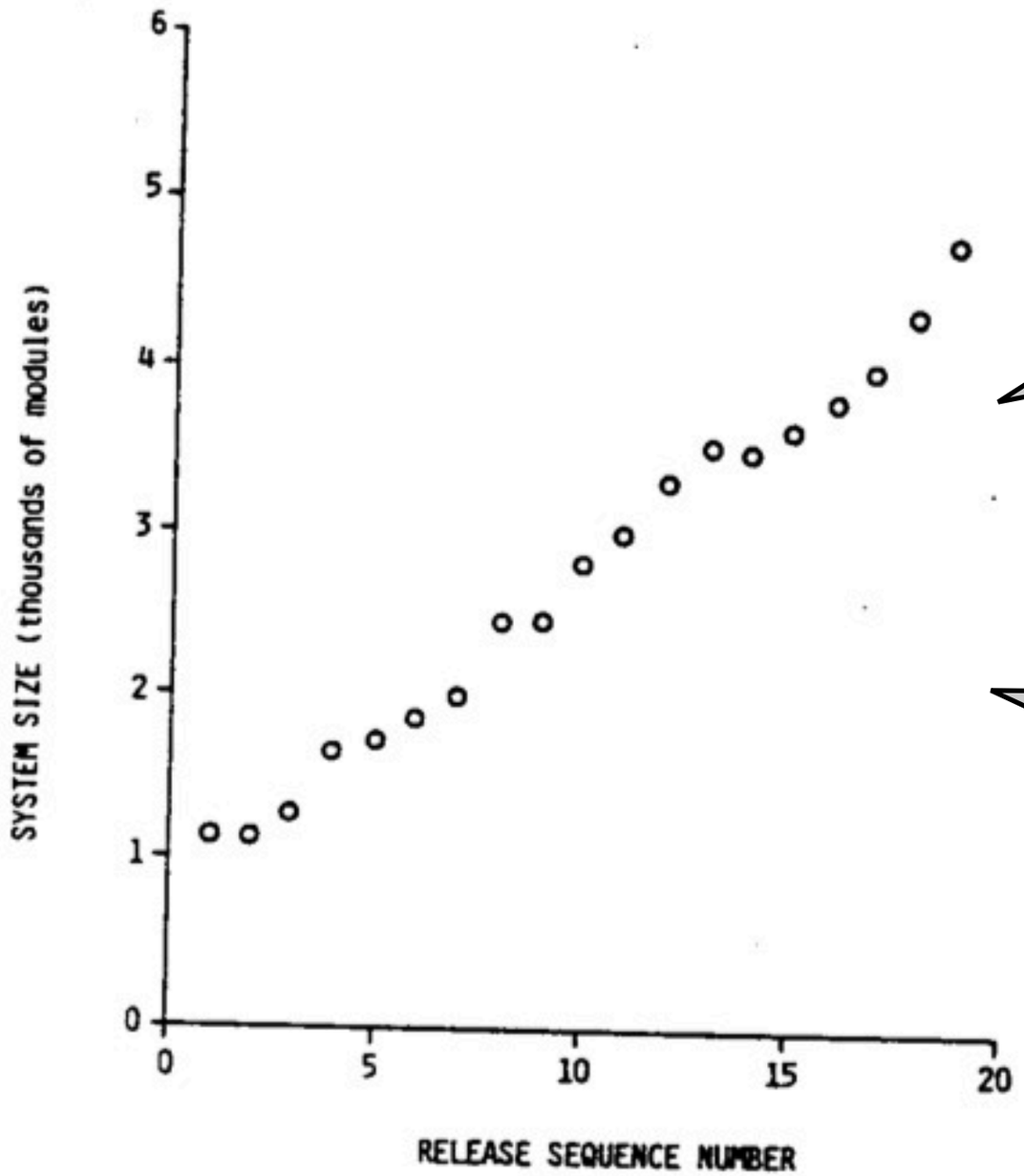


Fig. 4. *E*-programs.

Quantitative Studies

- **Collection of data** on a large scale, industrial project (IBM OS 360)
- **Analysis over**
    - Elapsed time
    - Release numbers
- **Metrics**
    - System size (number of modules)
    - Incremental growth
    - Modules changed (indicates complexity)
    - Interval
- **Statistical analysis shows trends in metrics evolution.**

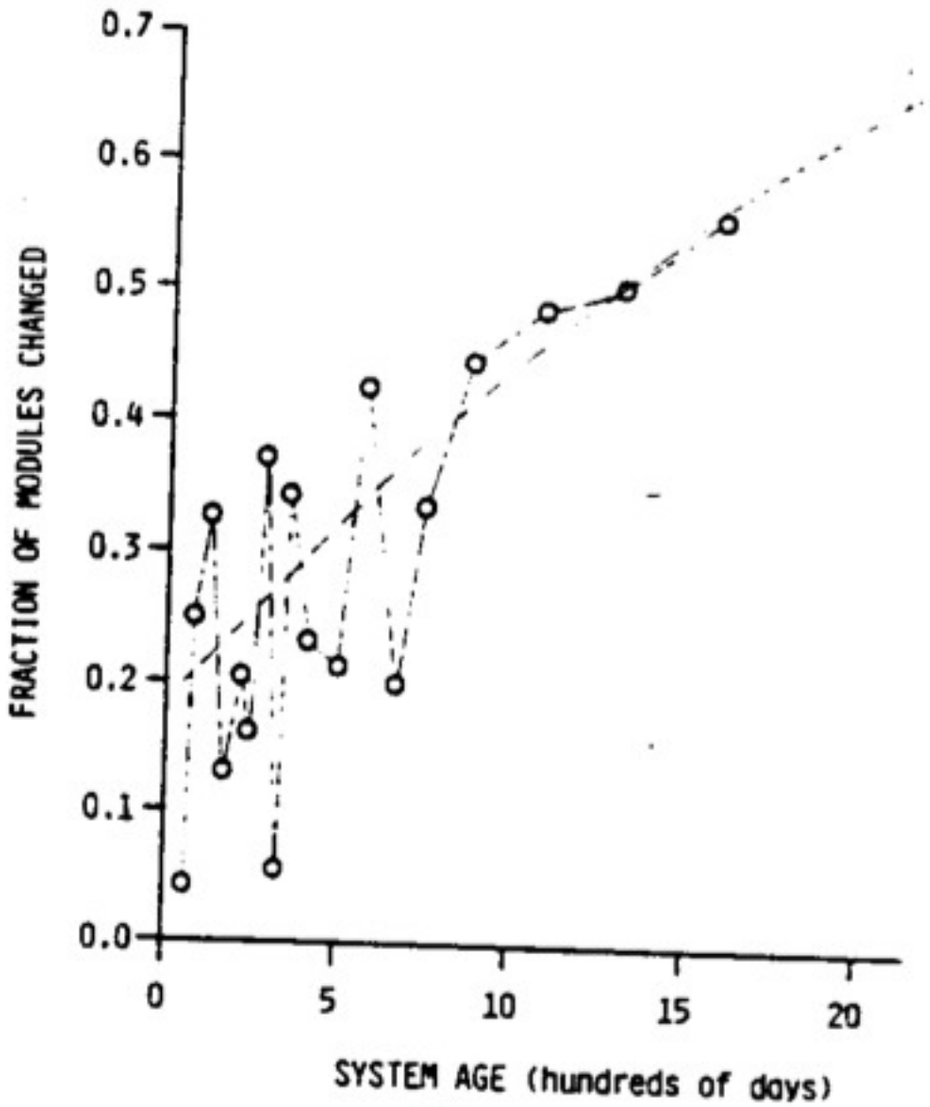
Quantitative Studies



The system grows in a predictable way. This reflects the constant evolution!

So... we're not only fixing bug then?

Quantitative Studies



The number of modules that must be changed for a release reflects the complexity of the system.

So... it becomes more and more complex then?

Lehman's "Laws" of Evolution

Software systems have to **evolve**, otherwise they gradually become useless.

If you don't take specific actions, software will become more **complex** and more difficult to adapt.

TABLE I
LAWS OF PROGRAM EVOLUTION

I. *Continuing Change*

A program that is used and that as an implementation of its specification reflects some other reality, undergoes continual change or becomes progressively less useful. The change or decay process continues until it is judged more cost effective to replace the system with a recreated version.

II. *Increasing Complexity*

As an evolving program is continually changed, its complexity, reflecting deteriorating structure, increases unless work is done to maintain or reduce it.

III. *The Fundamental Law of Program Evolution*

Program evolution is subject to a dynamics which makes the programming process, and hence measures of global project and system attributes, self-regulating with statistically determinable trends and invariances.

IV. *Conservation of Organizational Stability (Invariant Work Rate)*

During the active life of a program the global activity rate in a programming project is statistically invariant.

Conservation of Familiarity (Perceived Complexity)

During the active life of a program the release content (changes, additions, deletions) of the successive releases of an evolving program is statistically invariant.

Lehman's "Laws" of Evolution (nineties view)

If you don't take specific actions, software **quality** will decline!

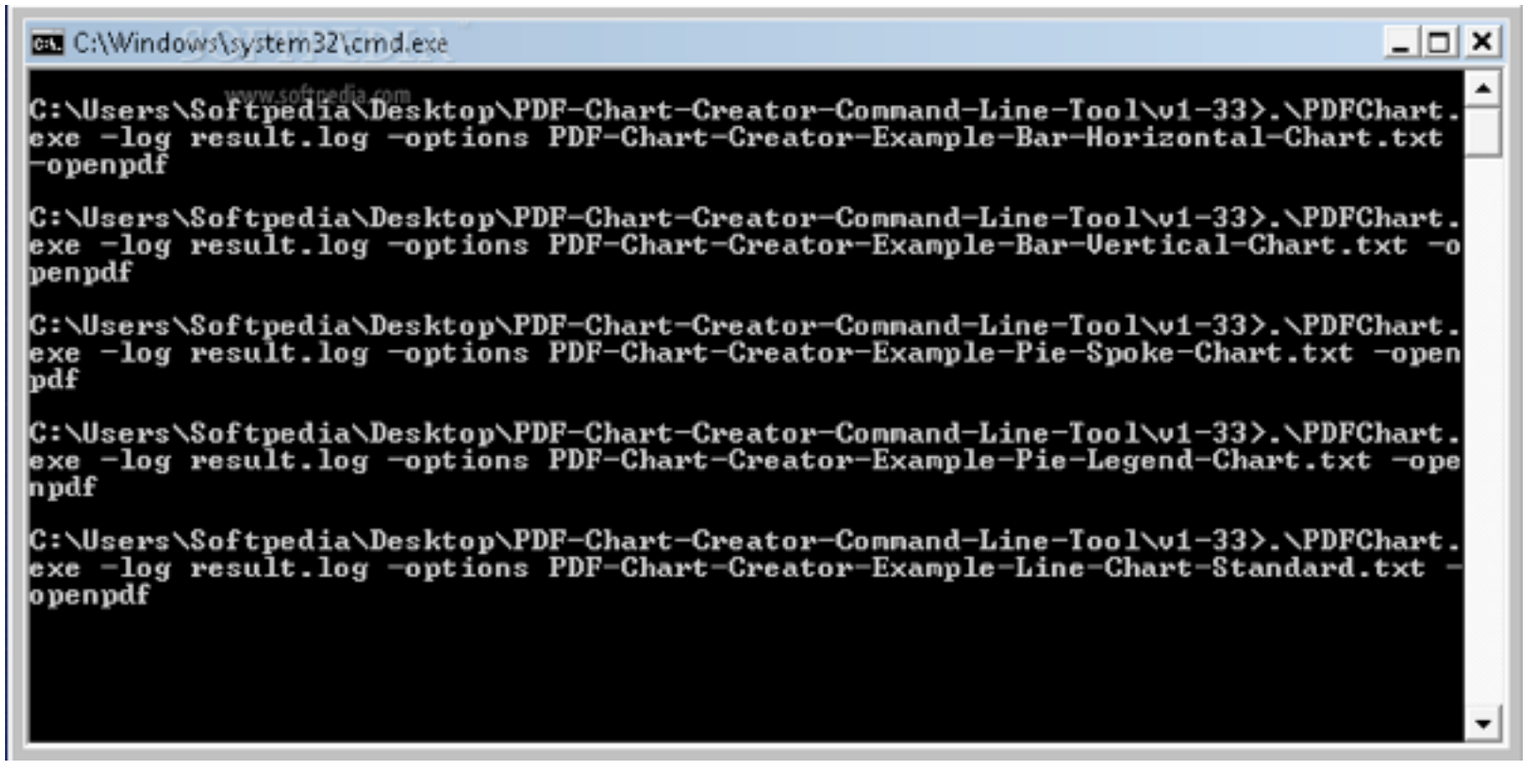
No.	Brief Name	Law
I 1974	Continuing Change	*E*-type systems must be continually adapted else they become progressively less satisfactory.
II 1974	Increasing Complexity	As an *E*-type system evolves its complexity increases unless work is done to maintain or reduce it.
III 1974	Self Regulation	*E*-type system evolution process is self regulating with distribution of product and process measures close to normal.
IV 1980	Conservation of Organisational Stability (invariant work rate)	The average effective global activity rate in an evolving *E*-type system is invariant over product lifetime.
V 1980	Conservation of Familiarity	As an *E*-type system evolves all associated with it, developers, sales personnel, users, for example, must maintain mastery of its content and behaviour [leh80a] to achieve satisfactory evolution. Excessive growth diminishes that mastery. Hence the average incremental growth remains invariant as the system evolves.
VI 1980	Continuing Growth	The functional content of *E*-type systems must be continually increased to maintain user satisfaction over their lifetime.
VII 1996	Declining Quality	The quality of *E*-type systems will appear to be declining unless they are rigorously maintained and adapted to operational environment changes.
VIII 1996	Feedback System (first stated 1974, formalised as law 1996)	*E*-type evolution processes constitute multi-level, multi-loop, multi-agent feedback systems and must be treated as such to achieve significant improvement over any reasonable base.

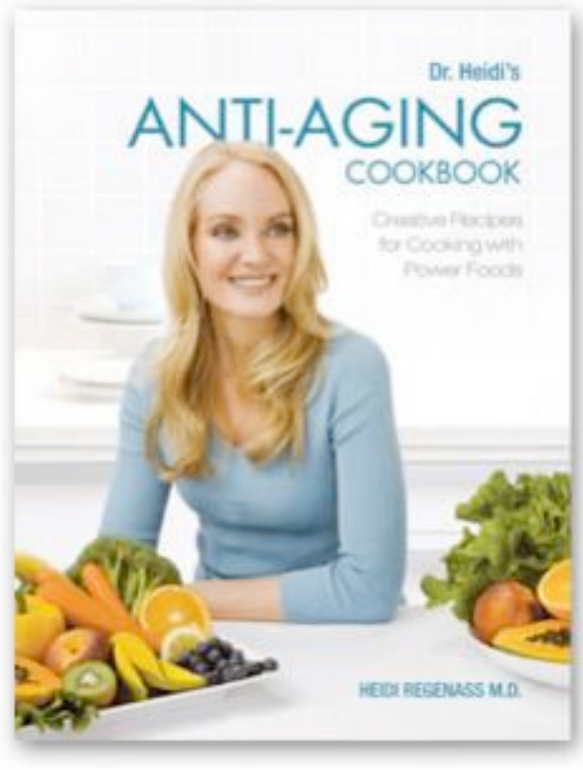
Software Aging

“Programs, like people, get old. We can’t prevent aging, but we can understand its causes, take steps to limit its effects, temporarily reverse some of the damage it has caused, and prepare for the day when the software is no longer viable.”

David Lorge Parnas, 1994

Software Aging





The causes of software aging

- **Lack of movement**
  - Caused by the failure of the product's owners to modify it to meet **changing needs**.
  - Unless software is frequently updated, its users will **become dissatisfied** and they will change to a new product as soon as the benefits outweigh the costs of retraining and converting.
- **Ignorant surgery**
  - Caused by the **changes** that are made to software.
  - Changes made by people who do not understand the original design concept almost always cause the **structure of the program to degrade**.
  - Software that has been repeatedly modified in this way becomes very expensive to update.

The costs of software aging

- The **symptoms** of software aging mirror those of human aging:
  - Owners of aging software find it increasingly **hard to keep up** with the market and lose customers to newer products (“weight gain”)
  - Aging software often **degrades in its performance** as a result of a gradually deteriorating structure.
  - Aging software often becomes “**buggy**” because of errors introduced when changes are made.

Reducing the costs of software aging

- **Preventive medicine**
  - **What can we do to delay the decay and limit its effects?**
  - Design for change
  - Keep records - documentation
  - Second opinion - reviews
- **Software geriatrics**
  - **What can we do to treat software aging that has already occurred?**
  - Stopping the deterioration
  - Retroactive documentation
  - Retroactive incremental modularization
  - Amputation
  - Major surgery - restructuring

Software Maintenance and Evolution: A Roadmap

A major challenge for the research community is to develop a good ***theoretical understanding*** *and underpinning for maintenance and evolution, which scales to* ***industrial*** *applications.* ***Most computer science research has been of benefit to the initial development of software.*** *Type theory and configuration management have in different ways made major contributions to maintenance. Many others claim to do so, but reliable empirical evidence is lacking.*

The ***staged model of software lifecycle*** *was introduced in [BENN99] and is summarized in Figure 1. It represents the software lifecycle as a* ***sequence of stages****, with initial development being the first stage. Its key contribution is to* ***separate the 'maintenance'*** *phase into an* ***evolution*** *stage followed by a* ***servicing*** *and* ***phase-out*** *stages.*

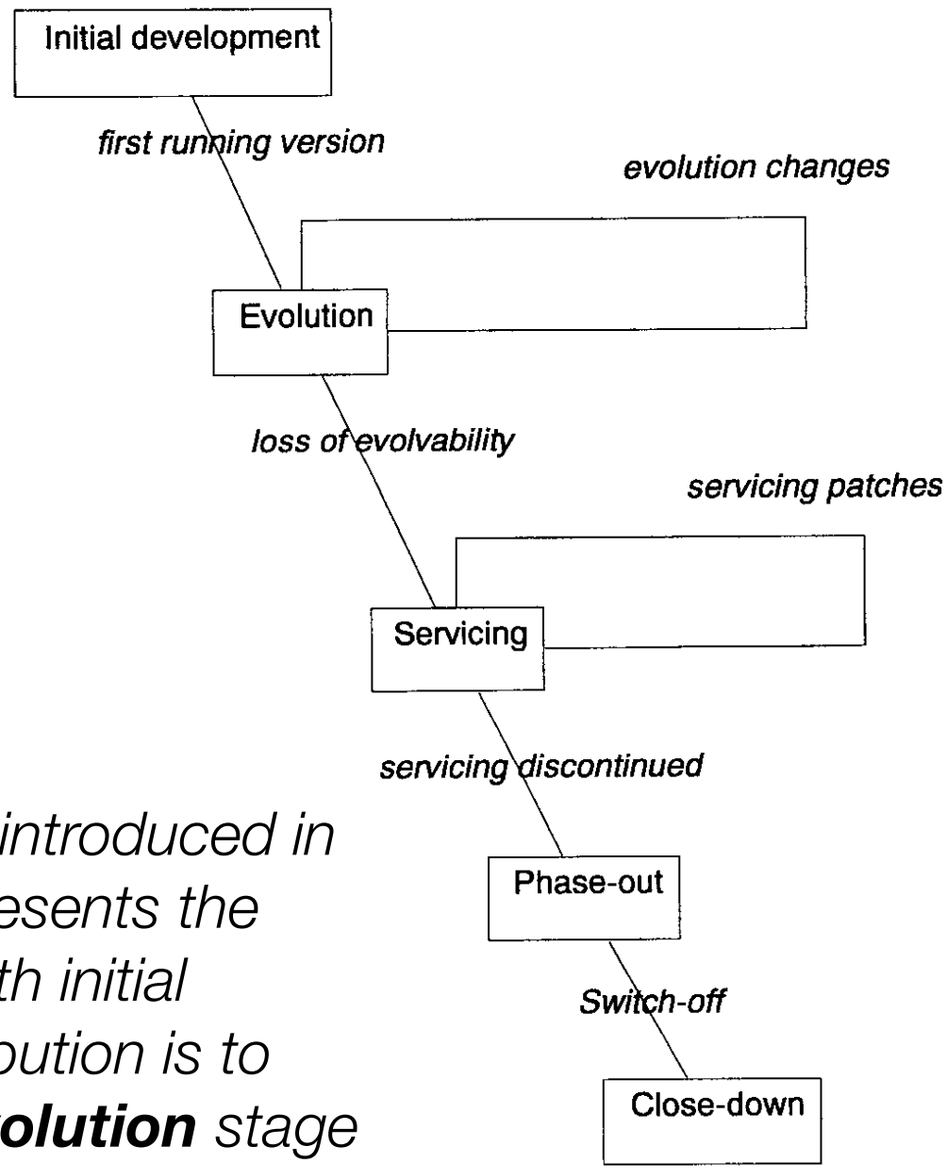


Figure 1. The simple staged model

Bennett, K. H. and Rajlich, V. T. 2000. Software maintenance and evolution: a roadmap. In Proceedings of the Conference on the Future of Software Engineering (Limerick, Ireland, June 04 - 11, 2000). ICSE '00. ACM, New York, NY, 73-87. DOI= http://doi.acm.org/10.1145/336512.336534

Software Maintenance and Evolution: A Roadmap

Each stage has very different technical solutions, processes, staff needs and management activities.

*An amplification of the staged model is the **versioned staged model**. The software team produces versions of the software during an **extended phase of evolution**, but the versions are no longer evolved, only serviced.*

All substantial changes in the functionality are implemented in the future versions.

If a version becomes outdated and the users need a new functionality, they have to replace their version with a new one.

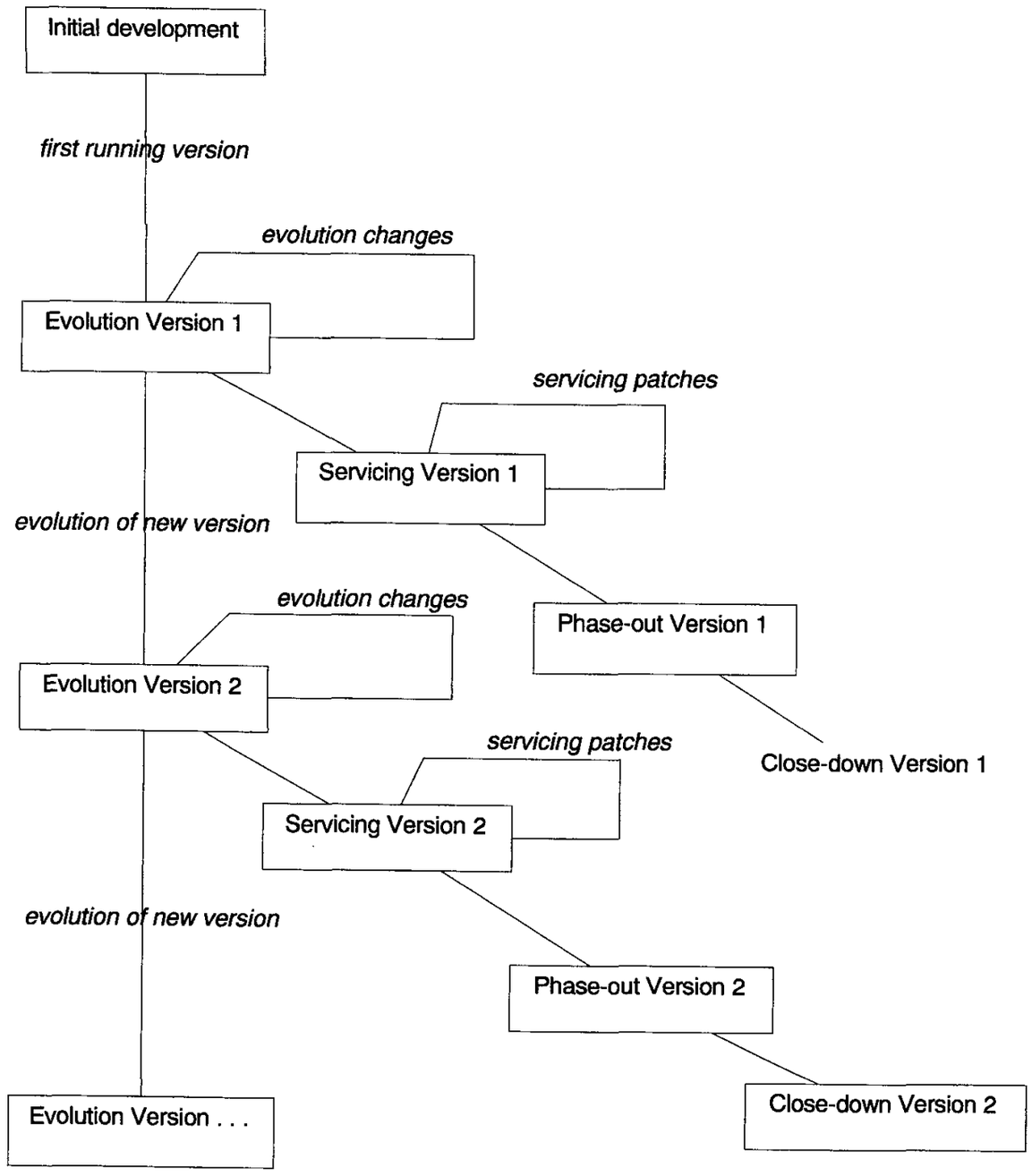


Figure 2. The versioned staged model

Bennett, K. H. and Rajlich, V. T. 2000. Software maintenance and evolution: a roadmap. In Proceedings of the Conference on the Future of Software Engineering (Limerick, Ireland, June 04 - 11, 2000). ICSE '00. ACM, New York, NY, 73-87. DOI= http://doi.acm.org/10.1145/336512.336534

Software Maintenance and Evolution: A Roadmap

- **Initial development stage**
  - **Research challenge**: find ways of developing software, so that it can be changed more easily and reliably in subsequent phases.
  - Two key outcomes of this phase: i) **architecture** and ii) **team knowledge**
- **Evolution stage**
  - **Goal**: implement possibly major changes without being able a priori to predict how user requirements will evolve.
  - **Management issue**: keep original architects and designers in the team - or risk to move into the servicing stage quickly.

Software Maintenance and Evolution: A Roadmap

- **Servicing stage**
  - **Goal**: implement **tactical changes**, at minimum cost.
  - **Big change in terms of project management**: only minor corrections/ enhancements should be done, senior staff members are no longer required, accurate cost prediction is needed. It is possible to outsource the servicing (how do we define SLAs?)
    - **Research challenge**: program comprehension. We need tools to understand the impact of changes, to display the program structure, to do regression testing. We also need tools for configuration management and version control of large distributed systems.
- **Phase-out and close down stages**

Methods & Tools

Overview

The documentation is missing or obsolete, and the original developers have departed. Your team has limited understanding of the system, and unit tests are missing for many, if not all, of the components. When you fix a bug in one place, another bug pops up somewhere else in the system. Long rebuild times make any change difficult. All of these are ***signs of software that is close to the breaking point****.*

Many systems can be upgraded or simply thrown away if they no longer serve their purpose. ***Legacy software, however, is crucial for operations and needs to be continually available and upgraded****.*

How can you reduce the complexity of a legacy system sufficiently so that it can continue to be used and adapted at acceptable cost?

Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Legacy System

- **Legacy**: a sum of money, or a specified article, given to another by will; anything handed down by an ancestor or predecessor (Oxford English Dictionary)
- **Legacy system**
  - A software system that you have **inherited**.
  - A software system that is still **valuable**.
  - A software system that **may not be easy to deal with**...

Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Dealing with Legacy Systems

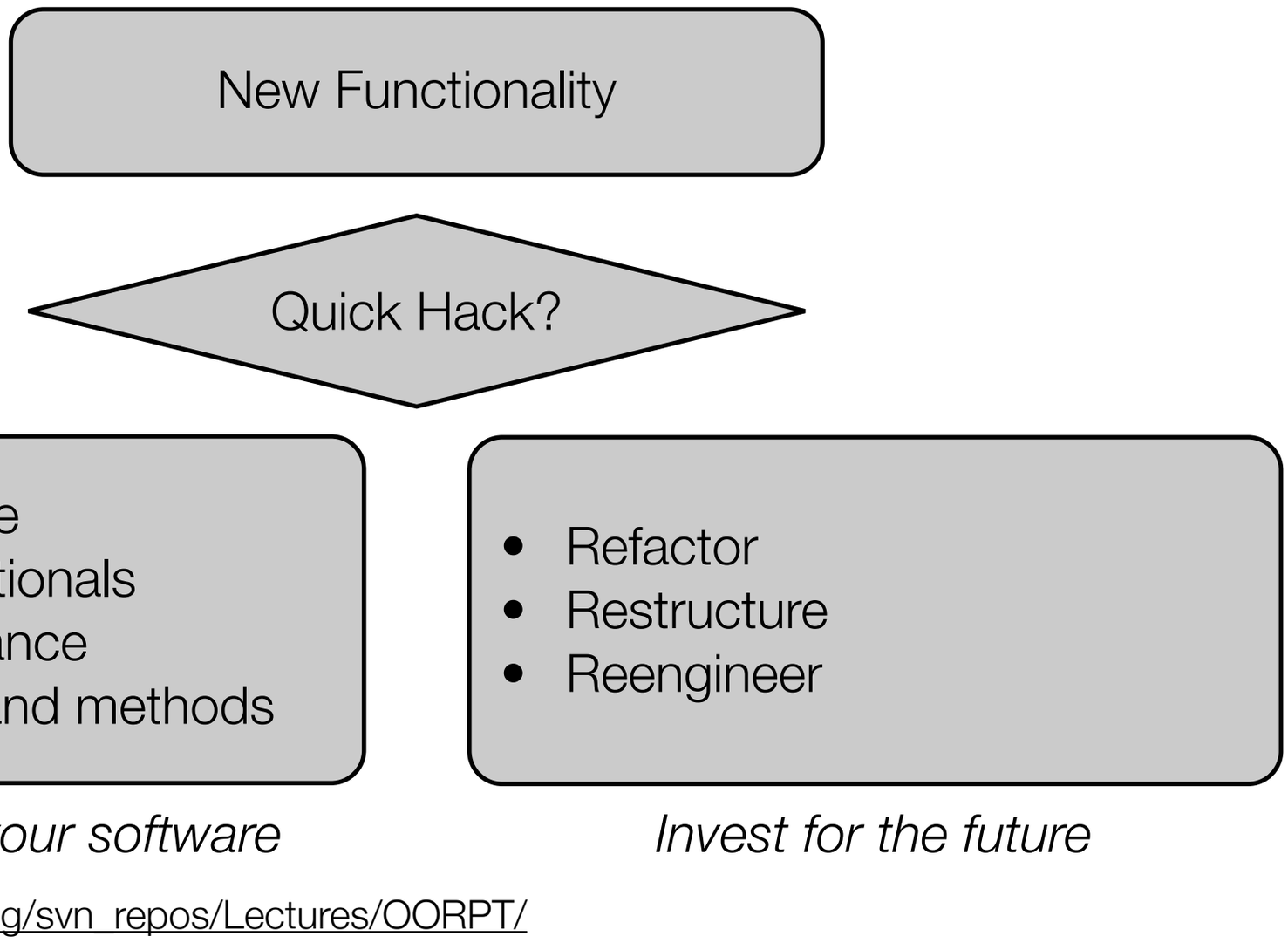
- **Typical problems**
  - Original developers have left or are not available.
  - Extensive patches and modifications have been made.
  - Documentation is not up-to-date or even missing.
  - Architecture may be not be optimal (improper layering, lack of modularity, etc.)

Evolution is more and more difficult...

Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Dealing with Legacy Systems

New or changing requirements will gradually degrade original design…
…unless extra development effort is spent to adapt the structure.



Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

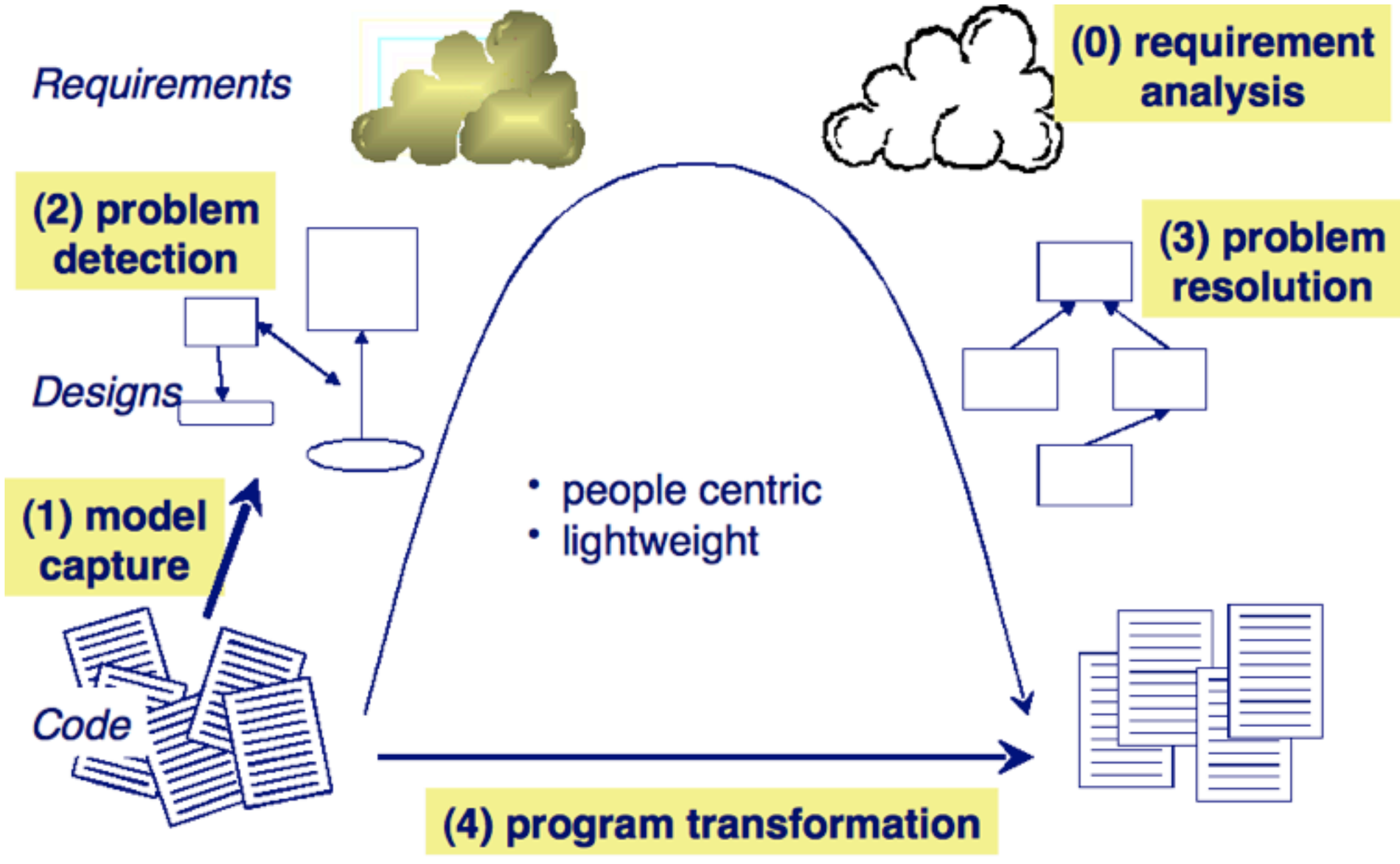
Terminology

- **Forward Engineering**
  - traditional process of moving from high-level abstractions and logical, implementation-independent designs to the physical implementation of a system
- **Reverse Engineering**
  - process of analyzing a subject system to identify the system's components and their interrelationships and create representations of the system in another form or at a higher level of abstraction.
- **Reengineering**
  - examination and alteration of a subject system to reconstitute it in a new form and the subsequent implementation of the new form.

Chikofsky and Cross, 1993

Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

The Reengineering Life-Cycle



Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Goals of Reengineering

- **Unbundling**
  - split a monolithic system into parts that can be separately marketed
- **Performance**
  - “first do it, then do it right, then do it fast” — experience shows this is the right sequence!
- **Port to other Platform**
  - the architecture must distinguish the platform dependent modules
- **Design extraction**
  - to improve maintainability, portability, etc.

Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Goals of Reverse Engineering

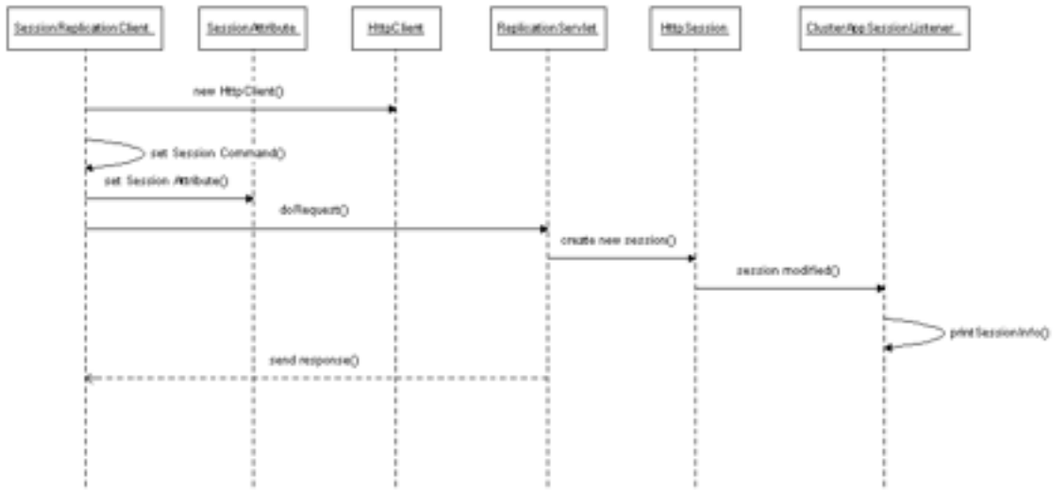
- **Cope with complexity**
  - need techniques to understand large, complex systems
- **Recover lost information**
  - extract what changes have been made and why
- **Detect side effects**
  - help understand ramifications of changes
- **Synthesize higher abstractions**
  - identify latent abstractions in software
- **Facilitate reuse**
  - detect candidate reusable artifacts and components

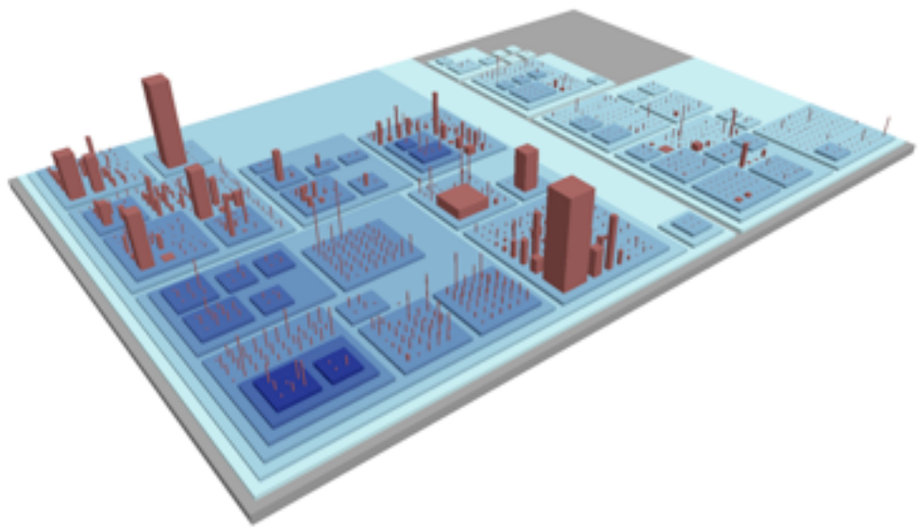
Chikofsky and Cross, 1993

Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Reverse Engineering Techniques

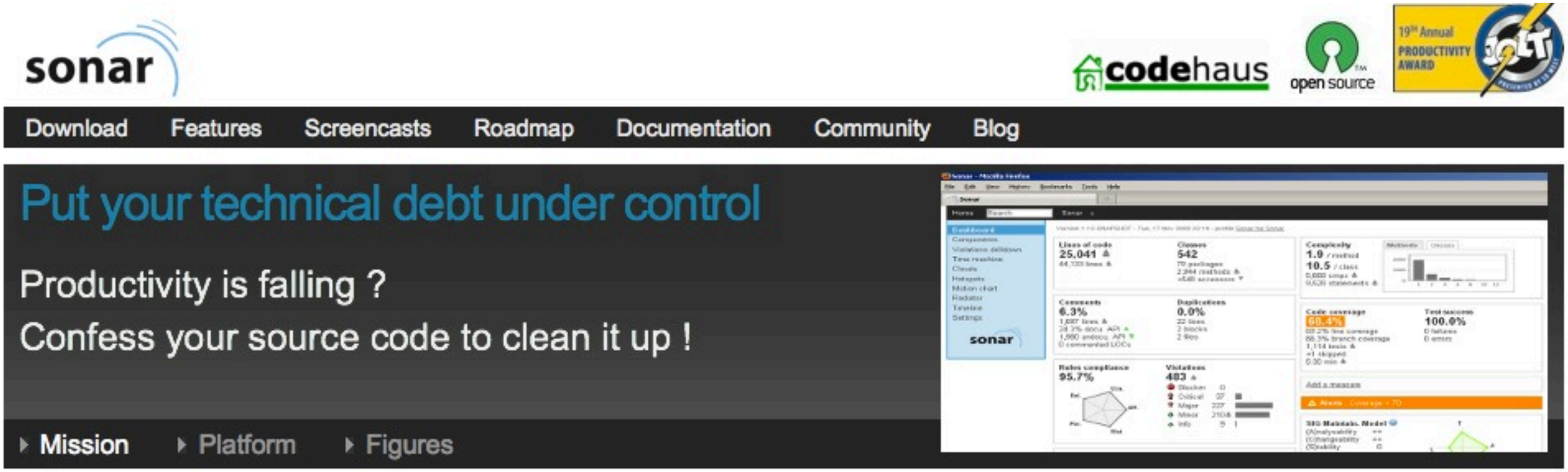
- **Redocumentation**
  - pretty printers
  - diagram generators
  - cross-reference listing generators
- **Design recovery**
  - software metrics
  - browsers, visualization tools
  - static analyzers
  - dynamic (trace) analyzers

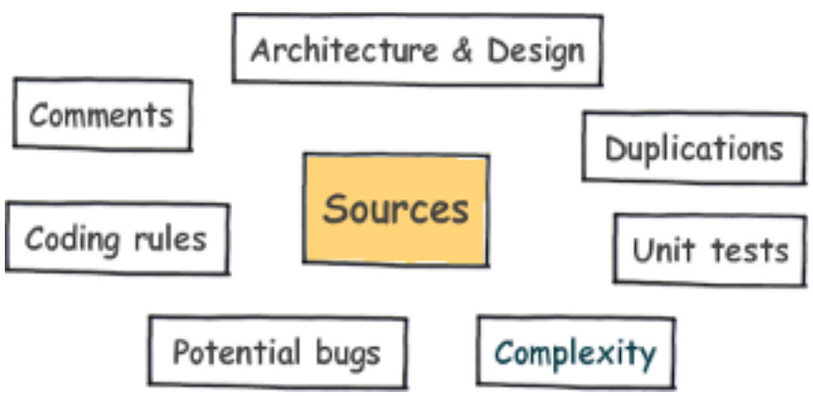




Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Tool: Sonar





http://sonar.codehaus.org/

Sonar: technical debt

- Concept invented by Ward Cunningham, also described by Martin Fowler
  - http://www.youtube.com/watch?v=pqeJFYwnkjE
  - http://martinfowler.com/bliki/TechnicalDebt.html

You have a piece of functionality that you need to add to your system.

***You see two ways to do it**, one is **quick** to do but is **messy** - you are sure that it will make further changes harder in the **future**. The other results in a **cleaner** design, but will take **longer** to put in place.*

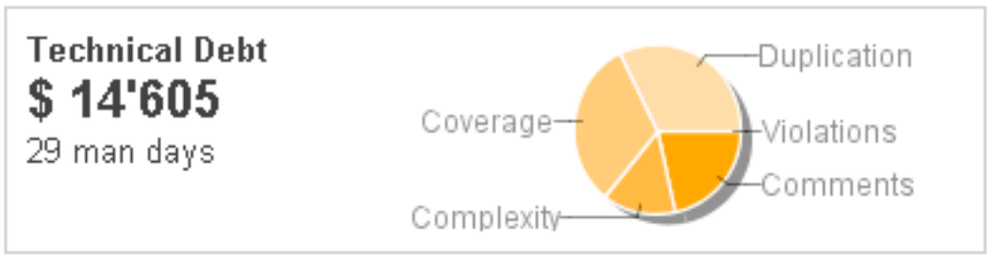
*Technical Debt is a wonderful **metaphor** to help us think about this problem. Doing things the quick and dirty way sets us up with a technical debt, which is **similar to a financial debt**.*

*Like a financial debt, the technical debt incurs **interest payments**, which come in the form of the extra effort that we have to do in future development because of the quick and dirty design choice. We can choose to continue paying the interest, or we can **pay down** the principal by **refactoring** the quick and dirty design into the better design. **Although it costs to pay down the principal, we gain by reduced interest payments in the future.***

Sonar: technical debt

- Concept invented by Ward Cunningham, also described by Martin Fowler
  - http://www.youtube.com/watch?v=pqeJFYwnkjE
  - http://martinfowler.com/bliki/TechnicalDebt.html

Debt(in man days) = cost_to_fix_duplications + cost_to_fix_violations + cost_to_comment_public_API + cost_to_fix_uncovered_complexity + cost_to_bring_complexity_below_threshold



The metaphor also explains why it may be sensible to do the quick and dirty approach.

*Just as a business incurs some debt to take advantage of a **market opportunity** developers may incur technical debt to hit an important deadline. The all too common problem is that development organizations let their debt get **out of control** and spend most of their future development effort paying crippling interest payments.*

Duplications = cost_to_fix_one_block * duplicated_blocks

Violations = cost_to fix_one_violation * mandatory_violations

Comments = cost_to_comment_one_API * public_undocumented_api

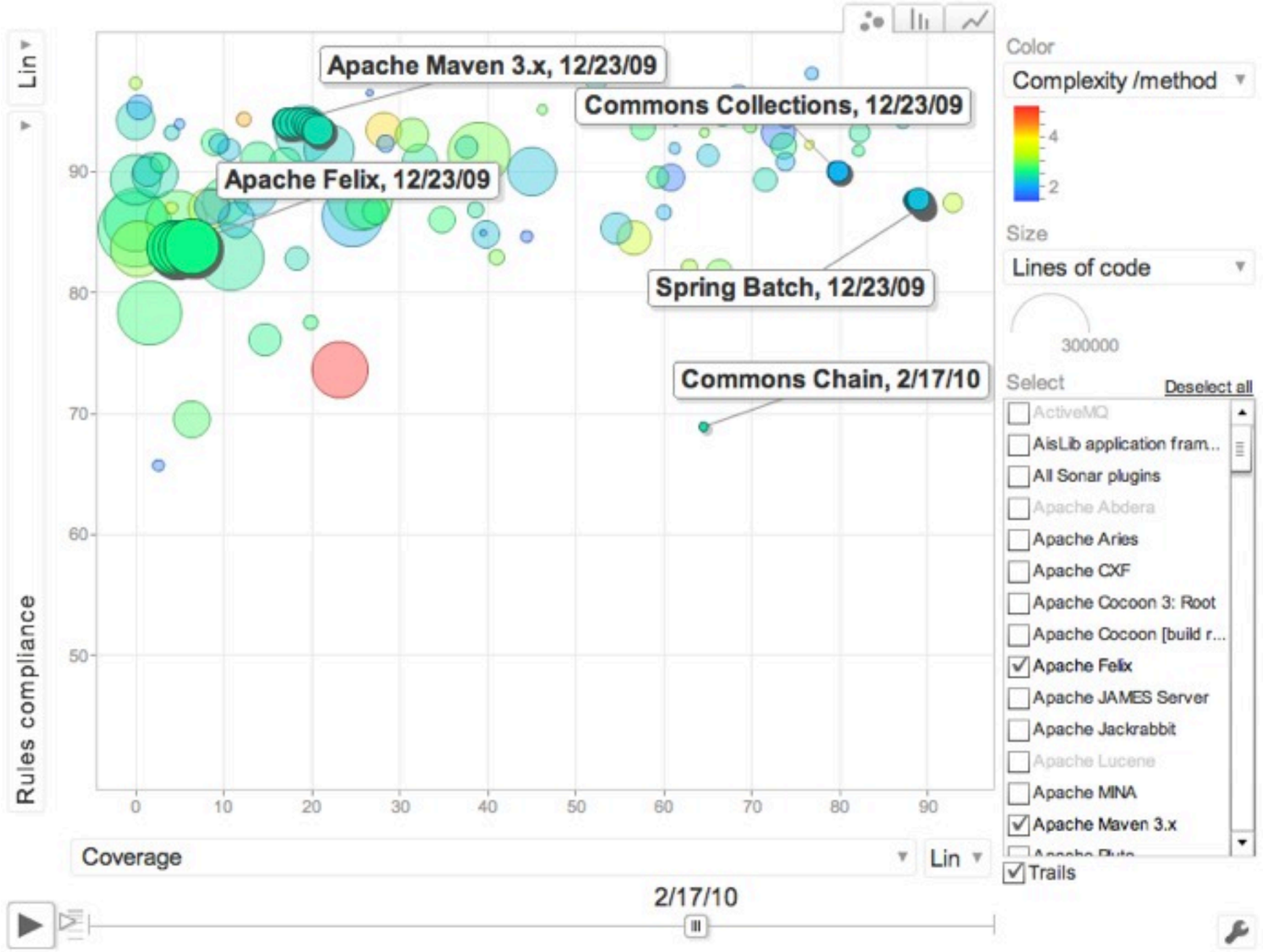
Coverage = cost_to_cover_one_of_complexity * uncovered_complexity_by_tests (80% of coverage is the objective)

Complexity = cost_to_split_a_method * (function_complexity_distribution >= 8) + cost_to_split_a_class * (class_complexity_distribution >= 60)

Sonar on open source projects

http://nemo.sonarsource.org/

Sonar on open source projects



http://nemo.sonarsource.org/

Sonar on open source projects

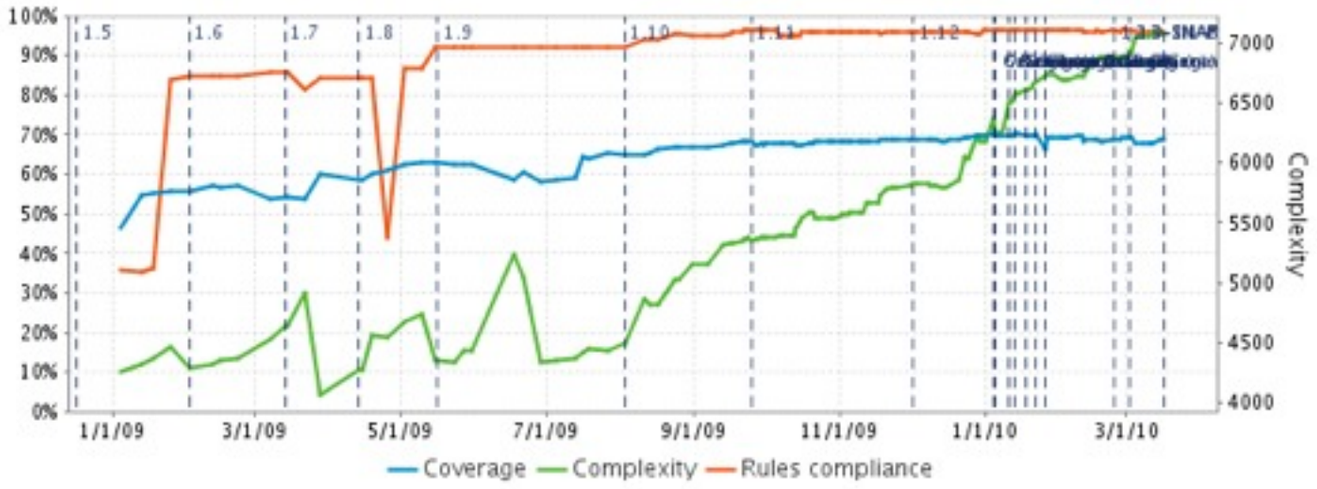
Name	Lines of code	Technical Debt ratio	Coverage	Duplicated lines (%)	Build time
AisLib application framework	12,187	9.6%	38.6%	1.1%	2010-03-13
Tapestry 5 Project	57,213	6.7%	51.8%	0.2%	2010-03-15
Commons Collections	20,901	10.1%	79.8%	3.3%	2010-03-14
MicroEmulator	28,344	11.7%		2.3%	2010-03-14
Apache Jackrabbit	206,604	16.6%	26.4%	4.6%	2010-03-14
Unitils	18,585	14.9%	2.8%	3.8%	2010-03-15
javagit	6,127	11.1%	61.2%	0.3%	2010-03-14
Wicket Parent	104,703	9.3%	44.7%	1.1%	2010-03-15
Commons Chain	3,901	14.4%	64.5%	21.9%	2010-03-14
Commons IO	6,779	5.2%	82.0%	2.3%	2010-03-14
Commons SCXML	7,331	9.8%	69.8%	7.2%	2010-03-14
Sonar	31,558	6.2%	68.6%	0.0%	2010-03-17

http://nemo.sonarsource.org/

Sonar on Sonar

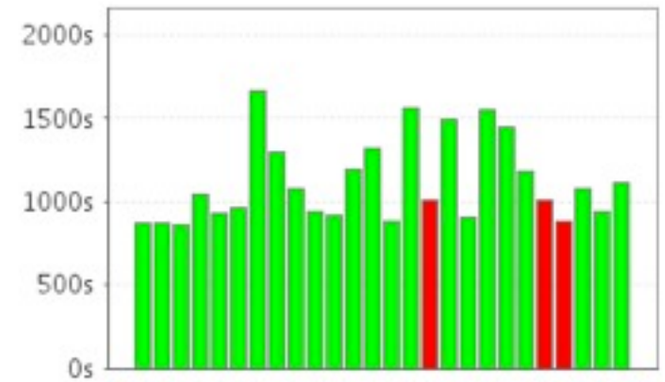
Lines of code
31,558 ▲
54,889 lines ▲
622 files ▲

Classes
667 ▲
89 packages
3,674 methods ▲
+686 accessors ▲



Build success
88.5% ▲
26 builds
3 failed

Average duration of successful builds
18:52 min ▲
Longest 27:45 min ▲
Shortest 14:12 min ▲



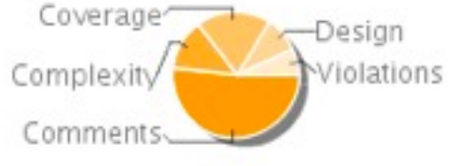
Rules compliance
96.0%

Violations
573 ▲

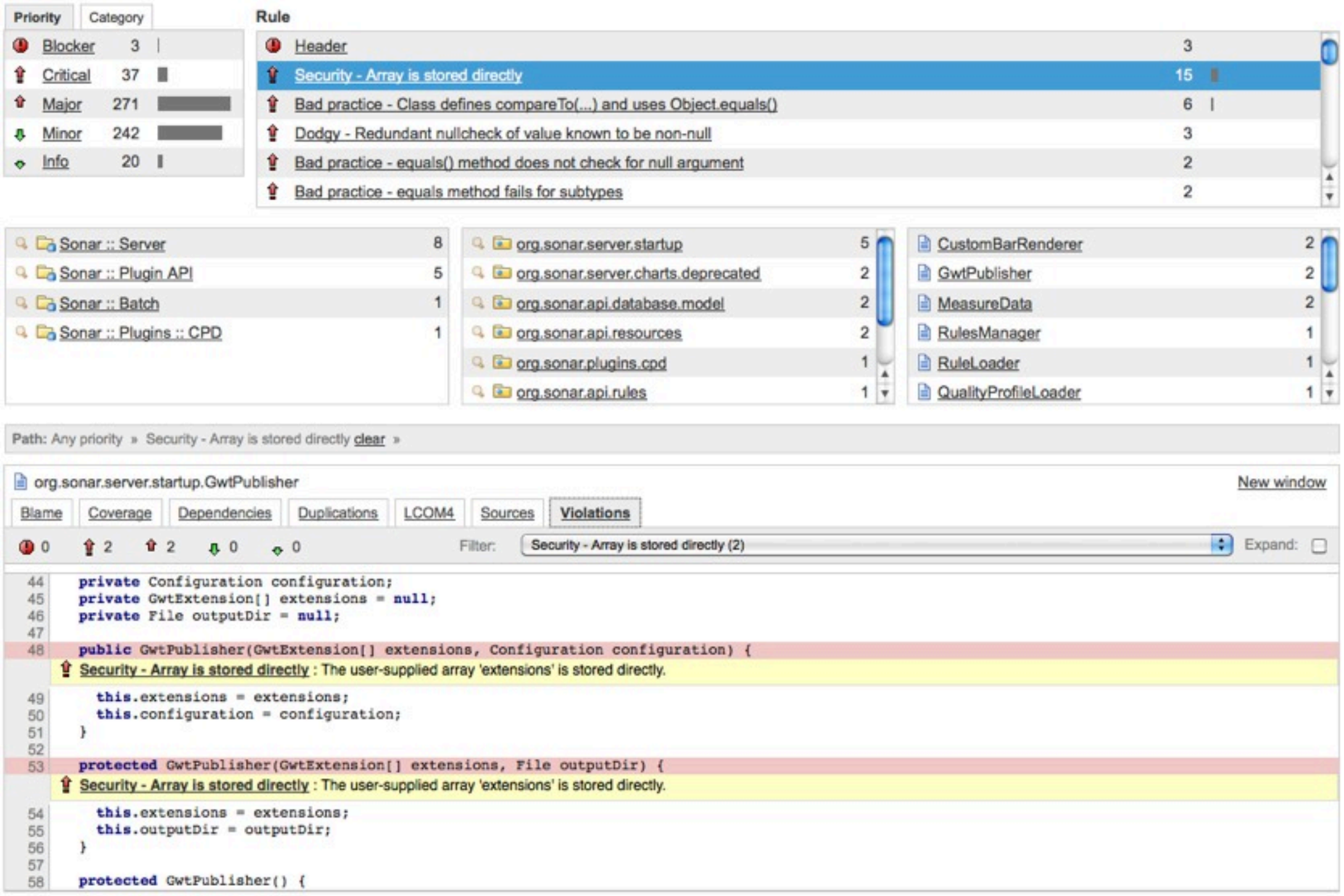
Blocker	3	
Critical	37	
Major	271 ▲	
Minor	242 ▲	
Info	20 ▲	

⚠ **Alerts** : Coverage < 70.

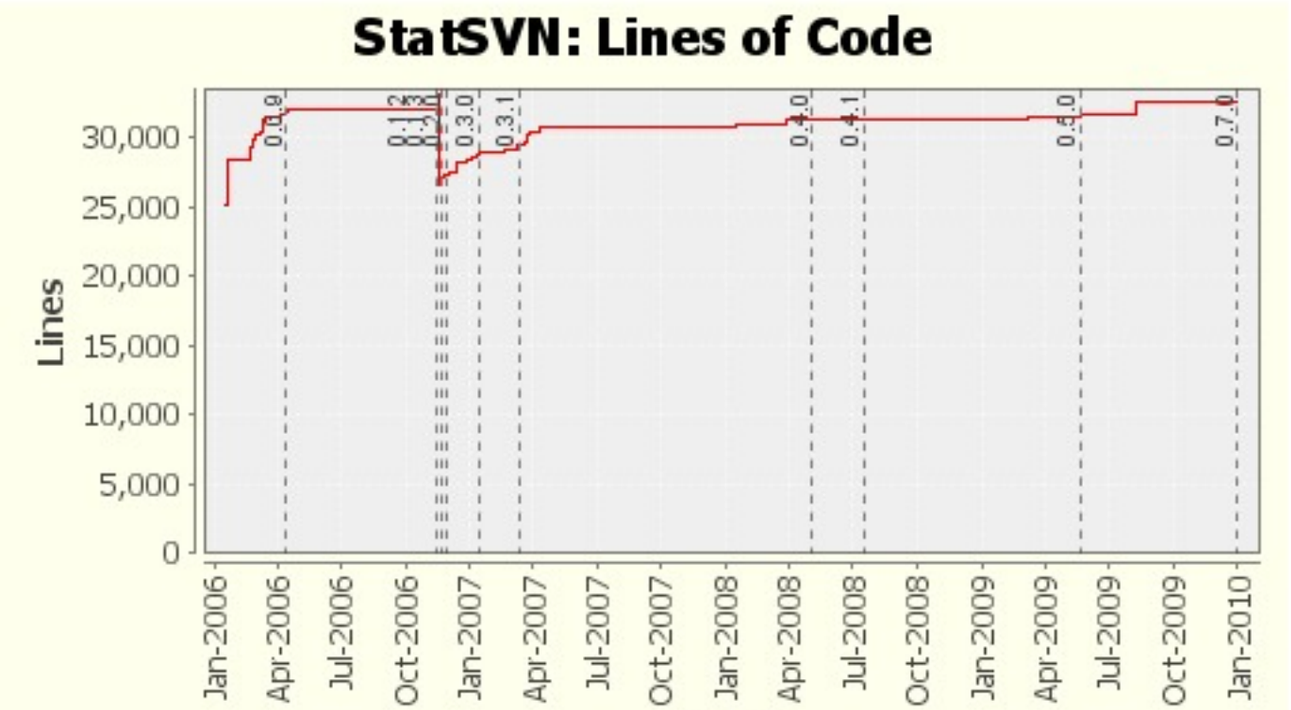
Technical Debt
6.2%
$ 53,525 ▲
107 man days ▲



Sonar on Sonar



Tool: StatSVN



Type	Files	LOC	LOC per file
*.info	1 (0.6%)	18122 (56.6%)	18122.0
*.java	60 (33.5%)	10090 (31.5%)	168.1
*.xml	16 (8.9%)	1686 (5.3%)	105.3
*.properties	15 (8.4%)	526 (1.6%)	35.0
*.bat	44 (24.6%)	474 (1.5%)	10.7
*.prefs	3 (1.7%)	329 (1.0%)	109.6
*.txt	7 (3.9%)	206 (0.6%)	29.4
*.rss	1 (0.6%)	179 (0.6%)	179.0
*.css	1 (0.6%)	146 (0.5%)	146.0
*.html	2 (1.1%)	93 (0.3%)	46.5
Others	5 (2.8%)	164 (0.5%)	32.8
Non-Code Files	24 (13.4%)	0 (0.0%)	0.0
Totals	179 (100.0%)	32015 (100.0%)	178.8

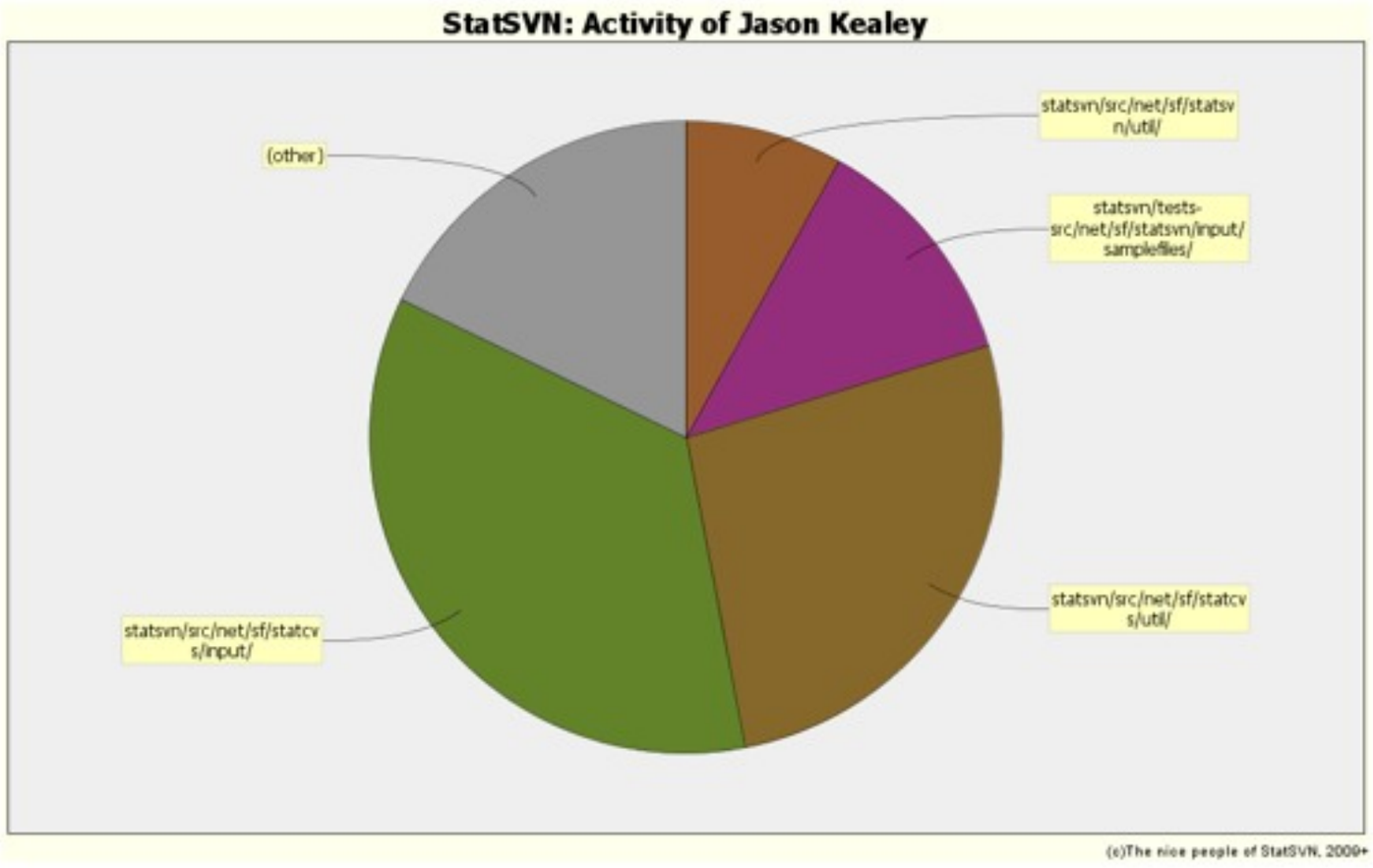
The nice people of StatSVN, 2009+

Files With Most Revisions

File	Revisions
statsvn/site/changes.xml	54
statsvn/src/net/sf/statsvn/Main.java	41
statsvn/project.xml	38
statsvn/src/net/sf/statcvs/input/SvnLogfileParser.java	34
statsvn/site/index.xml	31
statsvn/project.properties	31
statsvn/src/net/sf/statsvn/util/SvnDiffUtils.java	27
statsvn/src/net/sf/statsvn/input/SvnLogfileParser.java	26
statsvn/src/net/sf/statcvs/input/SvnXmlLogFileHandler.java	24
statsvn/.classpath	22
statsvn/build.xml	21
statsvn/src/net/sf/statcvs/Main.java	20
statsvn/src/net/sf/statcvs/input/Builder.java	19
statsvn/src/net/sf/statsvn/input/Builder.java	19
statsvn/src/net/sf/statcvs/util/SvnDiffUtils.java	19
statsvn/src/net/sf/statcvs/input/FileBuilder.java	18
statsvn/src/net/sf/statcvs/util/SvnInfoUtils.java	17
statsvn/src/net/sf/statsvn/input/FileBuilder.java	17
statsvn.bat	17
statsvn/src/net/sf/statcvs/output/ConfigurationOptions.java	16

http://www.statsvn.org/

Tool: StatSVN



Number of Developers: 4

Author	Author Id	Changes	Lines of Code	Lines per Change
Jason Kealey	jkealey	379 (16.1%)	14310 (40.1%)	37.7
Benoit Xhenseval	benoitx	1620 (68.7%)	14014 (39.3%)	8.6
Jean-Philippe Daigle	jpdaigle	213 (9.0%)	3758 (10.5%)	17.6
Gunter Mussbacher	gunterm	147 (6.2%)	3576 (10.0%)	24.3
	Totals	2359 (100.0%)	35658 (100.0%)	15.1

http://www.statsvn.org/

Developer of the Month

Month	Author	Lines	Tweet This
January 2010	Benoit Xhenseval	18	TWEET THIS
December 2009	Jason Kealey	16	TWEET THIS
August 2009	Jason Kealey	3386	TWEET THIS
June 2009	Benoit Xhenseval	20	TWEET THIS
May 2009	Benoit Xhenseval	293	TWEET THIS
April 2009	Benoit Xhenseval	17	TWEET THIS
March 2009	Benoit Xhenseval	599	TWEET THIS
July 2008	Benoit Xhenseval	2	TWEET THIS
June 2008	Benoit Xhenseval	742	TWEET THIS
May 2008	Benoit Xhenseval	12	TWEET THIS
April 2008	Benoit Xhenseval	153	TWEET THIS
March 2008	Benoit Xhenseval	1657	TWEET THIS
January 2008	Jason Kealey	175	TWEET THIS
July 2007	Benoit Xhenseval	16	TWEET THIS
June 2007	Jean-Philippe Daigle	43	TWEET THIS
May 2007	Jason Kealey	1	TWEET THIS
April 2007	Benoit Xhenseval	557	TWEET THIS
March 2007	Benoit Xhenseval	1387	TWEET THIS
February 2007	Benoit Xhenseval	141	TWEET THIS
January 2007	Benoit Xhenseval	1205	TWEET THIS
December 2006	Benoit Xhenseval	1730	TWEET THIS
November 2006	Benoit Xhenseval	5310	TWEET THIS
August 2006	Jason Kealey	27	TWEET THIS
April 2006	Jason Kealey	1354	TWEET THIS
March 2006	Jason Kealey	4862	TWEET THIS
February 2006	Jason Kealey	3309	TWEET THIS
January 2006	Jean-Philippe Daigle	3292	TWEET THIS

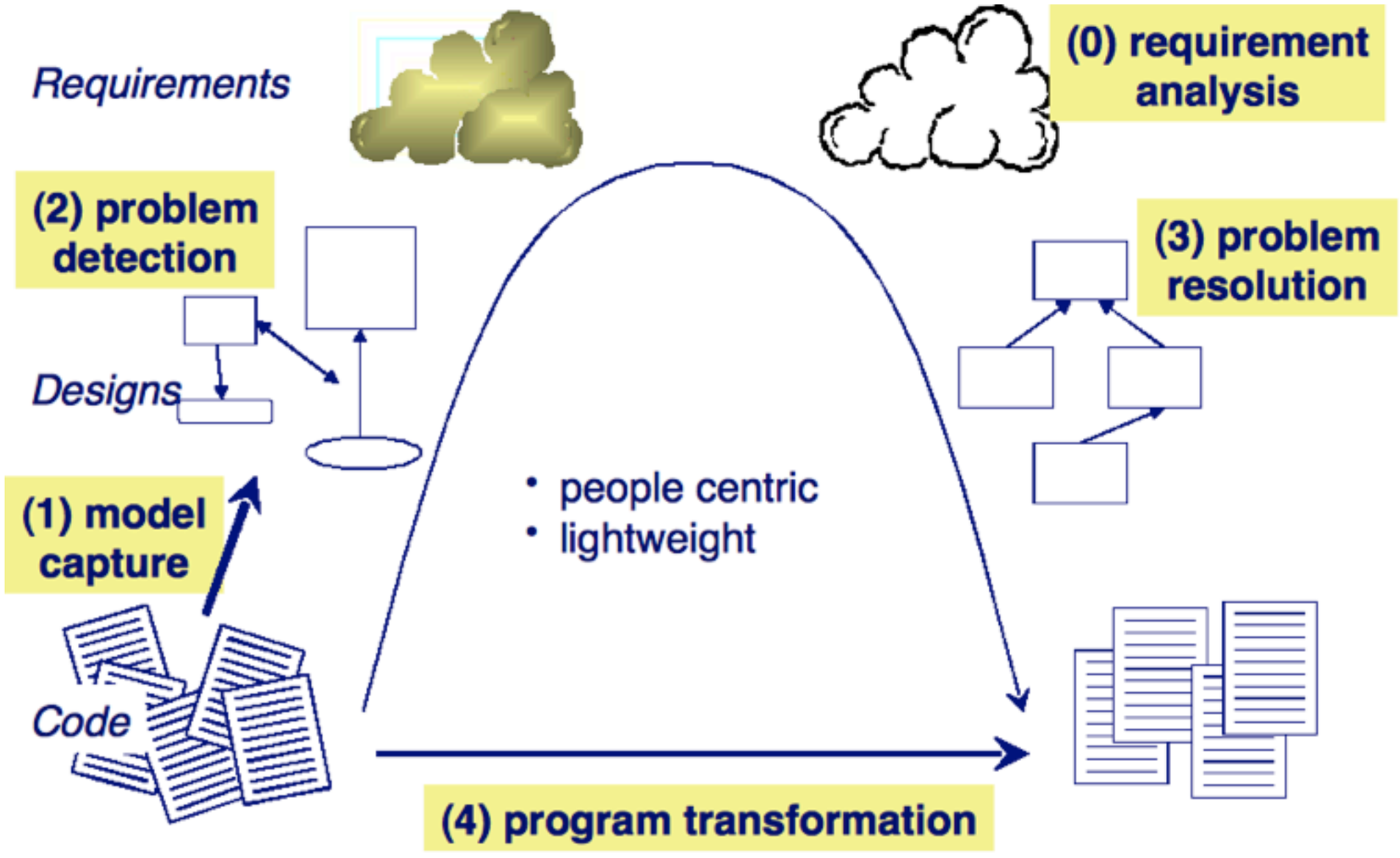
References

- **Mining Software Repositories community**
  - http://msr.uwaterloo.ca/msr2010/
- **Tools**
  - **Sonar**: http://sonar.codehaus.org
  - **StatSVN**: http://www.statsvn.org
  - **Bugzilla**: http://www.bugzilla.org
- **Visualization**
  - http://code.google.com/apis/charttools
  - http://prefuse.org, http://flare.prefuse.org
  - http://processing.org

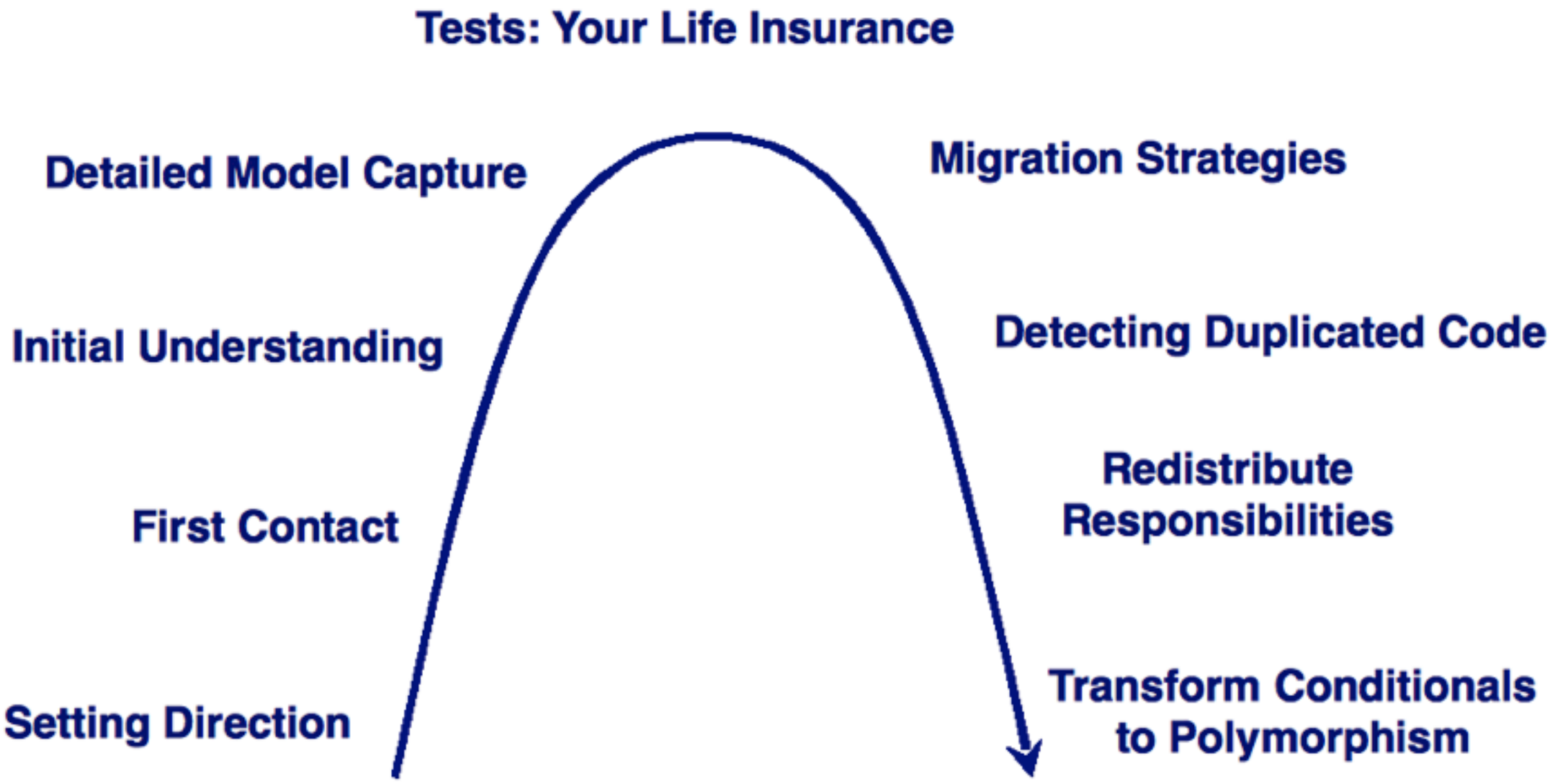
Object-Oriented Reengineering Patterns

http://scg.unibe.ch/download/oorp/

The Reengineering Life-Cycle

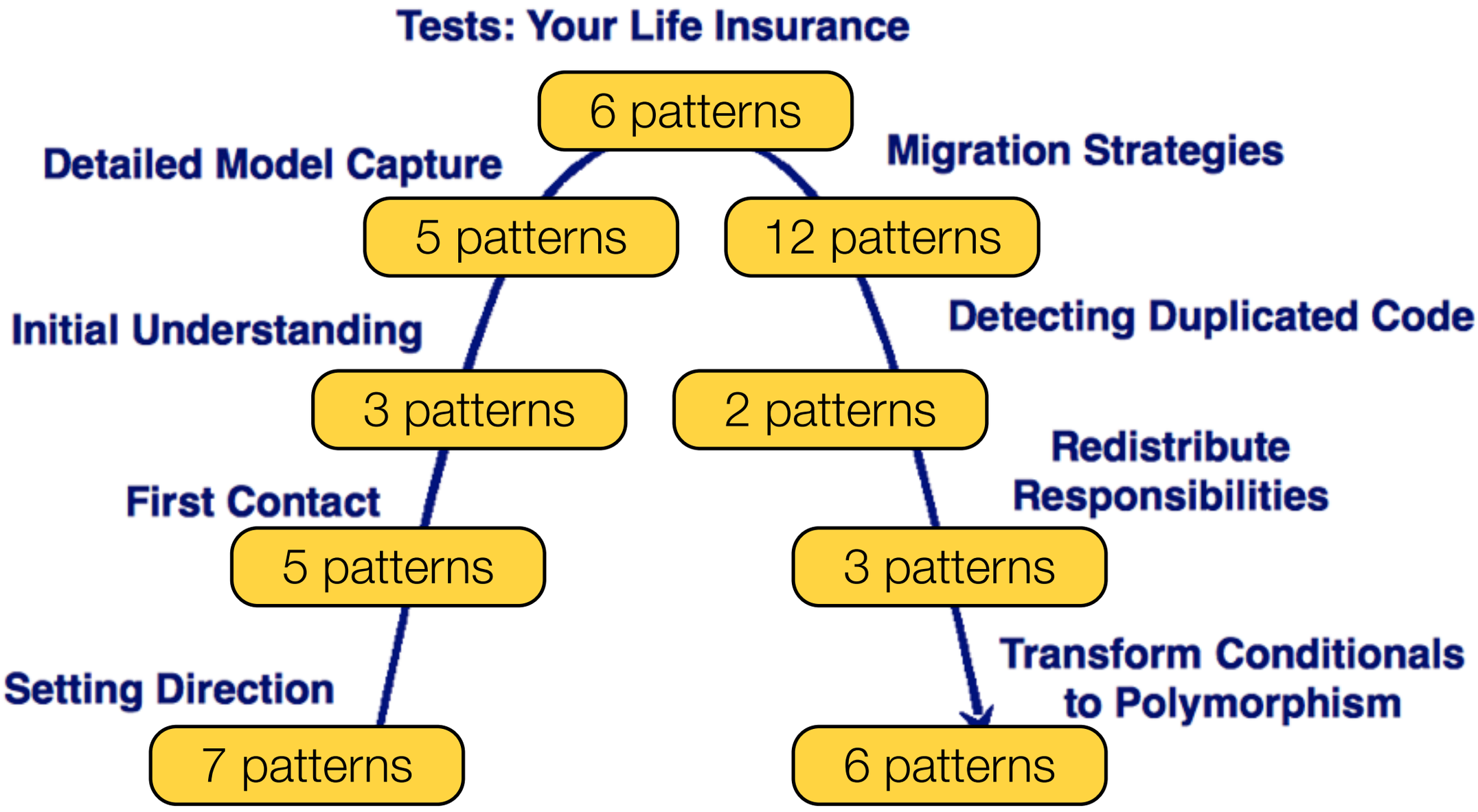


A Map of Reengineering Patterns



Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

A Map of Reengineering Patterns



Based on https://www.iam.unibe.ch/scg/svn_repos/Lectures/OORPT/

Reverse Engineering Patterns

Reverse engineering patterns encode expertise and trade-offs in ***extracting design*** *from* ***source code***, ***running systems*** *and* ***people***.

Mission Impossible

- **“Allo, PK Consulting”?**
  - “Yes”
- **“We have got a small problem with our fancy social networking site...”**
  - “Yes?”
- **“As soon as there are 20 concurrent users, it implodes...”**
  - “Yes...”
- **“Can you help us?”**
  - “Yes.”

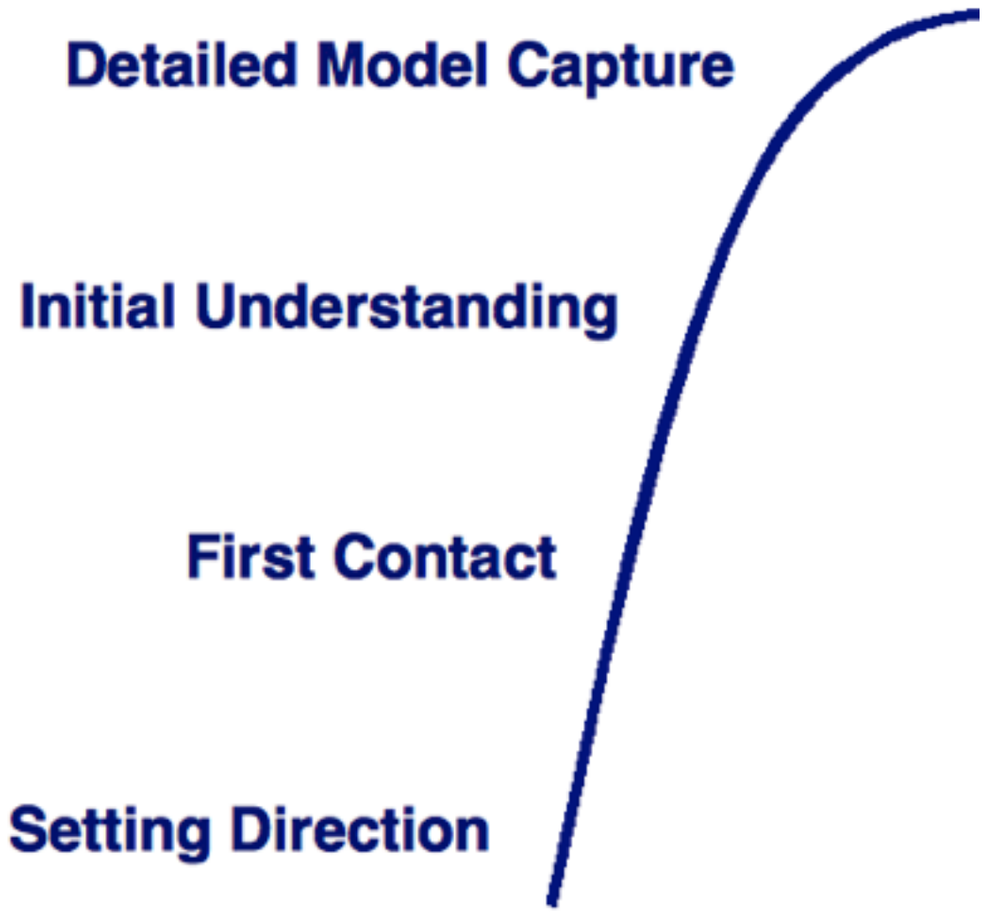
Mission Impossible

- **“Jim”**
  - “Yes?”
- **“You just finished your last client engagement, right...?”**
  - “Yes”
- **“You know Facebook and Twitter, right..?”**
  - “Yes...”
- **“Good. Your mission is to go fix a big social networking site. This message will self destruct in 10 seconds...”**
  - “Youpi.”

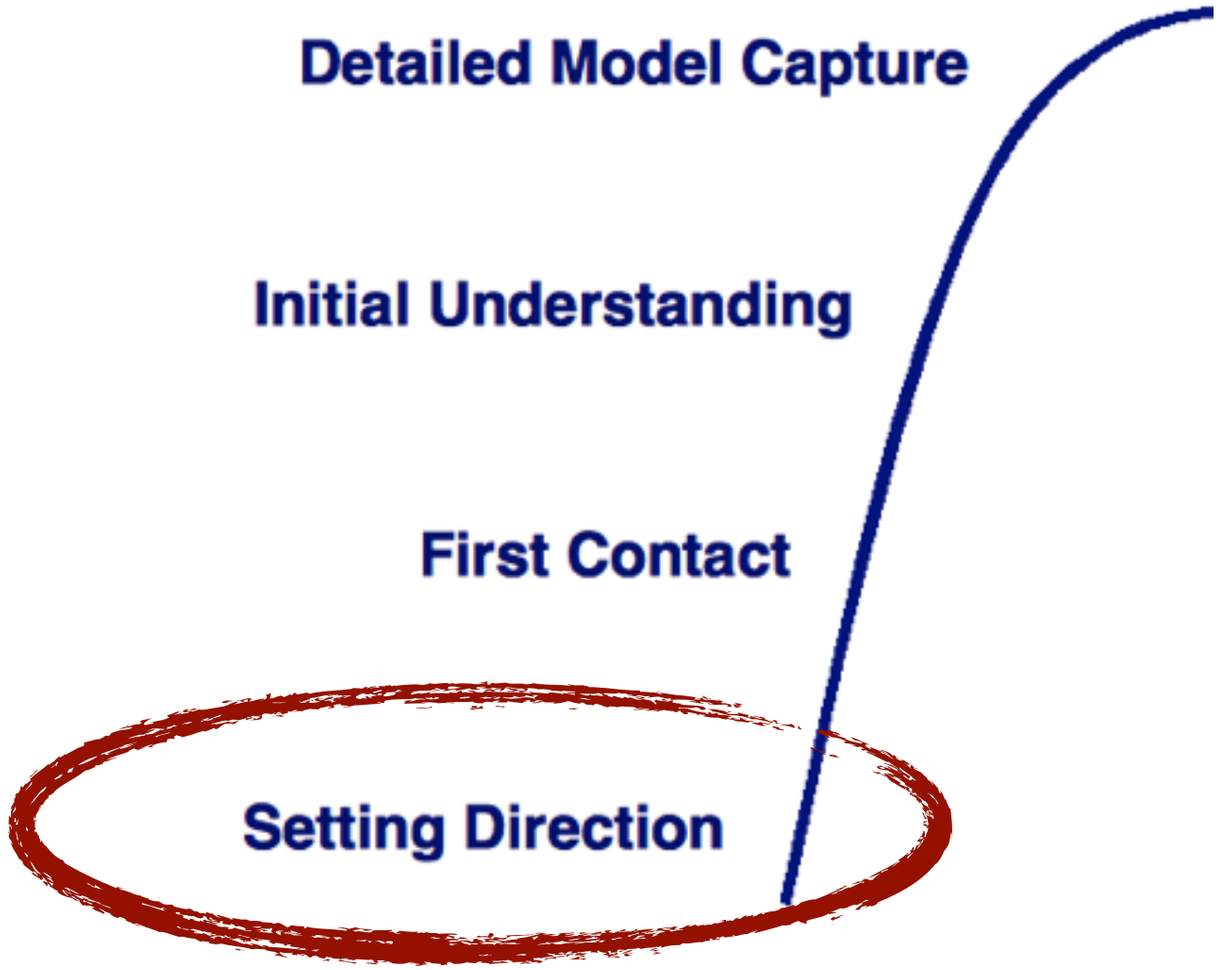
Reverse Engineering Patterns

- When you start a reengineering project, you will be pulled in **many different directions**, by management, by the users, by your own team.

- How do you **set the direction** of the reengineering effort, and how do you **maintain direction** once you have started?



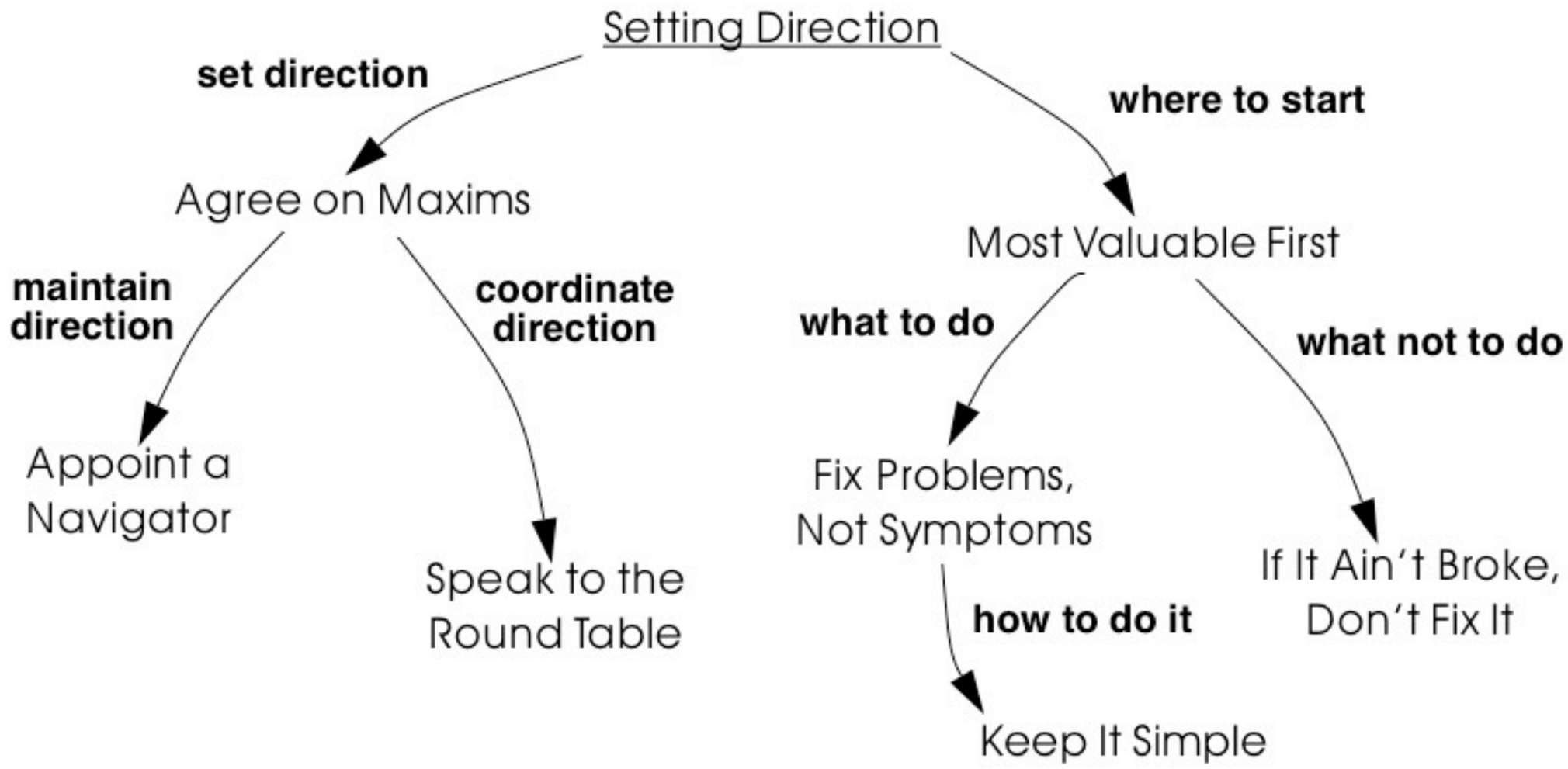
Setting Direction



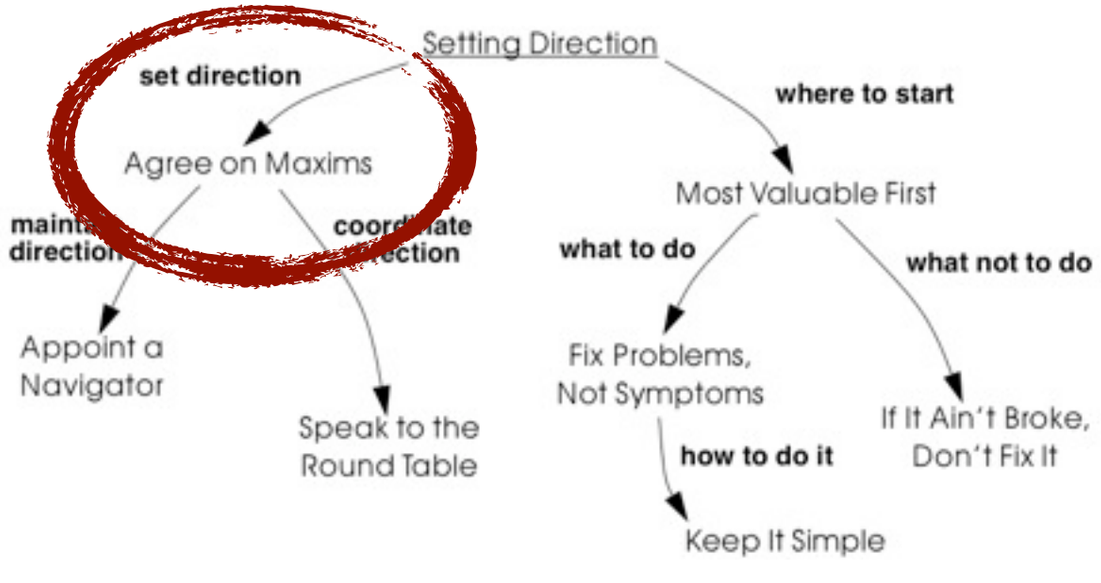
Setting Directions: Forces

- A typical reengineering project will be burdened with a lot of interests that pull in **different directions**.
- Technical, ergonomic, economic and political considerations will make it difficult for you and your team to **establish and maintain focus**.
- Communication in a reengineering project can be complicated by either the presence or absence of the **original development team**.
- The legacy system will pull you towards a certain **architecture** that may not be the best for the future of the system.
- You will detect many problems with the legacy software, and it will be **hard to set priorities**.
- It is easy to **get seduced** by focussing on the technical problems that interest you the most, rather than what is best for the project.
- It can be difficult to decide **whether to wrap, refactor or rewrite** a problematic component of a legacy system. Each of these options will address different risks, and will have different consequences for the effort required, the speed with which results can be evaluated, and the kinds of changes that can be accommodated in the future.
- When you are reengineering the system, you **may be tempted to over-engineer** the new solution to deal with every possible eventuality.

Setting Directions: Patterns



Agree on Maxims

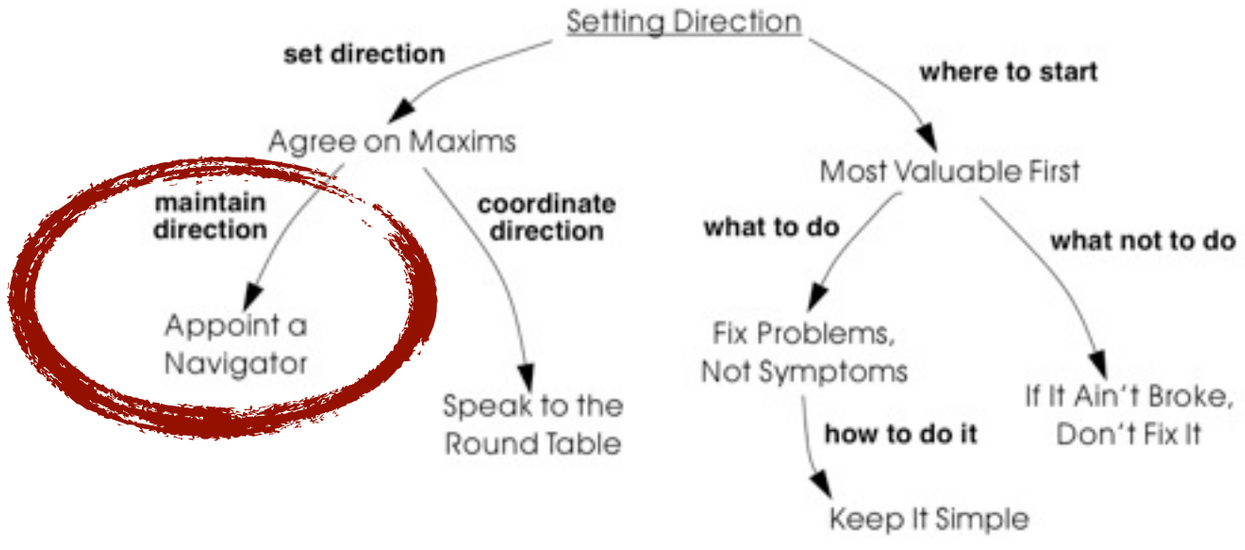


Setting Direction: Agree on Maxims

- **Problem**
  - How do you establish a common sense of purpose in a team?
- **Solution**
  - Establish the key priorities for the project and identify **guiding principles** that will help the team to **stay on track**.
- **Examples**
  - “The central subsystem can be taken down without impact on end-users”
  - “Every external system must be simulated with a mock system”

You should **Agree on Maxims** in order to establish a common understanding within the reengineering team of what is at stake and how to achieve it.

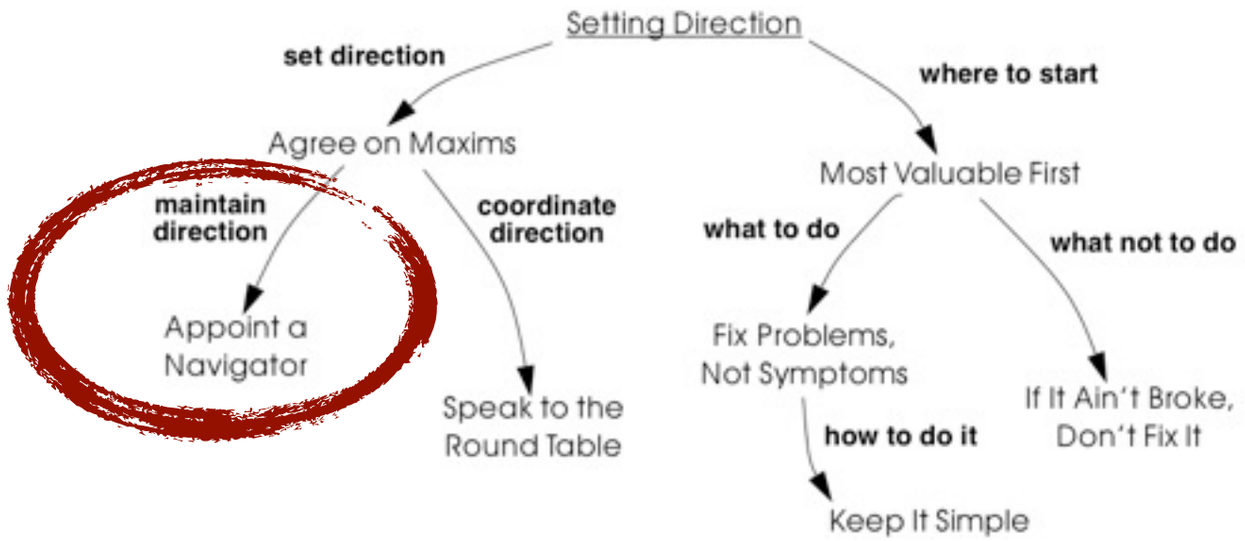
Appoint a Navigator



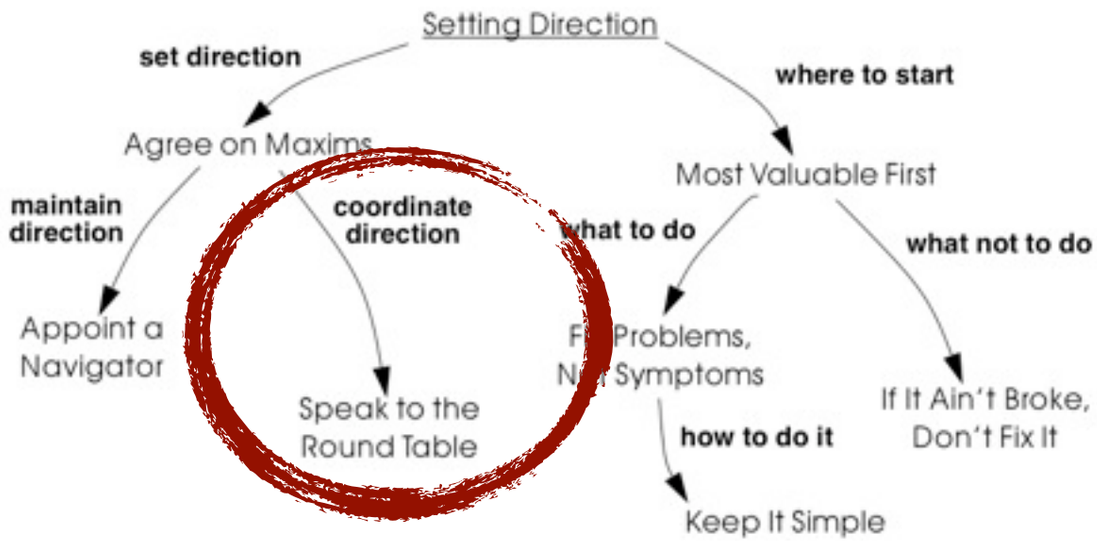
Setting Direction: Appoint a Navigator

- **Problem**
  - How do you maintain **architectural vision** during the course of a complex project?
- **Solution**
  - Appoint a **specific person** whose responsibility in role of navigator is to **ensure** that the architectural vision is maintained.

You should **Appoint a Navigator** to maintain the architectural vision



Speak to the Round Table

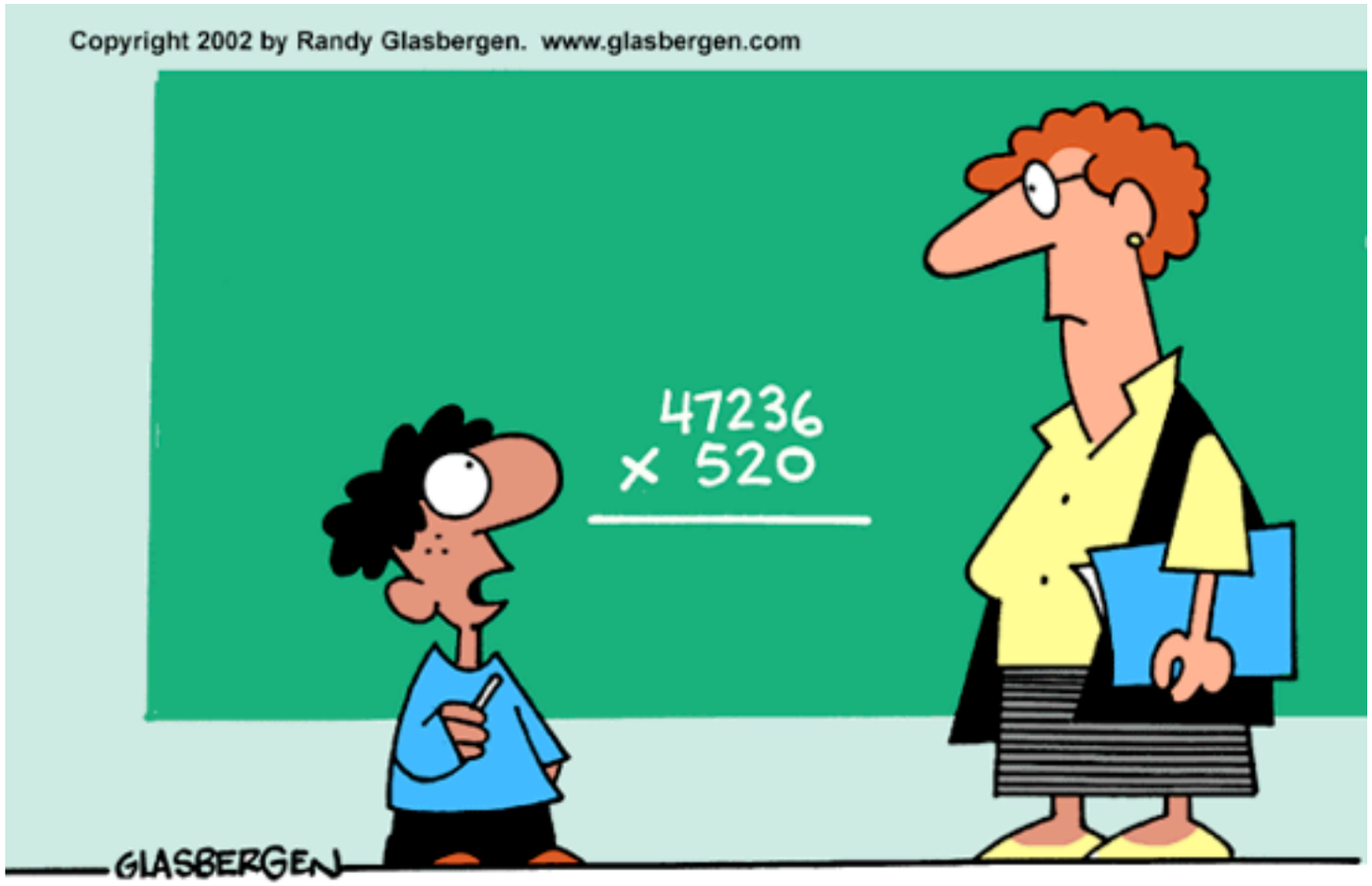


Setting Direction: Speak to the Round Table

- **Problem**
  - How do you keep your team **synchronized**?
- **Solution**
  - Hold **brief**, **regular round table meetings**.

Everyone should **Speak to the Round Table** to maintain team awareness of the state of the project.

Most Valuable First



"AREN'T THERE ENOUGH PROBLEMS IN THE WORLD ALREADY?"

Setting Direction: Most Valuable First

- **Problem**
  - Which problems should you focus on **first**?
- **Solution**
  - Start working on the aspects which are **most valuable** to your **customer**.
- **Who is the your customer?**
  - Many stakeholders, but who makes decisions?
- **What is the most valuable?**
  - try to understand the customer's **business model**
  - try to determine what **measurable** goal the customer wants to obtain

To help you focus on the right problems and the critical decisions, it is wise to tackle the **Most Valuable First**.

Fix Problems, Not Symptoms

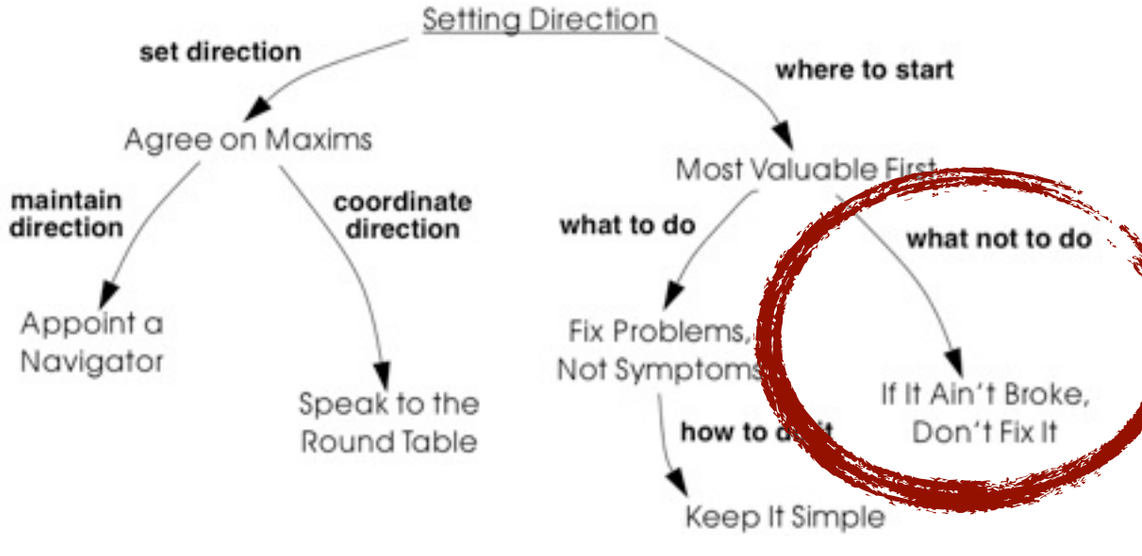
"My team has created a very innovative solution, but we're still looking for a problem to go with it."

Setting Direction: Fix Problems, Not Symptoms

- **Problem**
  - How can you possibly tackle all the reported problems?
- **Solution**
  - Address the **source of a problem**, rather than particular requests of your stakeholders.

In order to decide whether to wrap, refactor or rewrite, you should **Fix Problems, Not Symptoms**.

If It Ain’t Broke, Don’t Fix It

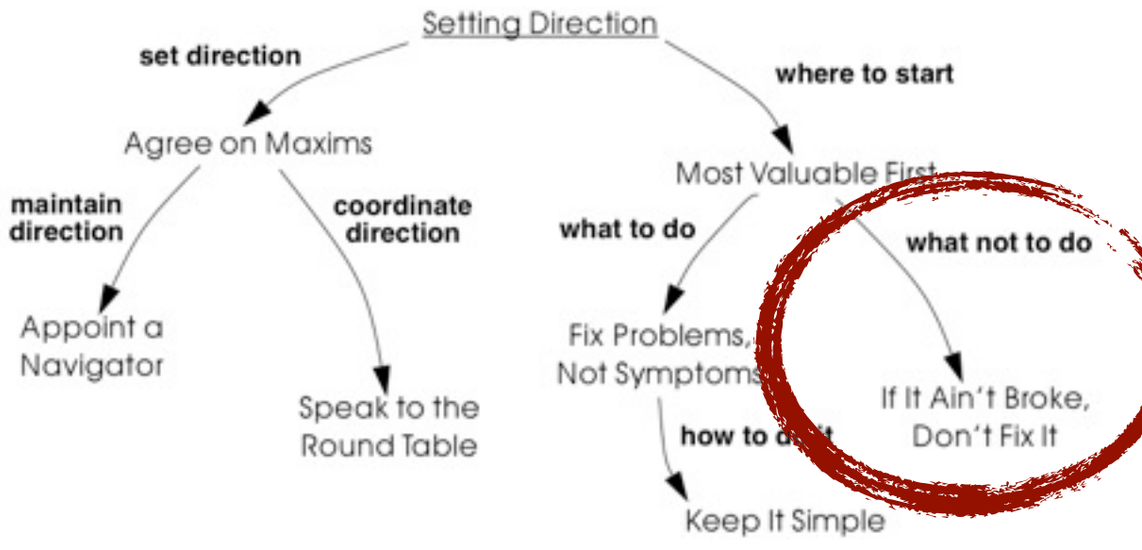


Setting Direction: If It Ain’t Broke, Don’t Fix It

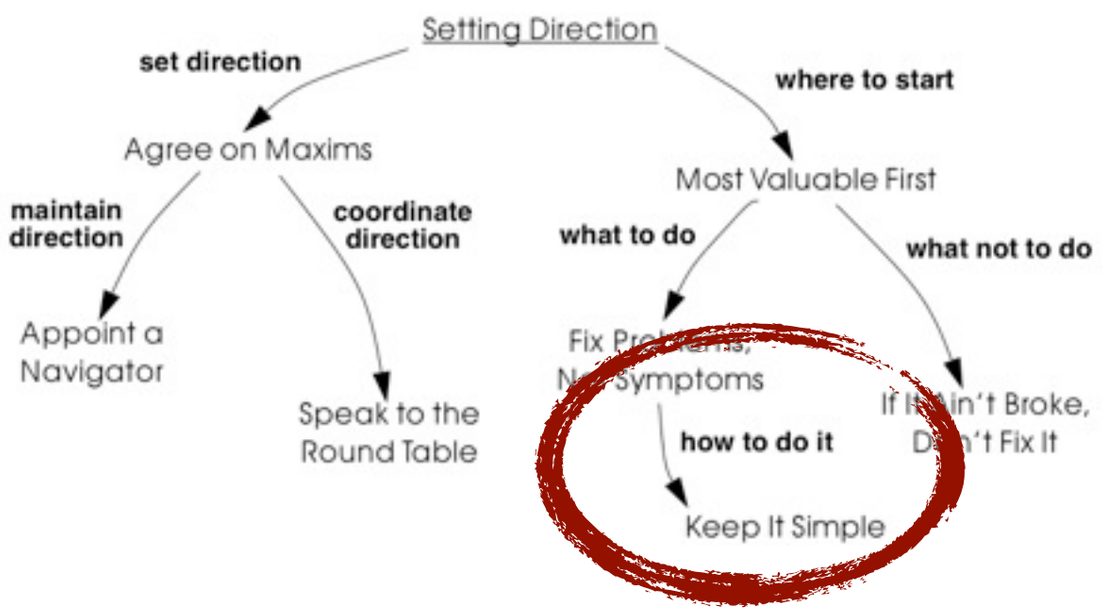
- **Problem**
  - Which parts of a legacy system should you reengineer and which should you leave as they are?
- **Solution**
  - Only fix the parts that are “broken” — those that can no longer be adapted to planned changes.
- **Which components are broken?**

Change for change’s sake is not productive, so **If It Ain’t Broke, Don’t Fix It**.

- components that need to be frequently adapted to meet new requirements, but are **difficult to modify** due to high complexity and design drift
- components that are valuable, but traditionally contain a **large number of defects**.



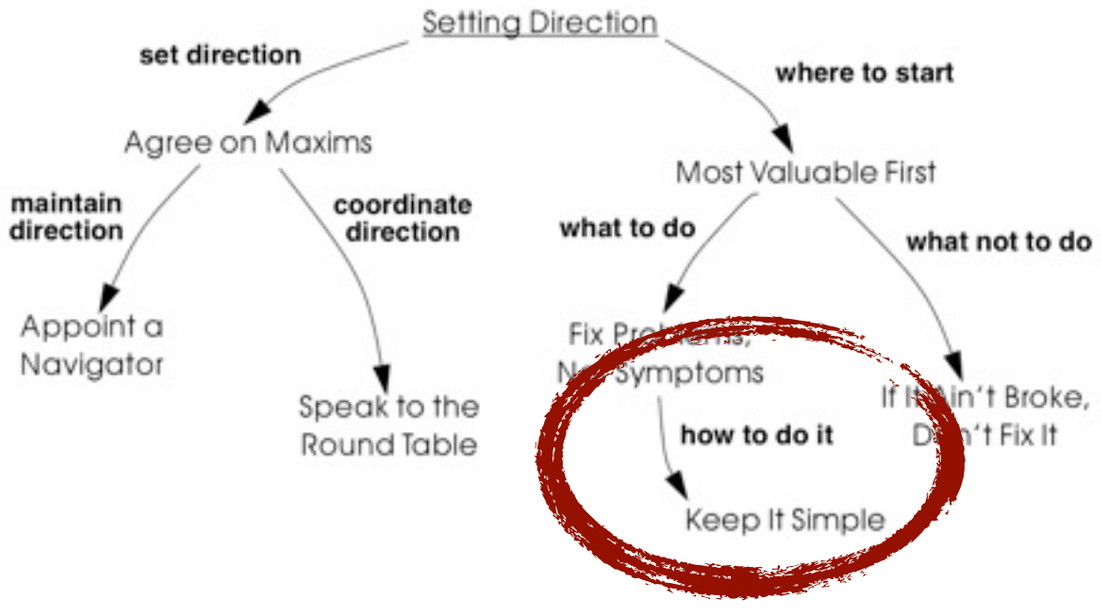
Keep It Simple



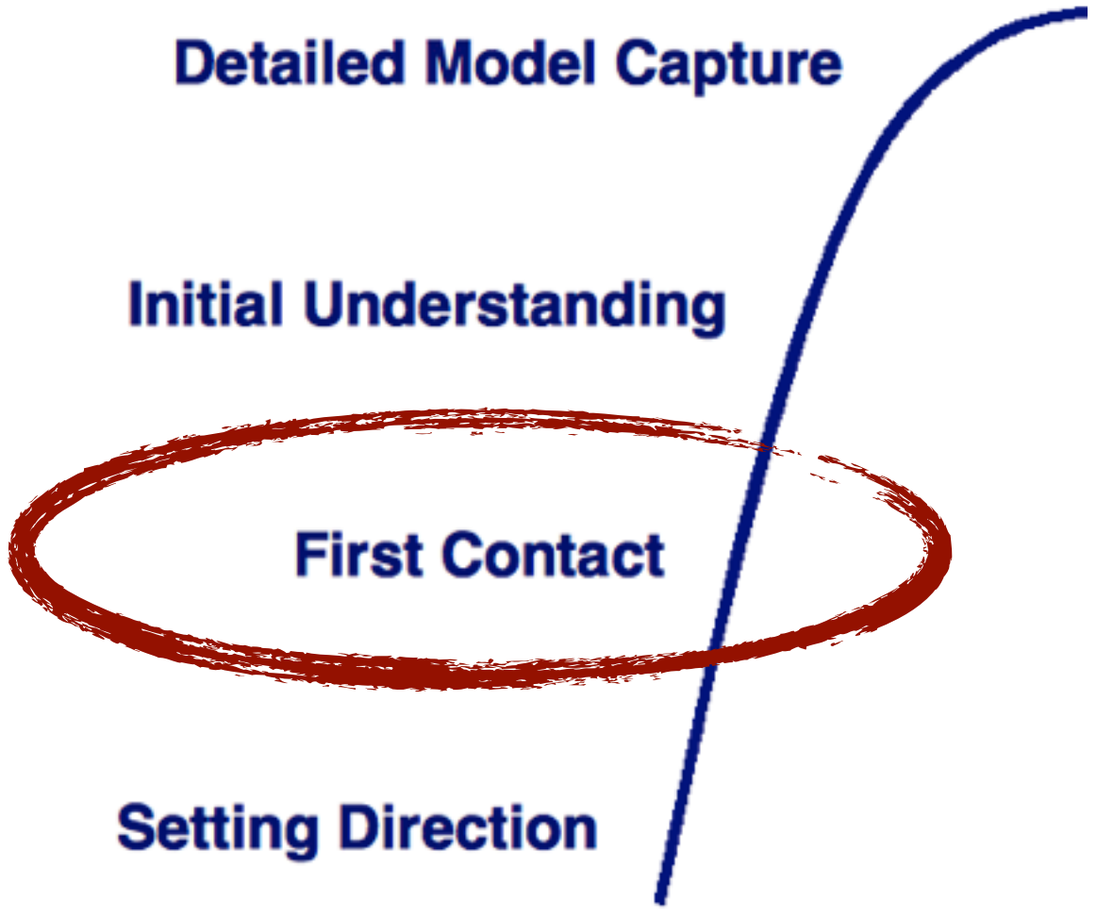
Setting Direction: Keep It Simple

- **Problem**
  - How much flexibility should you try to build into the new system?
- **Solution**
  - Prefer an adequate, but simple solution to a potentially more general, but complex solution.
- **Discussion**
  - Flexibility is a double-edged sword. An important reengineering goal
  - is to accommodate future change. But too much flexibility will make the new system so complex that you may actually impede future change.

Although you may be tempted to make the new system very flexible and generic, it is almost always better to **Keep It Simple**.



First Contact

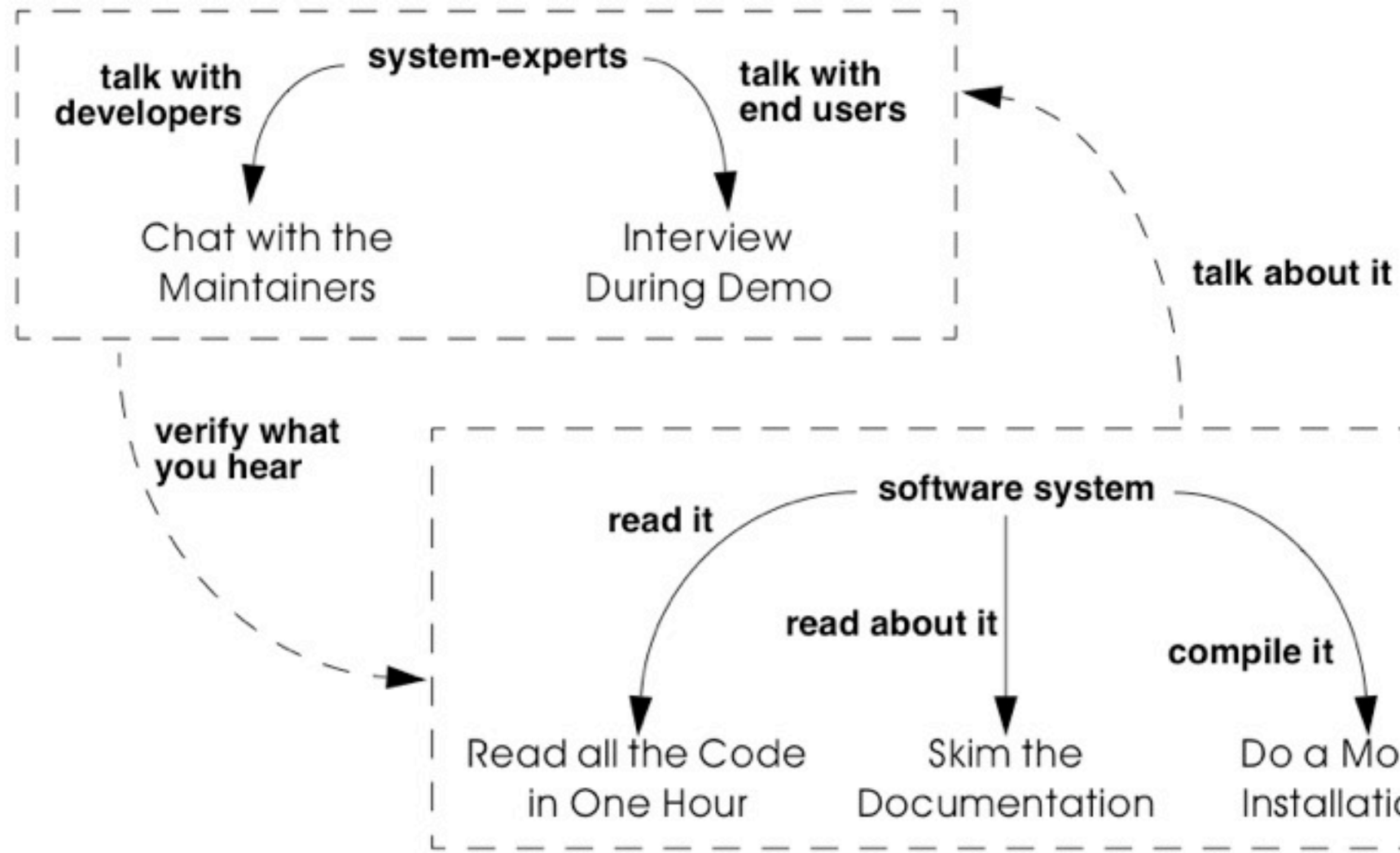


*"All the patterns in this cluster can be applied to the very **early stages** of a reengineering project: you're facing a system that is **completely new for you**, and **within a few days** you must determine whether something can be done with it and **present a plan** how to proceed."*

First Contact: Forces

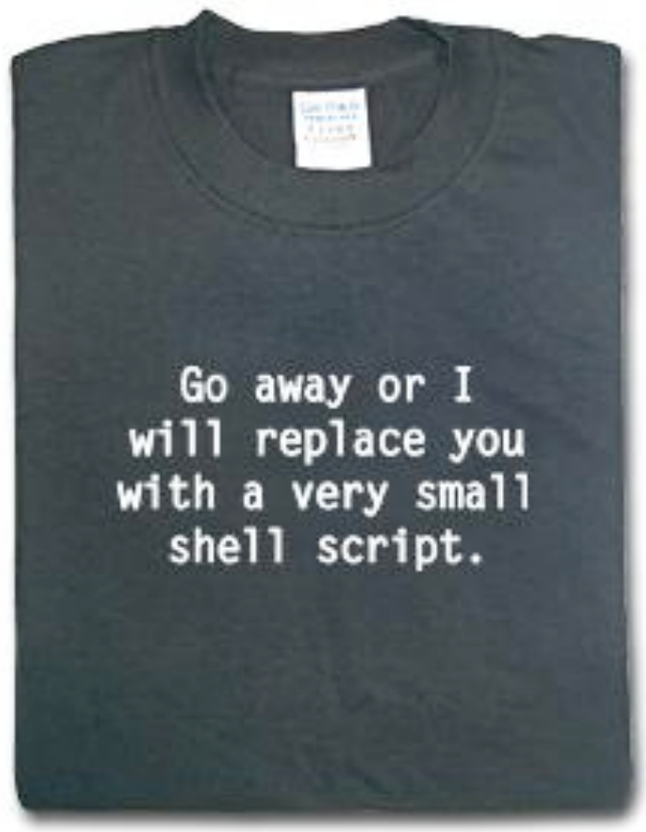
- **Legacy systems are large and complex**. Consequently, **split** the system into manageable pieces, where a manageable piece is one you can handle with a single reengineering team.
- **Time is scarce**. It is tempting to start an activity that will keep you busy for a while instead of addressing the root of the problem.Therefore, **defer all time-consuming activities** until later and use the first days of the project to **assess the feasibility** of the project's goals.
- **First impressions are dangerous**. There is no way to avoid that risk during your first contact with a system, however you can minimize its impact if you always **double-check your sources**.
- **People have different agendas**. In order to make the project a success, you must keep convincing the **faithful**, gain credit with the **fence sitters** and be wary of the **sceptics**.

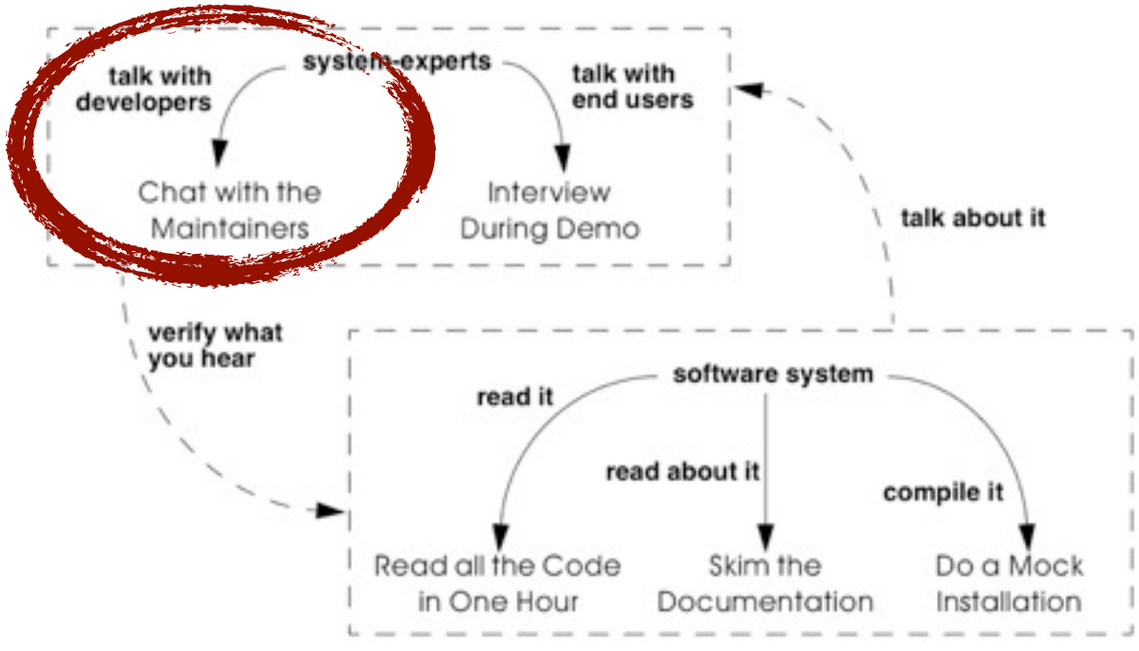
First Contact: Patterns



*"**Wasting time** is the largest risk when you have your first contact with a system, therefore these patterns should be applied during a short time span, **say one week**. After this week you should **grasp the main issues** and based on that knowledge **plan** further activities, or — when necessary — cancel the project."*

Chat with Maintainers

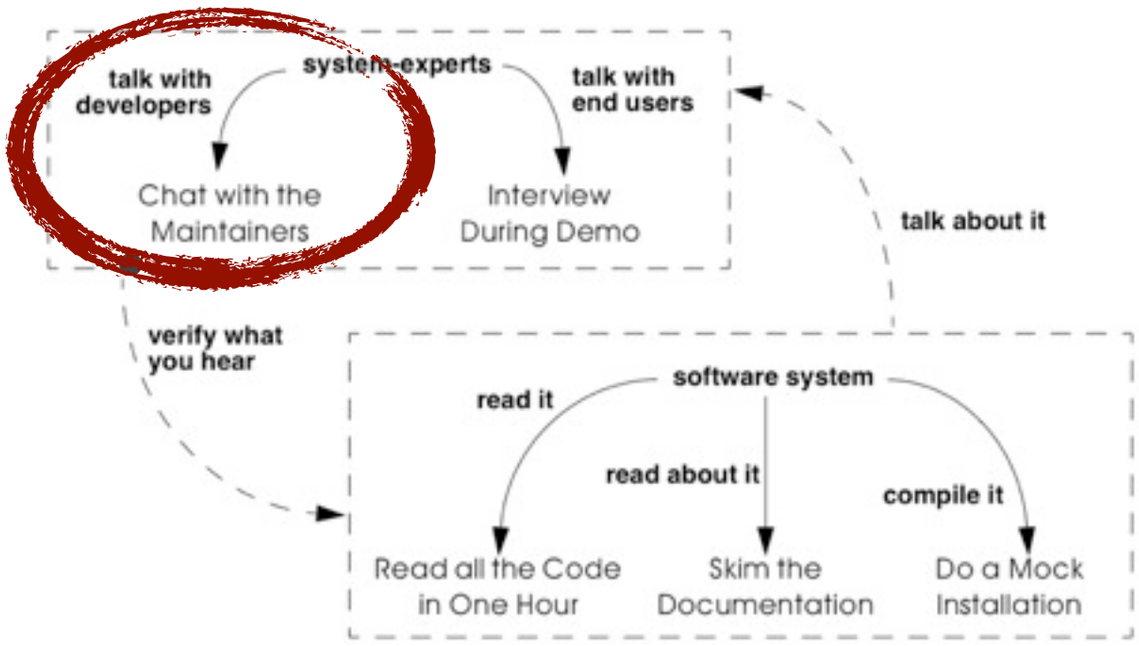




First Contact: Chat with the Maintainers

- **Problem**
  - How do you get a good perspective on the **historical** and **political** context of the legacy system you are reengineering?
- **Solution**
  - Discuss with the system maintainers. As **technical people** who have been intimately involved with the legacy system, they are well aware of the **system's history** and the **people-related issues** that influenced that history.
- To avoid misleading information, treat the maintainers as "**brothers in arms**".

Learn about the **historical** and **political context** of your project through discussions with the people maintaining the system.



First Contact, Chat with Maintainers: Questions (1)

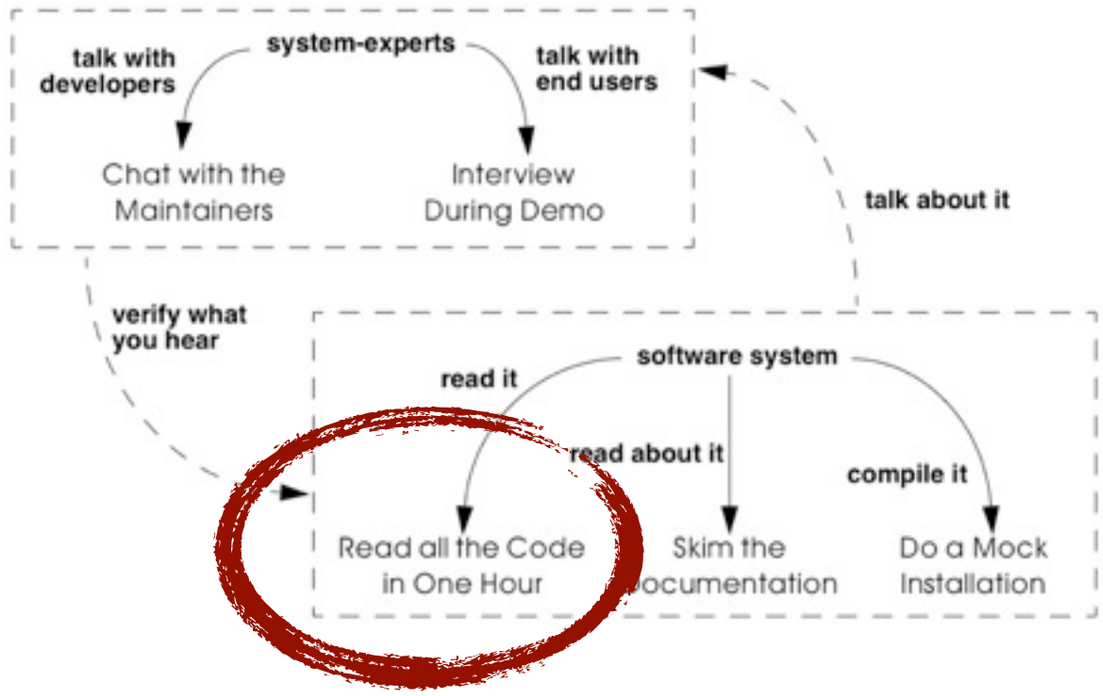
- **What was the easiest bug you had to fix during the last month? And what was the most difficult one?**
  - Good starters because they **show that you are interested in the maintenance work**.
  - Will provide you with **some concrete examples** of maintenance problems you might use in later, more high-level discussions.
- How does the maintenance team **collect bug reports** and **feature requests**? **Who decides** which request gets handled first? Is there a **version or configuration management system** in place?
  - Help to **understand the organization** of the maintenance process and the internal **working habits**.
  - Helps to assess the relationships **within the team** and **with the end users**.

First Contact, Chat with Maintainers: Questions (2)

- **Who was part of the development/maintenance team during the course of years? How did they join/leave the project? How did this affect the release history of the system?**
  - It is a good idea to ask about persons because people generally have a good recollection of former colleagues.
- **How good is the code? How trustworthy is the documentation?**
  - You will have to verify their claims yourself afterwards
- **Why is this reengineering project started? What do you expect from this project? What will you gain from the results?**
  - It is crucial to ask what the maintainers will gain from the reengineering project as it is something to keep in mind during the later phases.

Read all the Code in One Hour

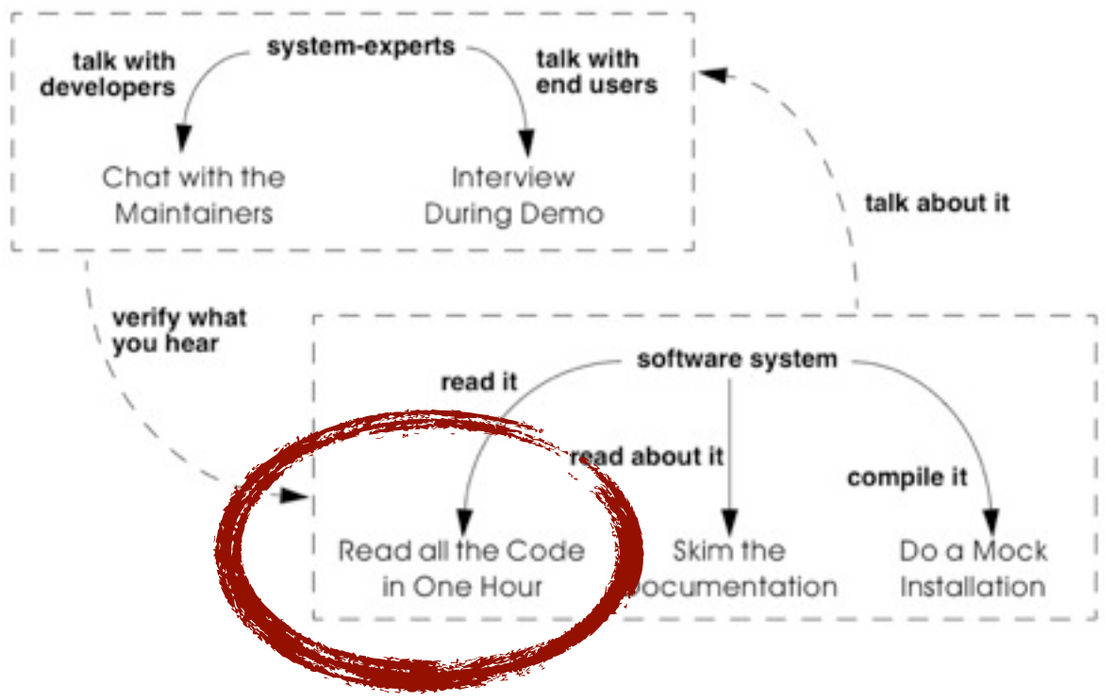
"My short-term goal is to bluff my way through this job interview. My long-term goal is to invent a time machine so I can come back and change everything I've said so far."



First Contact: Read all the Code in One Hour

- **Problem**
  - How can you get a **first impression** of the quality of the source code?
  - The system is large, so there is **too much data** to inspect for an accurate assessment.
  - You're unfamiliar with the software system, so you do not know **how to filter out what's relevant**.
  - You have **reasonable expertise** with the implementation language being used.
  - Your reengineering project has a **clear goal**, so you can assess the kind of code quality required to obtain that goal.
- **Solution**
  - Take a short time (i.e., approximately one hour) to read the source code.
  - Produce a report (general assesment, entities which seem important, suspicious coding styles - "smells", parts which needs to be investigated further)

Assess the state of a software system by means of a **brief, but intensive code review**.



First Contact: Read all the Code in One Hour

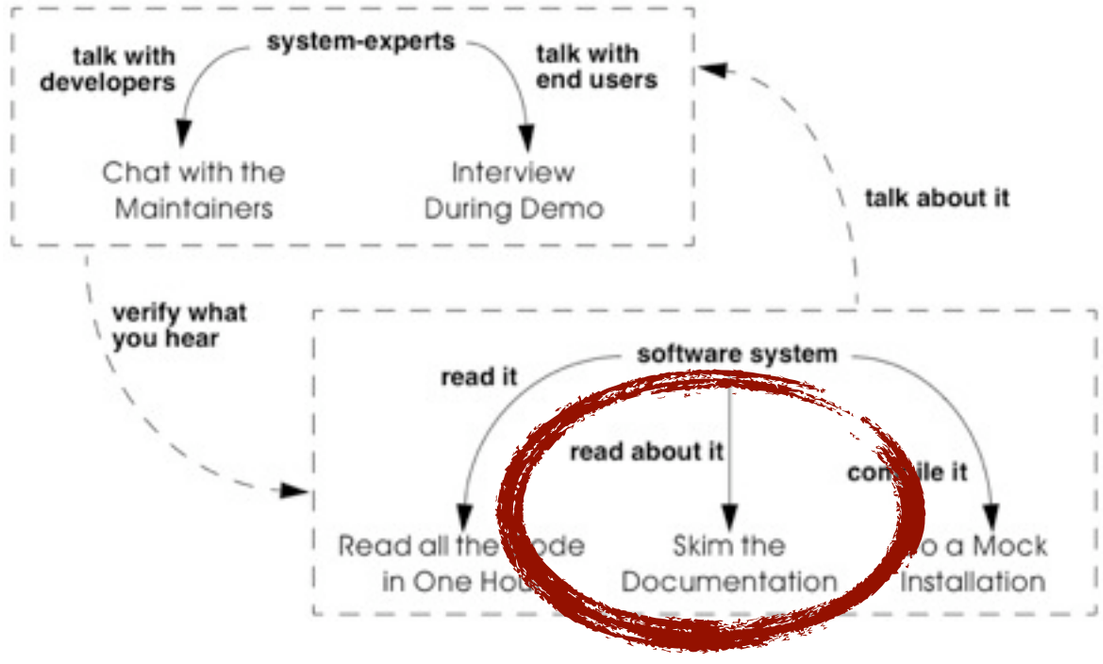
- **Pros**
  - **Start efficiently**. Reading the code in a short amount of time is very efficient as a starter. Indeed, by limiting the time and yet forcing yourself to look at all the code, **you mainly use your brain and coding expertise to filter out what seems important**.
  - **Judge sincerely**. By reading the code directly you **get an unbiased view of the software system** including a sense for the details and a glimpse on the kind of problems you are facing.
  - **Learn the developers vocabulary**. Acquiring the vocabulary used inside the software system is essential to understand it and communicate about it with other developers.
- **Cons**
  - **Obtain low abstraction**. Via this pattern, you will get some insight in the solution domain, but only very little on how these map onto problem domain concepts.

Skim the Documentation

First Contact: Skim the Documentation

- **Problem**
  - How to identify those **parts of the documentation** that might be of help?
  - Documentation, if present, is usually intended for the development team or the end users and as such not immediately relevant for reengineering purposes.
- **Solution**
  - Prepare a list summarizing those **aspects of the system** that seem interesting for your reengineering project.
  - Then, match this list against the documentation and meanwhile make a crude **assessment of how up to date** the documentation seems.
  - Finally, summarize your findings in a short report.

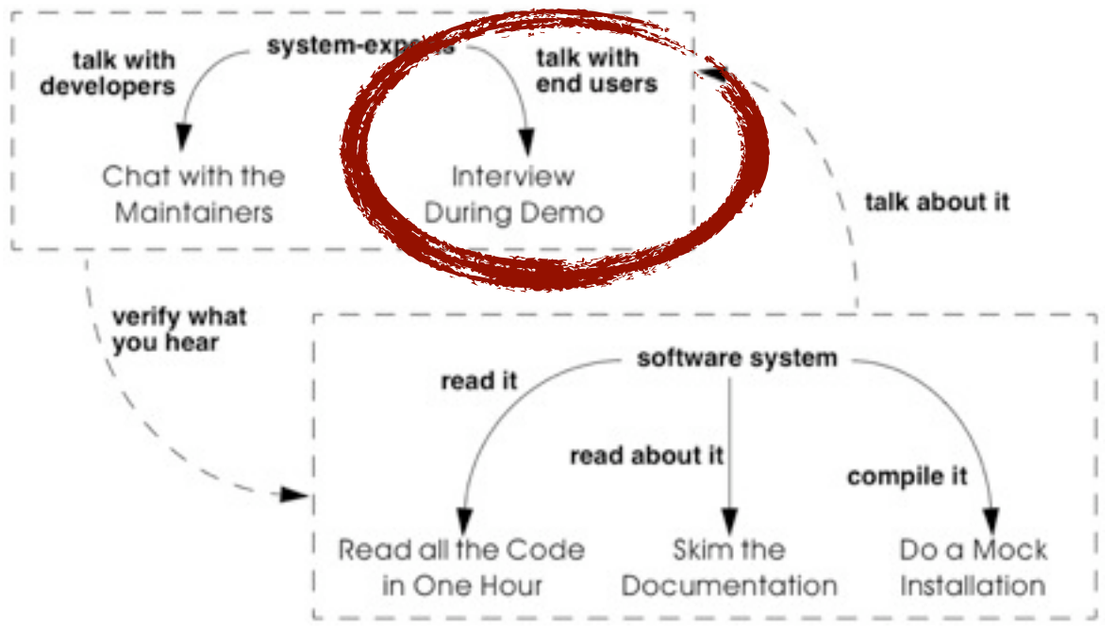
Assess the relevance of the documentation by reading it in a limited amount of time.



First Contact: Skim the Documentation

- **Hints**
  - A **table of contents** gives you a quick overview of the structure and the information presented.
  - **Version numbers and dates** tell you how up to date that part of the documentation is.
  - **Figures** are a a good means to communicate information.
  - **Screen-dumps**, sample print-outs, sample reports, command descriptions, reveal a lot about the functionality provided by the system.
  - **Formal specifications** (e.g., state-charts), if present, usually correspond with **crucial functionality**.
  - An **index**, if present contains the terms the author considers significant.

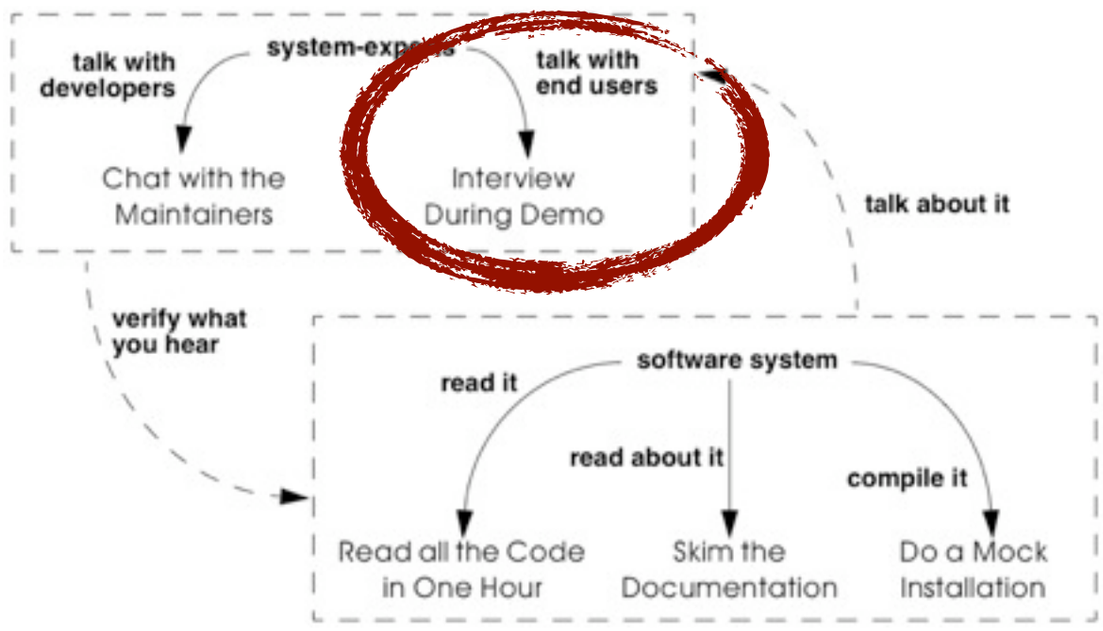
Interview During Demo



First Contact: Interview During Demo

- **Problem**
  - How can you get an idea of the typical **usage scenarios** and the **main features** of a software system?
  - Typical usage scenarios vary quite a lot depending on the **type of user**.
  - If you ask the users, they have a tendency to complain about **what's wrong**, while for reverse engineering purposes you're mainly interested in **what's valuable**.
  - You can **exploit the presence of a working system and a few users** who can demonstrate how they use the software system.
- **Solution**
  - Observe the system in operation by seeing a demo and interviewing the person who is demonstrating.
  - **Note that the interviewing part is at least asenlightening as the demo**.
  - Write a short report.

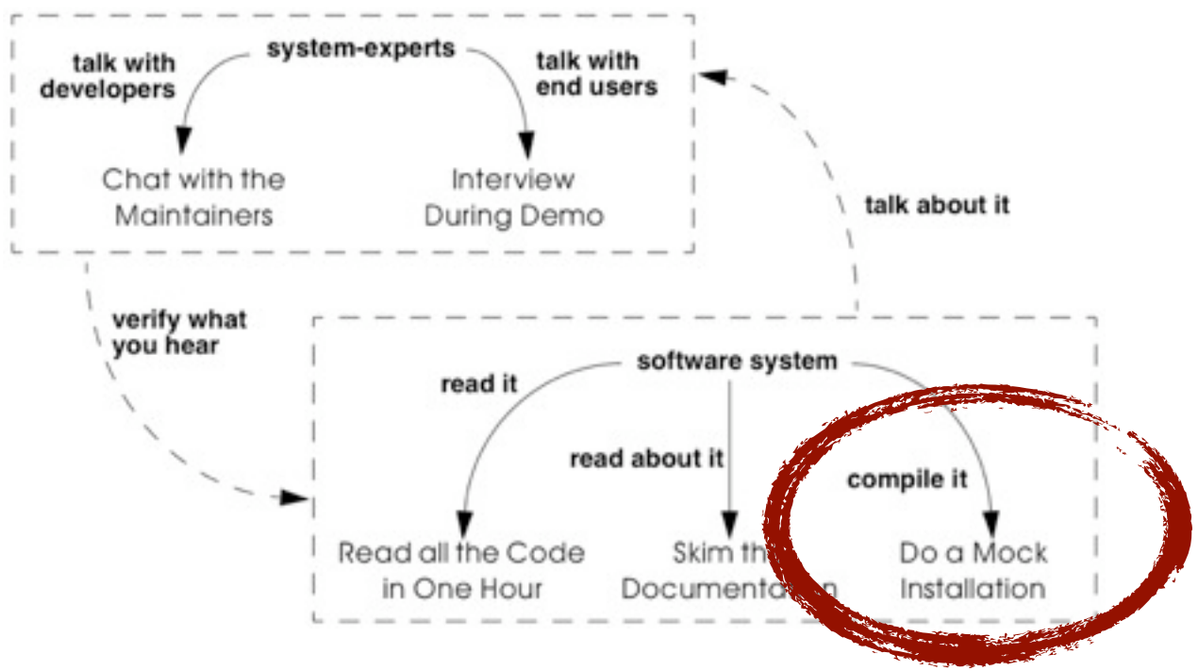
Obtain an **initial feeling for the appreciated functionality** of a software system by seeing a demo and interviewing the person giving the demo.



First Contact: Interview During Demo

- **Hints**
  - An **end-user** should tell you **how the system looks like from the outside** and explain some detailed usage scenarios based on the **daily working practices**.
  - A **manager** should inform you how the system fits within the **rest of the business domain**.
  - A **person from the sales department** ought to compare your software system with **competing** systems.
  - A **person from the help desk** should demonstrate you which features **cause most of the problems**.
  - A **system administrator** should show you all that is happening behind the scenes of the software system. **Ask for past horror stories** to assess the reliability of the system.
  - A **developer** may demonstrate you some of the subsystems. Ask how this subsystem communicates with the other subsystems and why (and who!) it was designed that way. Use the opportunity to **get insight in the architecture of the system** and the trade-offs that influenced the design.

Do a Mock Installation

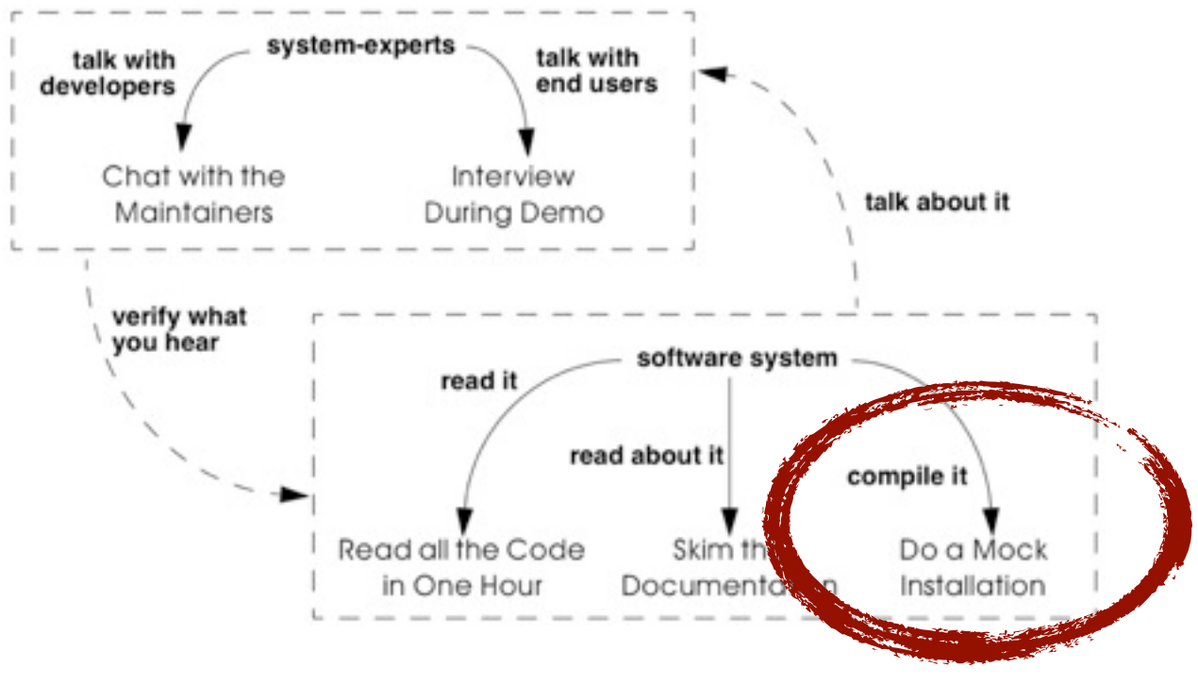


First Contact: Do a Mock Installation

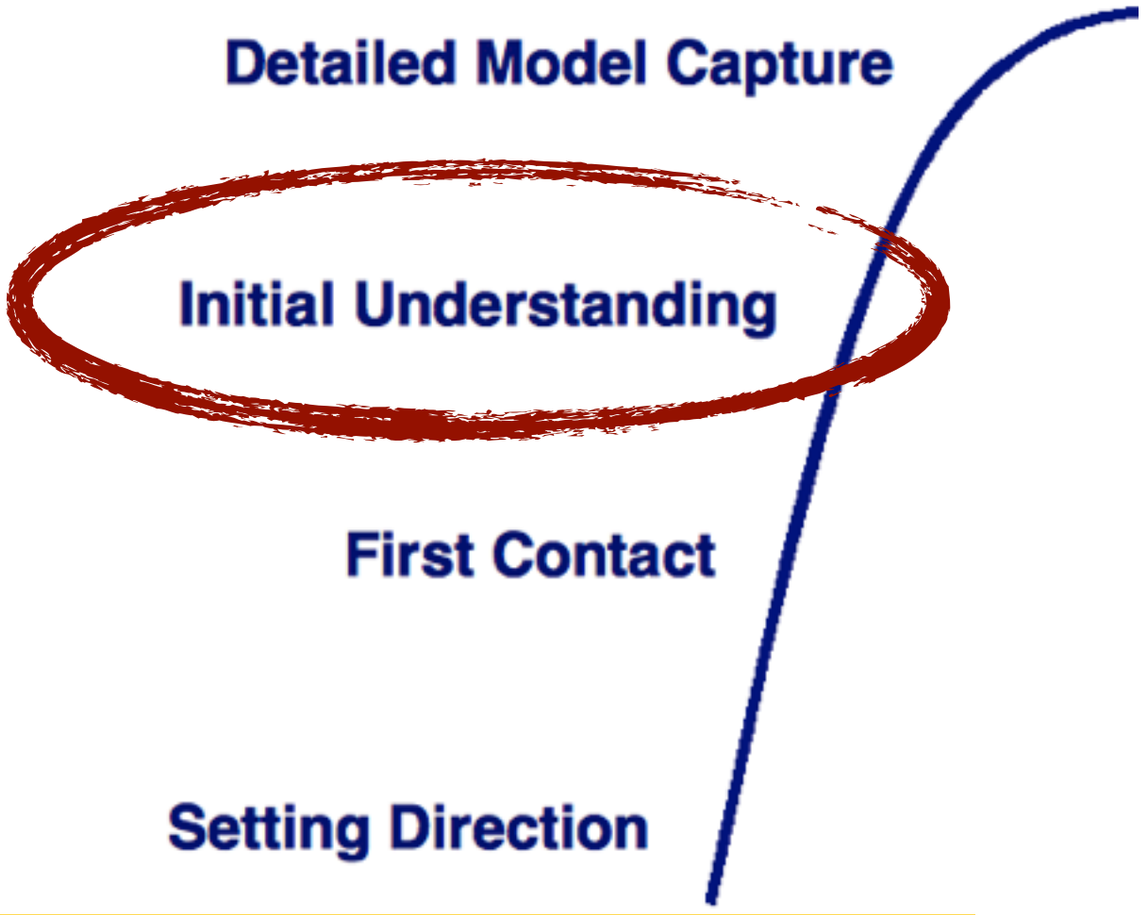
- **Problem**
  - How can you be sure that you will be able to (re)build the system?
  - The system is new for you, so you do not know which files you need to build the system.
  - You have access to the source code and the necessary build tools (i.e., the makefiles, compilers, linkers).
  - Maybe the system includes some kind of self test, which you can use to verify whether the build or install succeeded.

Check whether you have the necessary artefacts available by installing the system and recompiling the code.

- **Solution**
  - Try to install and build the system in a clean environment during a limited amount of time (at most one day). Run the self test if the system includes one

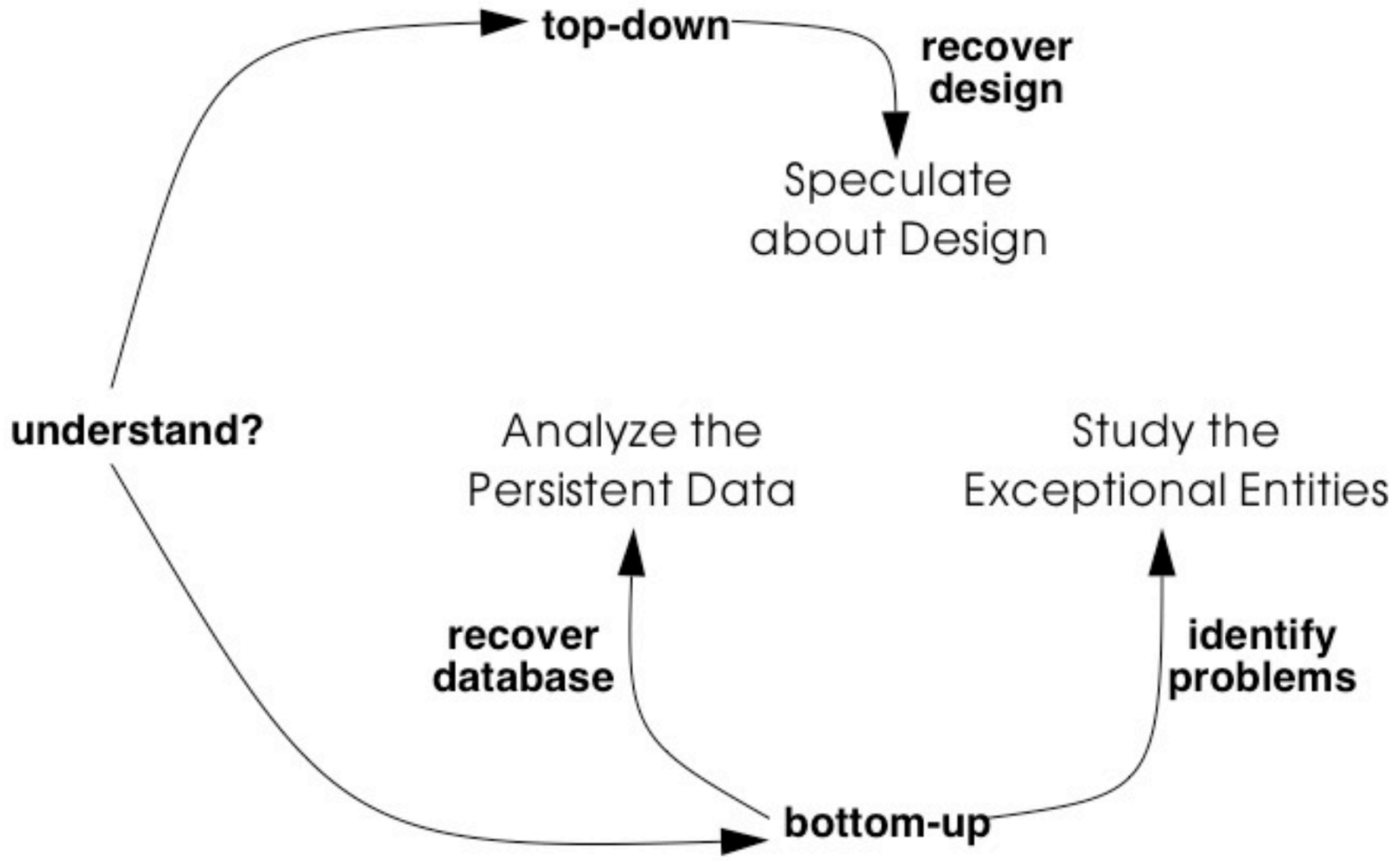


Initial Understanding



“The patterns in First Contact should have helped you to get some first ideas about the software system. ***Now is the right time to refine those ideas into an initial understanding and to document that understanding*** *in order to support further reverse engineering activities”*

Initial Understanding: Patterns



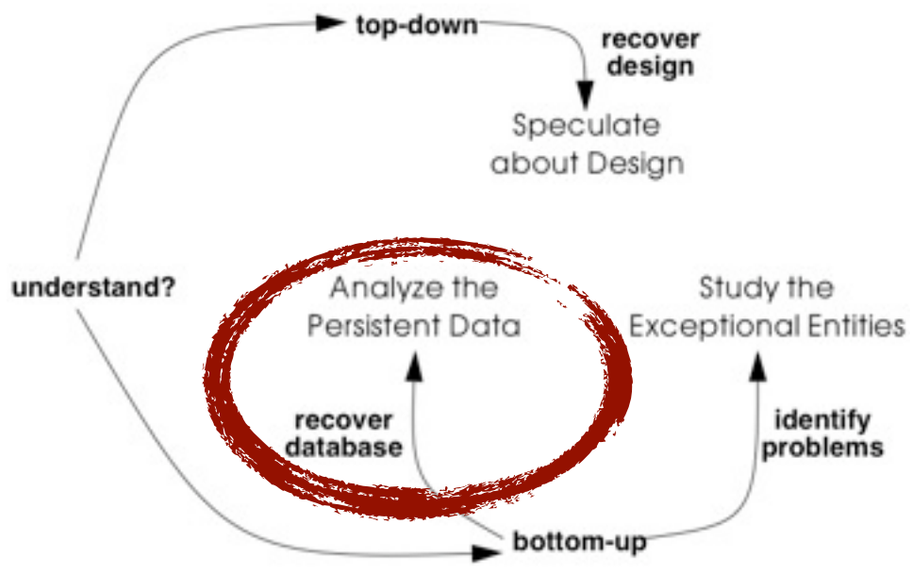
Initial Understanding: Overview

- These patterns rely mainly on **source code** because this is the only trustworthy information source.
- Two approaches for studying source code (both are valuable):
  - **Top-down**: start from a high-level representation and verify it against the source-code (see Speculate About Design)
  - **Bottom-up**: start from the source-code, filter out what's relevant and cast the relevant entities into a higher-level representation (see Analyze the Persistent Data and Study the Exceptional Entities).
- There is not a unique order in which to perform these activities.

Initial Understanding: Analyse the Persistent Data

- **Problem**
  - Which object structures represent the **valuable data**?
- **Solution**
  - Analyze the **database schema** and filter out which structures represent valuable data.
  - **Derive a class diagram** representing those entities to **document that knowledge** for the rest of the team.
- **Note**
  - The book describes a detailed procedure on how to how perform this activity.

Learn about objects that are so **valuable** they must be kept inside a **database** system.



Initial Understanding: Speculate about Design

- **Problem**
  - How do you recover the way **design concepts** are represented in the source-code?
  - There are **many design concepts** and there are countless ways to represent them in the programming language used.
  - Much of the source-code won't have anything to do with the design but rather with implementation issues.
- You have a **rough understanding of the system's functionality** and you therefore have an initial idea which design issues should be addressed.
- You have **development expertise**, so you can imagine how you would design the problem yourself.
- You are **somewhat familiar with the main structure** of the source code so that you can find your way around.

- **Solution**
  - Use your **development expertise** to conceive a **hypothetical class diagram** representing the design.
  - Refine that model by **verifying** whether the names in the class diagram occur in the **source code** and by adapting the model accordingly.
  - **Repeat the process** until your class diagram stabilizes.

Progressively **refine a design** against source code by **checking hypotheses** about the design against the source code.

Initial Understanding: Speculate about Design

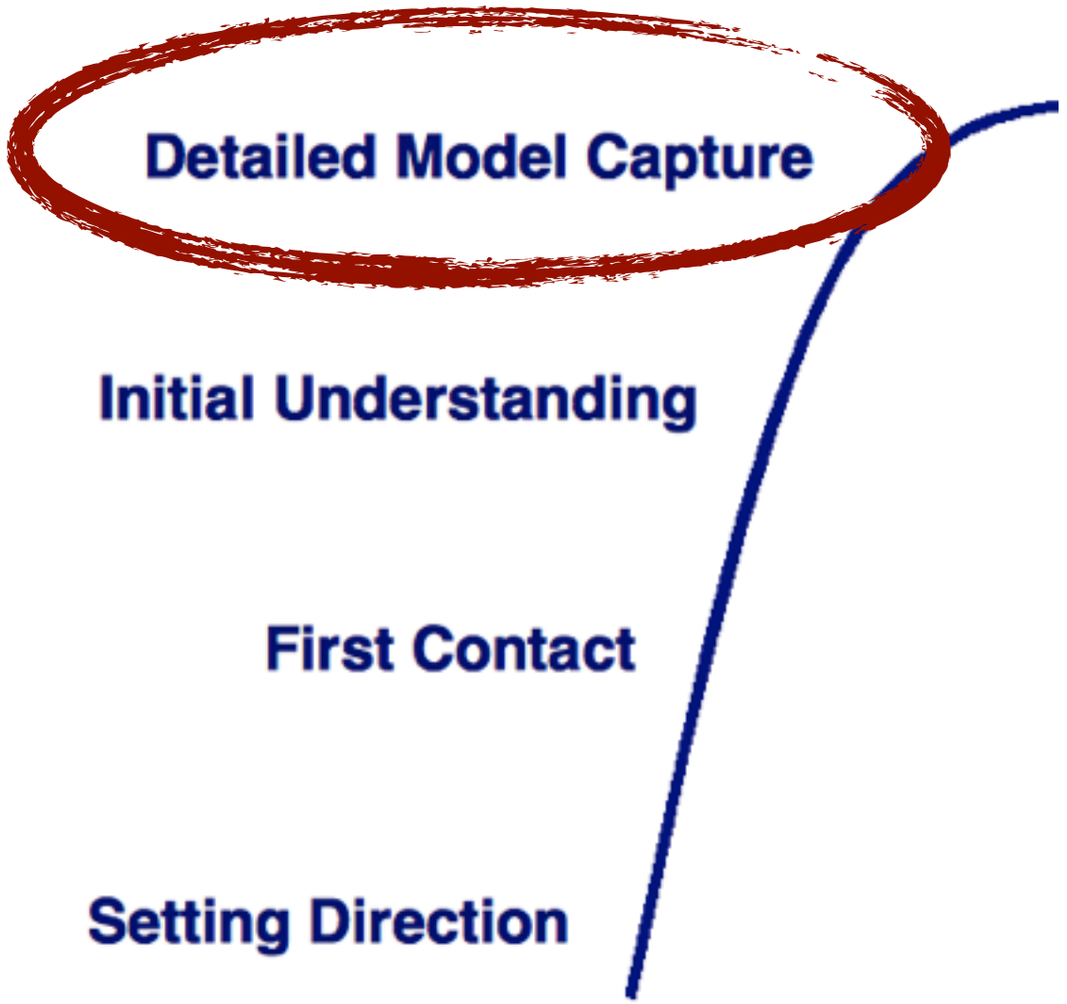
- **Pro**
  - **Scales well.** Speculating about what you'll find in the source code is a technique that scales up well. This is especially important because for large object-oriented programs (over a 100 classes) a bottom-up approach quickly becomes impractical.
- **Con**
  - **Requires expertise.** A large repertoire of **knowledge** about **idioms**, **patterns**, **algorithms**, **techniques** is necessary to recognize what you see in the source code. As such, the pattern should preferably **be applied by experts**.

Initial Understanding: Analyse the Persistent Data

- **Problem**
  - How can you **quickly identify potential design problems** in large software systems?
  - **No easy way to discern problematic from good designs**. Assessing the quality of a design must be done in the terms of the problem it tries to solve, thus can never be inferred from the design alone.
  - The system is large, thus a detailed assessment of the design quality of every piece of code is not feasible.
  - You have a **metrics tool** at your disposal, so you can quickly collect a number of measurements about the entities in the source-code.
  - You have the necessary tools to browse the source-code, so you can verify manually whether certain entities are indeed a problem.
- **Solution**
  - Measure the structural entities forming the software system (i.e., the inheritance hierarchy, the packages, the classes and the methods) and look for
  - exceptions in the quantitative data you collected. Verify manually whether these anomalies represent design problems.

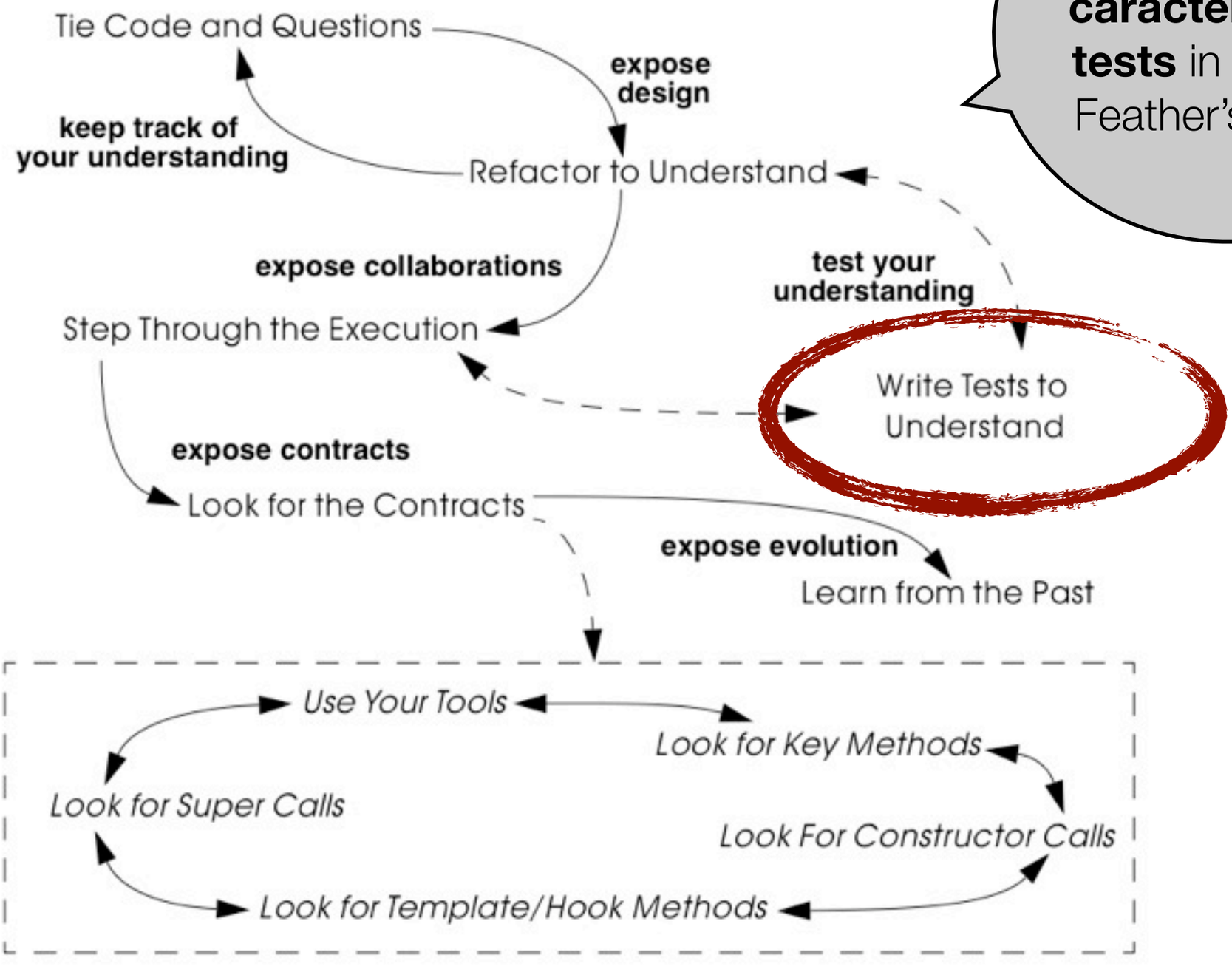
Identify **potential design problems** by collecting measurements and studying the exceptional values.

Detailed Model Capture



*"Your main priority now is to build up a **detailed model** of **those parts of the system** that will be important for your reengineering effort. Most of the patterns concerned with Detailed Model Capture entail considerably **more technical knowledge**, use of **tools** and investment of **effort** than the patterns we have applied up to now"*

Detailed Model Capture



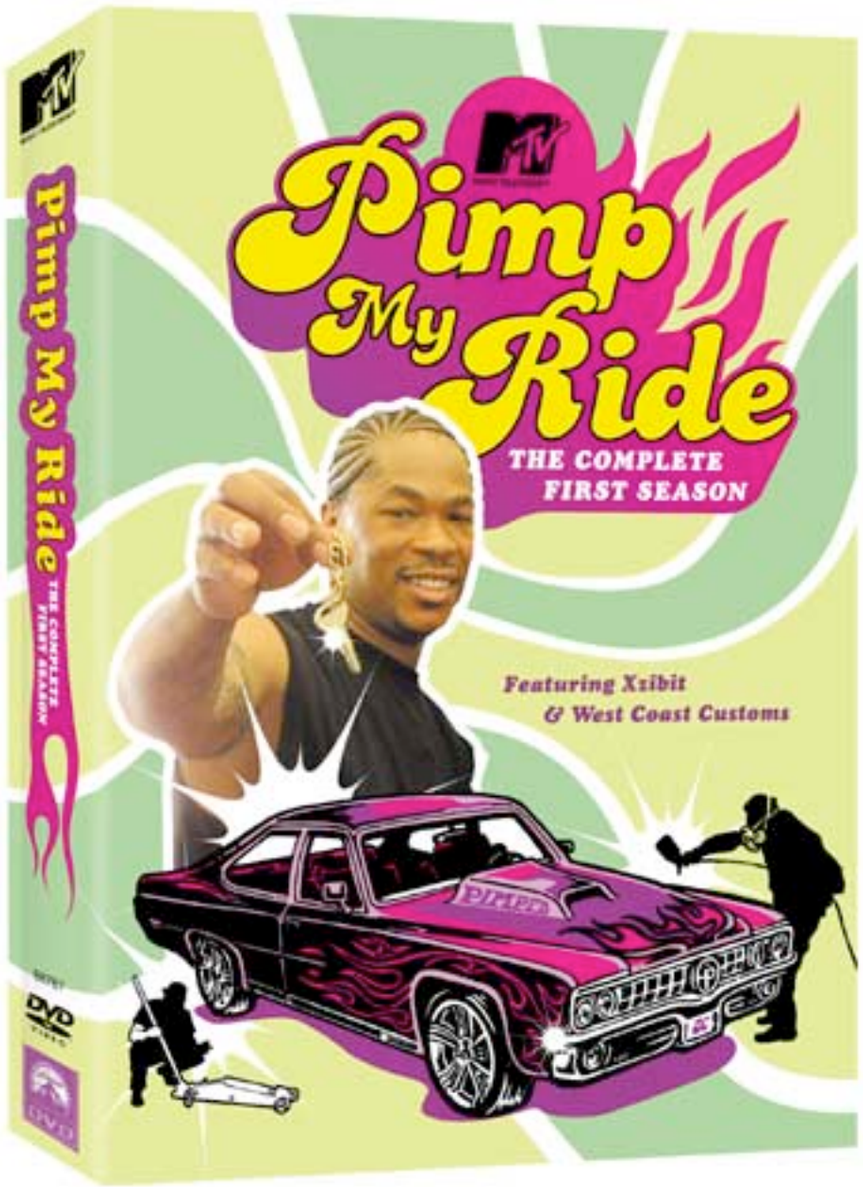
Remember **caracterization tests** in Michael Feather's book?

Patterns

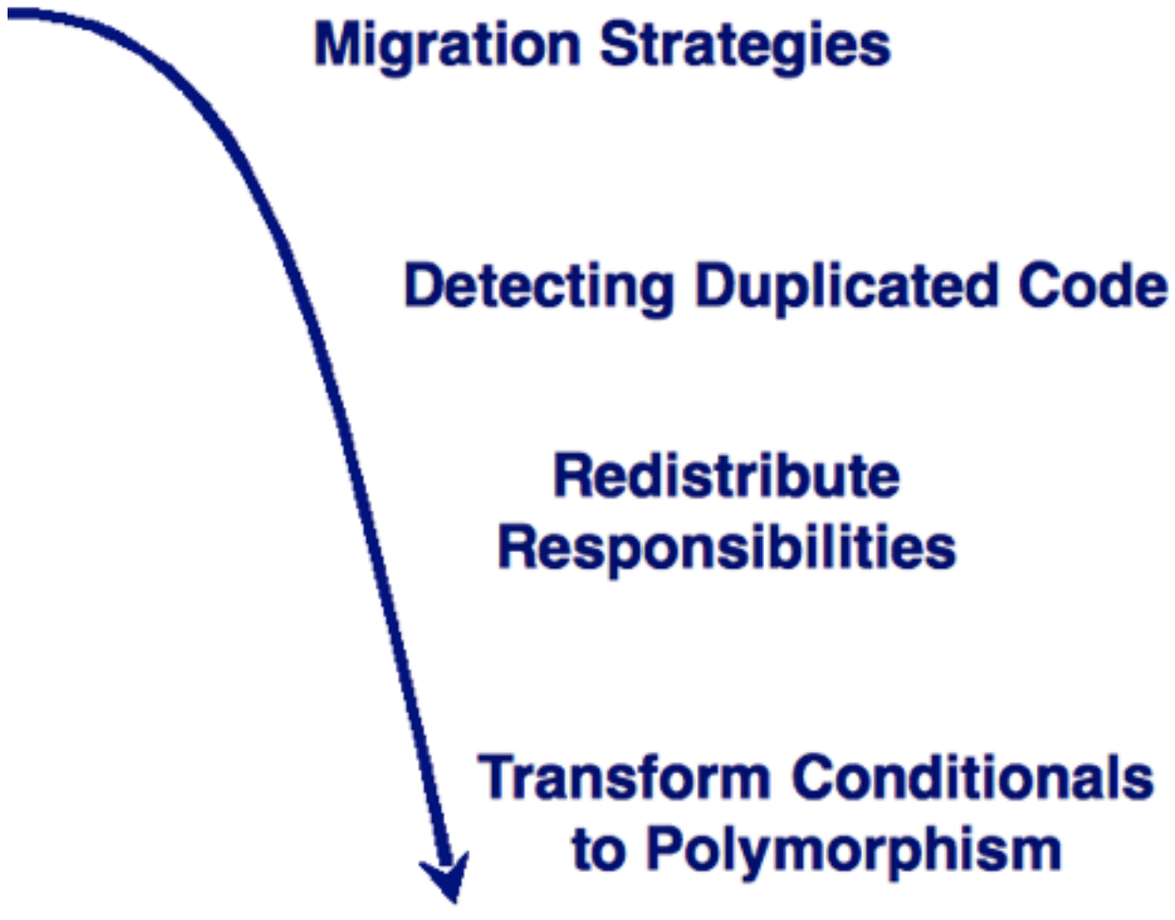
- **Tie Code and Questions**
  - Keep the questions and answers concerning your reengineering activities synchronized with the code by storing them directly in the source files.
- **Refactor to Understand**
  - Iteratively refactor a part of a software system in order to validate and reflect your understanding of how it works.
- **Step Through the Execution**
  - Understand how objects in the system collaborate by stepping through examples in a debugger.
- **Look for the Contracts**
  - Infer the proper use of a class interface by studying the way clients currently use it.
- **Learn from the Past**
  - Obtain insights into the design by comparing subsequent versions of the system.
- **Write Tests to Understand**
  - Record your understanding of a piece of code in the form of executable
  - tests, thus setting the stage for future changes.

Reengineering Patterns

Reengineering patterns encode expertise and trade-offs in ***transforming legacy code*** *to resolve problems that have* ***emerged****.*



Reengineering Patterns



http://scg.unibe.ch/download/oorp/