Università degli Studi dell'Insubria

An integrated approach to the evaluation of ICT-based process innovation

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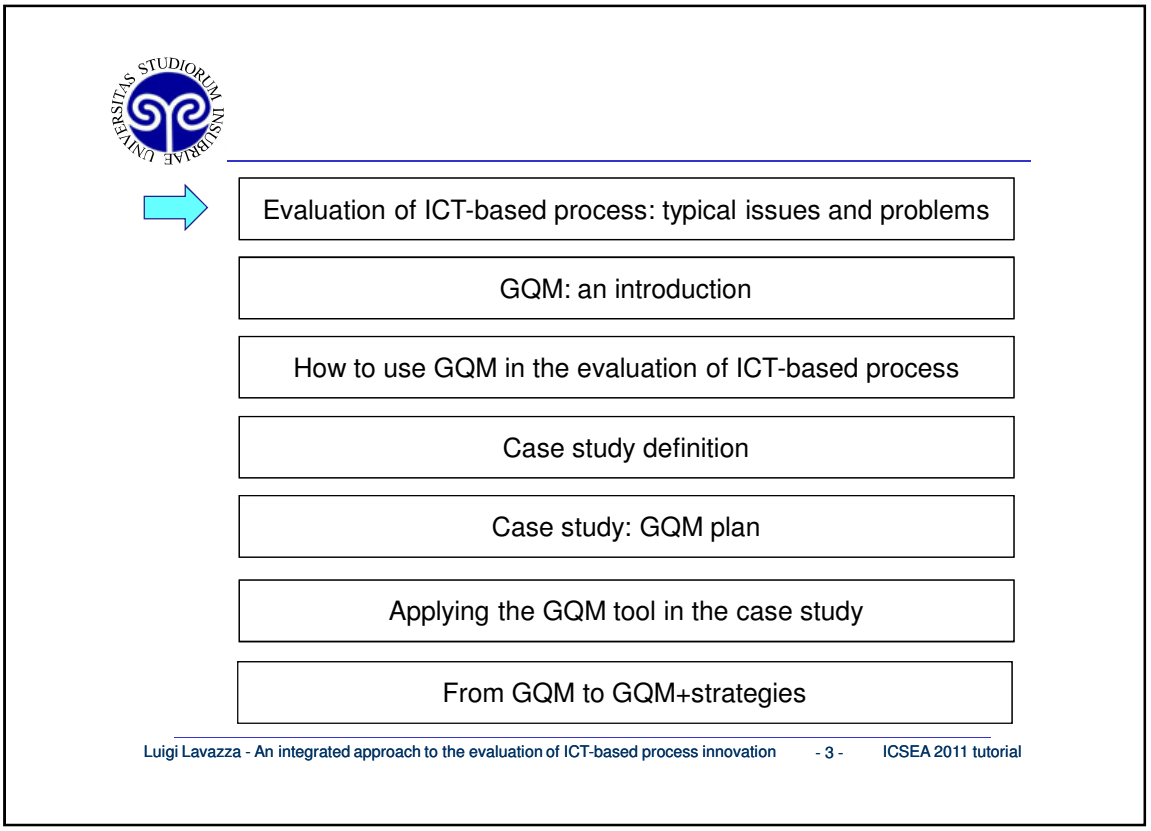
Tutorial contents

- Evaluation of ICT-based process: typical issues and problems
- GQM: an introduction
- How to use GQM in the evaluation of ICT-based process
- Case study definition
- Applying the GQM tool in the case study
  - Defining the plan
  - Setting up a database for storing measures
  - Connecting queries to elements of the GQM plan
  - Statistical analysis of the measures
  - Reporting
- From GQM to GQM+strategies



ICT-based process: a reference model

- E, P |- R
  - E = environment
    - given, its rules and behaviour cannot be changed
  - P = process, i.e., actions performed in the environment
    - designed by us, subject to constraints (e.g., cost)
    - If the process is ICT-based, P contains at least a hardware/software machine
  - R = results, i.e., consequences of the process execution on the environment
- E, P |- R can be seen as a description of the *current* situation:

ICT-based process *improvement*

- The current situation is not satisfactory. I.e., in E, P |- R results R need to be improved.
- Let's say that the desired results are defined by R'.
- Since E is given, and R is consequence of E and P, we have to devise a new P that can deliver the required results:

  E, P' |- R'
- Of course, in general we are interested in minimizing the (cost of) changes, i.e., in minimizing ΔP in

  E, P+ΔP |- R'

  where ΔP is the process change (P' = P+ΔP).

Different types of "objectives"

- In E, P+ΔP |- R'
  - ΔP is the process change objective, while
  - R' is the final objective.
- In other words, we aim at implementing the process change ΔP because we are interested in achieving R'.
- This is important to keep in mind!
- After implementing ΔP, we need to measure that its results actually match R'.
  - In fact, we expect that E, P+$\Delta P_{planned}$ |- R',
    but we have to verify that E, P+$\Delta P_{implemented}$ |- R' !

Evaluation of ICT-based process: typical issues and problems

- When evaluating process improvement initiatives, the measurement plan has a set of fixed characteristics:
  - Typical purpose: evaluation
  - Typical Quality Foci: efficiency, time, amount of work done (e.g., number of procedures completed), etc.
  - Variation Factors depend on the context.
    - People factor is often very relevant (but in a non-human centred activity it could be less relevant…)

Evaluation of ICT-based process: typical issues

- In process improvement initiatives a typical issue concerns the comparison of the situation after innovation with respect to the situation before innovation.

$$E, P \vdash R$$
$$E, P' \vdash R'$$

- Measure of R and R' provide an indication of
  - Whether the objective (R') has been achieved
  - If not, to what extent we have improved (R'-R)

Evaluation of ICT-based process: typical issues

E, P |- R
E, P' |- R'

- If the objective (R') has been achieved, we still would like to know it it happened by chance or because P' was correctly implemented and executed.
- Thus, we measure P', i.e., the process after the innovation.

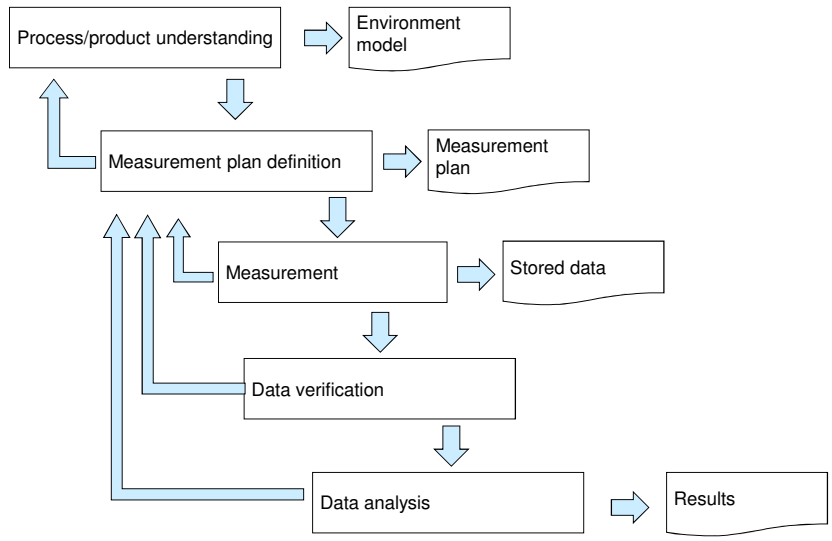
Evaluation of ICT-based process: typical issues

- In any case, it may happen that the environment does not behave as usual during the evaluation of the results of process improvement, i.e.,

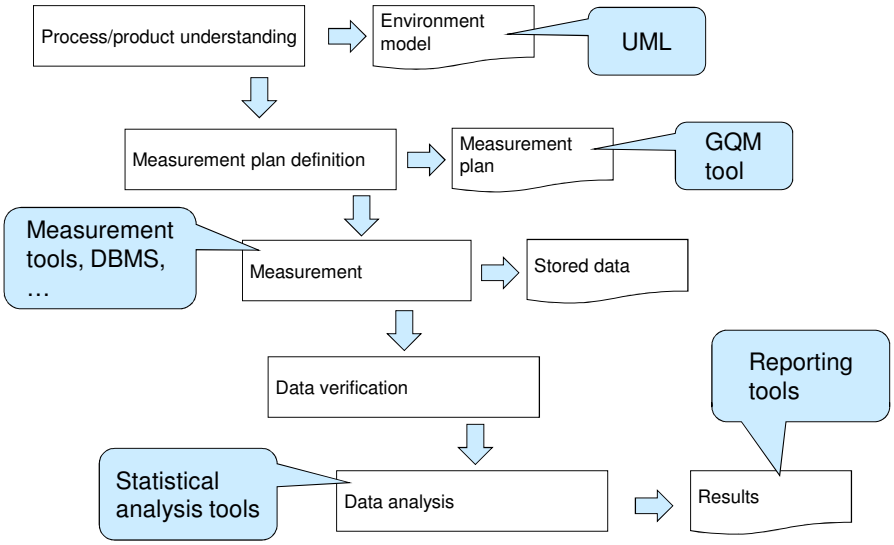
E, P |- R
E', P' |- R'

- Thus, it is the case that we measure also the environment.

The evaluation process



The evaluation process: tool support



Tools for the evaluation process

- Problem: you need different tools.
- As usual, integrating tools that provide very different functionalities can be very hard.
- Solution: the GQM tool integrates
  - The definition of GQM plans
  - The creation and execution of tables and queries for storing and retrieving measurement data
    - Tables and queries are associated to GQM elements (e.g., metrics, questions, etc.)
  - The execution of statistical analysis and the creation of reports
  - MySQL is used as a DBMS
  - R is used a statistical analysis tool
- The connection of GQM elements to process and product models in not yet supported

Evaluation of ICT-based process: typical issues and problems

GQM: an introduction

How to use GQM in the evaluation of ICT-based process

Case study definition

Case study: GQM plan

Applying the GQM tool in the case study

From GQM to GQM+strategies

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Goal-oriented software measurement: the Goal/Question/Metrics approach

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reduction from a presentation by Prof. H.D. Rombach

The QIP-EF-G/Q/M Methodology

- Used for the experimentally-based improvement of process and product
- Conceived and developed at the University of Maryland by Prof. Basili's group
- Applied in diverse industrial environments (e.g., NASA, Motorola, …, Allianz, …)

The QIP-EF-G/Q/M Methodology

- Composed of three fundamental elements
  - Quality Improvement Paradigm (QIP)
  - Experience Factory (EF)
  - Goal/Question/Metric (GQM) paradigm
- QIP is the reference framework
  - EF and GQM are two tools
- The fundamental idea is that improvement requires
  - knowledge of current state
  - reuse of process knowledge
  - establishment of quantifiable objectives
  - verification of goal's attainment

QIP

- The QIP is a version of the scientific method tailored to the specific application field—Software Engineering—though it can be applied in other fields as well
- The idea is that every software project is an experiment:
  - it is unique
  - its results are not easily predictable (at least at this stage of technology)
  - its results cannot be reused as-is (at least at this stage of technology
- Every project gives an opportunity for a software organization to augment and refine its own knowledge on
  - processes
  - products
  - resources

QIP: Motivations

- Quality development a priori
  - Formalize process planning
  - Formalize assessment and improvement of processes and products
  - Analyze engineering methods to determine where, how, when, … they are applicable and what results they yield
    - most Software Engineering methods are not formal, but heuristic
- Adapt processes
  - Process models must be tailored to the specific context
    - In particular, with respect to project objectives
  - Experience can be reused only after the required adaptation

QIP: Motivations

- Make the process treatable
  - Process must be kept under control
    - it is necessary to measure
  - Measurement too must be adapted to
    - context, objectives, who uses the results
  - It is mandatory that the project team provides the fundamental knowledge and ideas
- Measurement planning
  - Preparation of the environment
  - Instrumentation of the process
  - Identification of the most appropriate experimental design
  - Top-down strategy
    - from “why” and “what” to measure to “how” to measure
  - Use of different mechanisms for data collection and validation
  - Building, evolution, and use of a measurement database
  - Identification of roles in measurement activities

QIP: Description

- ***Planning and quantitative analysis*** *of the software development process*

- *6 iteration steps: experience is adapted and reused at each iteration*

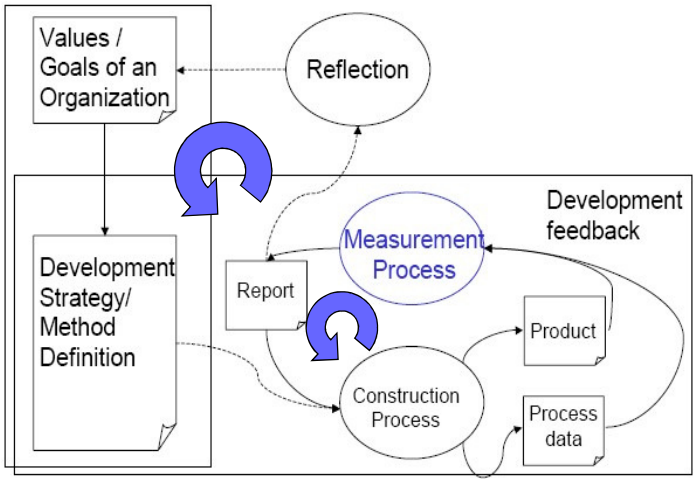
QIP: Description

- Characterize the project and the environment with respect to process models and measures.
- Establish process improvement goals.
- Choose process model, supporting methods and tools for the project, including support for measurement.
- Execute the process. At the same time, data are collected, validated, and analyzed to provide real-time support for the project.
- Analyze data to assess current practices, uncover problems, record facts, and provide improvement recommendations.
- Make experience reusable, by building updated models and other forms of structured knowledge.

QIP: Description

- Two feedback loops:
  - to the project at hand—on line
    - problem prevention and solution
    - project monitoring and support
    - alignment of the processes with the goals
  - to the organization—off line
    - comparison of actual data to the expected ones
    - explanation of the reasons for the discrepancies
    - build-up of experience in terms of
      - processes
      - products
      - documents
      - models
      - …
- QIP may have other loops
  - the main loop describes the prevailing direction

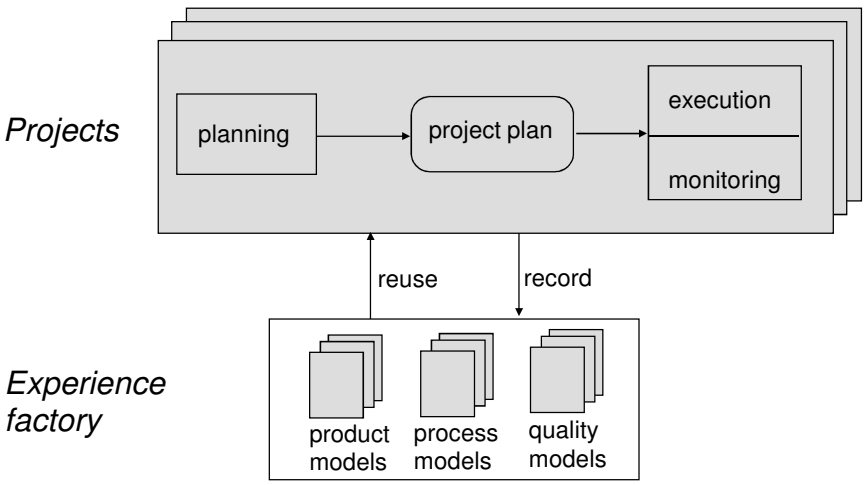
The conceptual framework



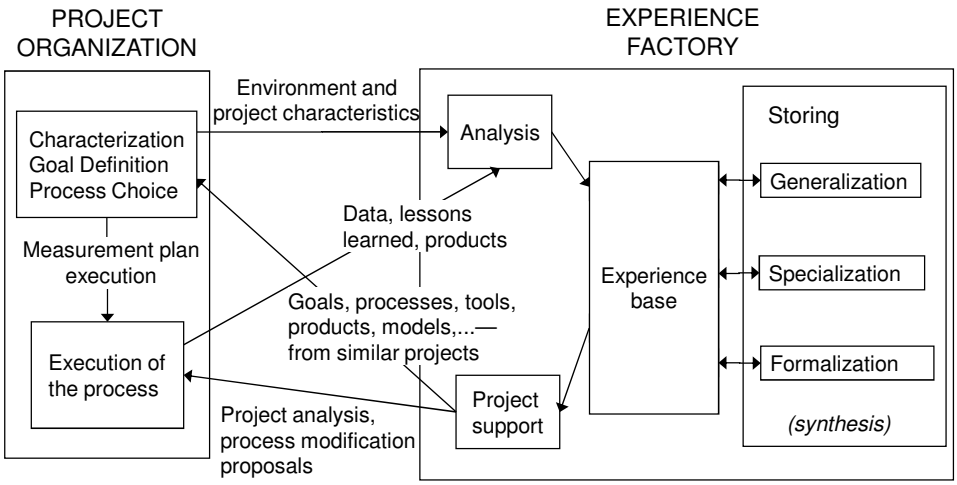
The Experience Factory

- A historic database (Experience Base) is needed to carry out assessments and comparisons
- The database must evolve to
  - tailor knowledge
  - generalize knowledge
  - allow for experience reuse
- Software engineers and managers need real-time indications, while organizations need post-mortem analyses.
- An infrastructure is needed: the Experience Factory

QIP and the experience factory



The Experience Factory



The Experience Factory

- The database contains
  - processes
  - products
  - documents
  - models
  - …
- The Experience Factory describes who must take care of measurement
  - a specific team
  - not the project team
  - the interactions between the measurement team and project team
- The Experience Factory is associated with costs
  - carry out a preliminary cost-benefits analysis

G/Q/M

- Process and product measurement must be carried out to reach **specific objectives**, closely related to the corporate and project objectives
  - *measurement for its own sake makes no sense*
- Existing models and measures cannot be reused as-is
  - it is necessary to verify if they are applicable to the specific case
- In the GQM paradigm
  - Top-down refinement of goals in metrics, via questions
  - Bottom-up interpretation and validation of the collected data, in the context at hand

Needed infrastructure technologies

- (Goal-oriented) measurement
- Explicit process modeling
- Comprehensive Reuse/Experience Factory

Introduction

- Software metrics
  - the usual principles of the metrics theory apply
- Measurements
  - techniques to measure software processes and products, in order to achieve a predefined goal
- Experiences
  - usefulness of metrics cannot be assessed out of context
  - there is no standard set of metrics
  - metrics have to be chosen, customized and used according to goals of interest and characteristics of the context

→ Measurement must be defined top-down.

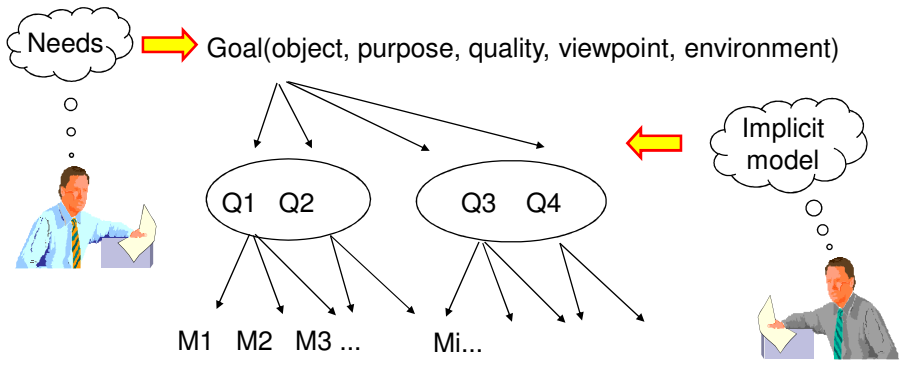
GQM at a glance

Objective of analysis	any process, product or model
Purpose	characterize, evaluate, forecast, explain, ...
Point of view	user, purchaser, developer, manager, company, ...
Paradigm	refine goals into questions and metrics
Options	select/tailor
Usage	quality and project management

Scope of GQM

- The GQM approach supports:
  - the operational definition of all kinds of measurement goals
  - their top-down refinement into metrics via questions
  - the explicit documentation of the refinement process
  - the participation of all expected beneficiaries in the goal definition and metrics identification process
  - the bottom-up interpretation of the collected data in the context of the goal
- Definition of goals and refinement can be guided by a set of templates and supported by tools.

GQM plan definition and execution



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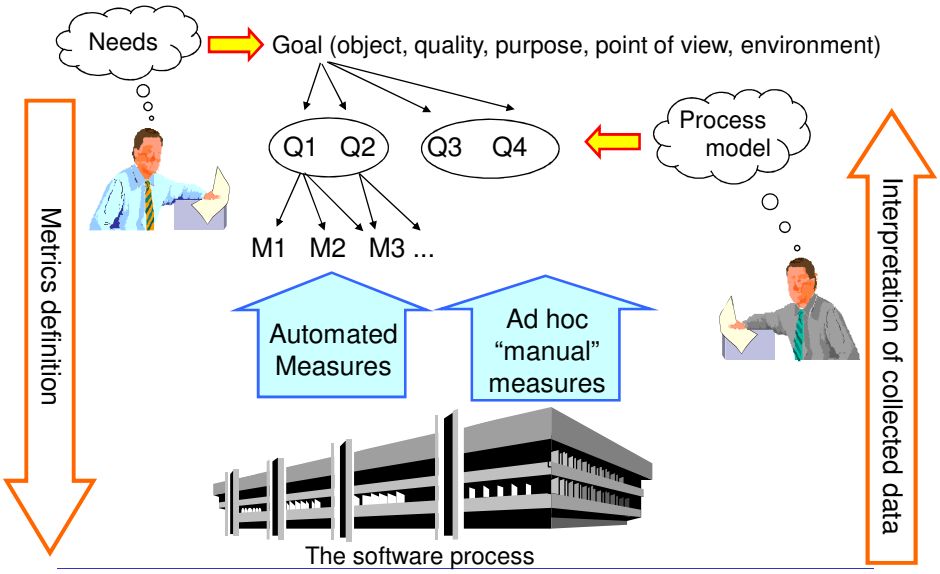


GQM plan structure

1. Goal defined for an object, for a variety of purposes, with respect to various models of quality, from various viewpoints, relative to a particular environment.
2. An abstraction sheet identifies the features to be measured, the factors that may affect the object's features, the current perceived situation and the way variation factors are believed to affect the observed qualities.
3. A set of questions operationally defines the goals (i.e., each part of the abstraction sheet)
4. A set of metrics is associated with each question to provide it with a quantitative answer.

Template for a GQM plan definition

- Analyze an object
  - (process, product, ...)
- for a purpose
  - (understand, evaluate, explain, optimize, control, certify, ...)
- with respect to a quality
  - (cost, correctness, safety, reliability, usability, effectiveness, ...)
- from a viewpoint
  - (user, purchaser, manager, developer, company, ...)
- in a given environment
  - (persons, resources, problems, ...)

Example

Analyze system testing method	[object]
for the purpose of evaluation	[purpose]
wrt defect removal effectiveness	[quality]
from the developers' viewpoints	[viewpoint]
in the context of ACME R&D laboratories	[environment]

Abstraction Sheet

- It is a high level view of the questions
- It is used to
  - acquire information from the project team
  - communicate information with people who do not participate in the experiment

GOAL	object	purpose	quality	point of view	environment
quality focus			variation factors		
baseline hypotheses			impact on baseline hypotheses		

Example - abstract sheet

GOAL	Object: system testing method	Purpose: evaluation	Quality: effectiveness of defect removal	Point of view: developers	Environment: ACME R&D laboratories
Quality focus ▸ system test • requirements • tests			Baseline hypotheses – detected anomalies • % of total existing anomalies • #tests per requirement		
Variation factors ▸ kind of product • size • programming language			Impact on baseline hypotheses – product size ⇧ ⇩ detected anomalies – prog. lang. level ⇩ ⇩ detected anomalies – #requirements ⇧ ⇩ detected anomalies		

Example - refinement

- Goal: analyse the effectiveness of the system testing
- Q1: How is the test defined?
  - M1: number of requirements
  - M2: Importance of each requirement
  - M3: Number of tests for each requirement
  - M4: Consistency between M2 and M3
- Q2: What kind of product is tested?
  - M5: LoC
  - M6: Programming language
- Q3: How many anomalies are detected?
  - M7: Number of detected anomalies
- Q4: Which is the cost of anomalies?
  - M7: Number of detected anomalies
  - M8: Effort in PersonHours to detect anomalies

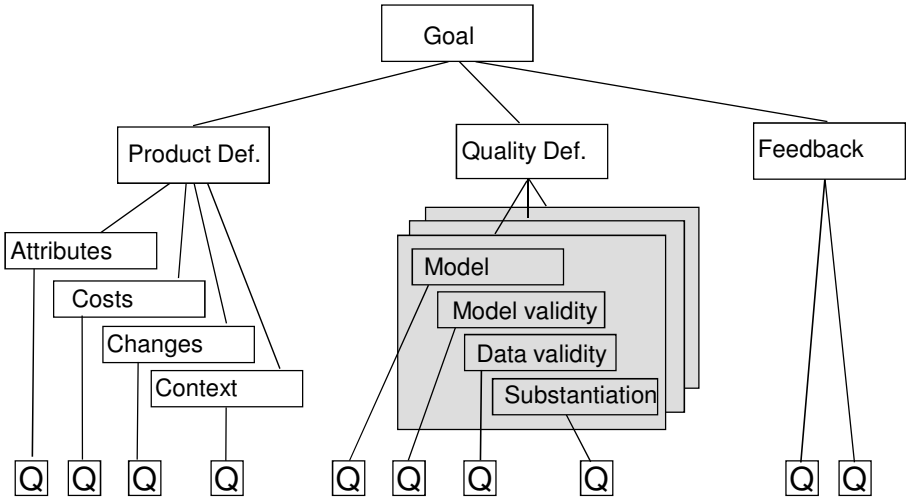
Guidelines for product-related questions

- Definition of the product
  - logical and physical attributes
    - quantitative characterization of size, complexity, ...
  - development cost
    - quantitative characterization of resources and effort spent
  - development changes
    - quantitative characterization of faults, failures, adaptations, enhancements, ...
  - operational context
    - quantitative characterization of users and their operational profile

Guidelines for product-related questions

- Definition of the quality perspective of interest (e.g., reliability, correctness, ...)
  - models used
  - validity of the model
  - validity of collected data
  - substantiation of the model
- Feedback (questions related to the improvement of the product)

Guidelines for product-related questions



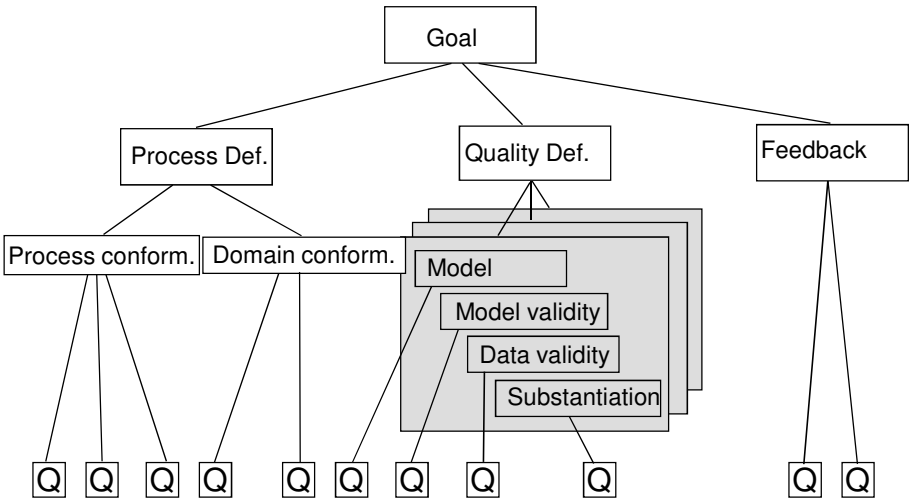
Guidelines for process-related questions

- Definition of the process
  - Process conformance
    - quantitative characterization of the process, and an assessment of how well it is performed
  - Domain conformance
    - quantitative characterization of the object to which the process is applied and an analysis of the performer's knowledge concerning the object

Guidelines for process-related questions

- Definition of the quality perspective of interest (e.g., cost, effectiveness, ...)
  - models used
  - validity of the model
  - validity of collected data
  - substantiation of the model
- Feedback (questions related to the improvement of the process)

Guidelines for process-related questions



Benefits of the GQM approach

- General applicability
- Metrics selection
- Metrics interpretation
- Reusability
- Tailorability
- Early validation
- Ownership
- Data protection/privacy

Types of metrics

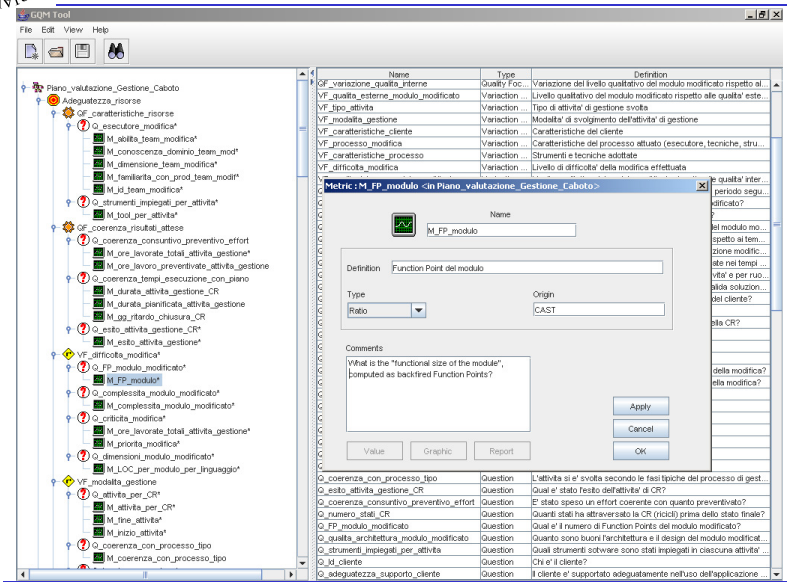
- Objective vs. subjective
  - e.g., LoC vs. knowledge of the problem
- Generic vs. specific
  - e.g., LoC v.s. lines of Ada code
- Complex vs. simple
  - e.g., number of anomalies vs. detection time, type, cause, effort to detect, effort to eliminate, etc. for each anomaly
- Direct vs. indirect
  - e.g., M6 = M4+M5
- Product vs. process

Types of metrics

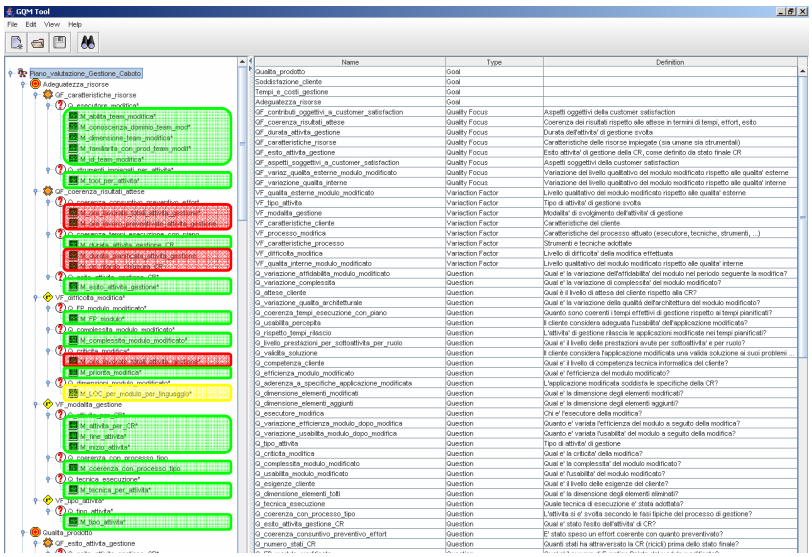
- Product
  - static attributes (e.g., size) → external measurement tools
  - dynamic behavior (e.g., reliability)
- Process
  - static attributes (e.g., size, complexity)
  - dynamic behavior (e.g., effort, faults)
  - plan adherence

- How to collect?
- automatically?
- via online forms?

The GQM tool



Feasibility of metrics



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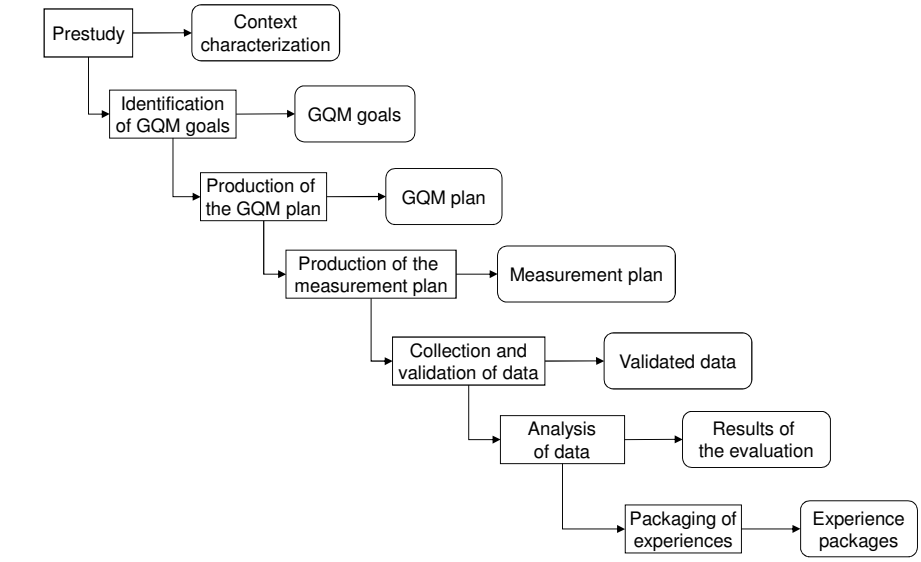
The GQM process

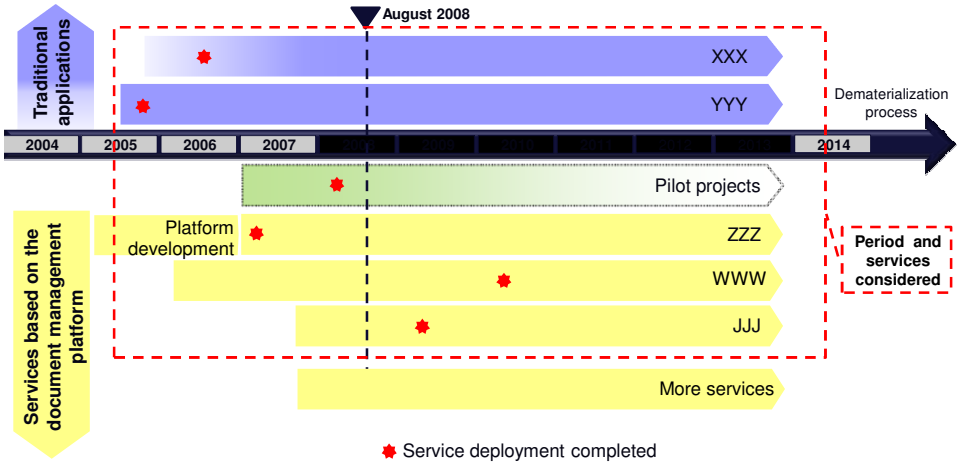


Running example

- In the following slides we make reference to a specific evaluation case, concerning the evaluation of dematerialization initiatives in a PA.

Context: the dematarialization process

Dematerialization process started. Objective: to base the whole PA document management on a single platform.



Context: definition of the characteristics of the analysis

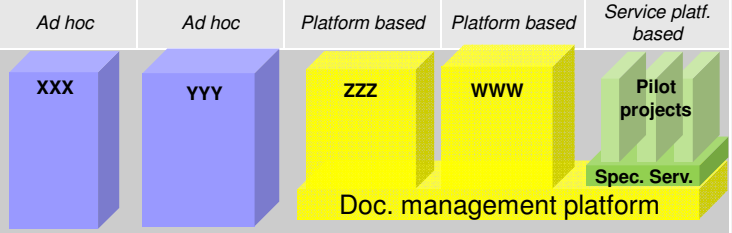
- What is the goal?
  - Assessing costs and benefits of the dematerialization initiative
  - How?
    - By evaluating the costs and benefits (in euro) of services
- Scope:
  - 5 initiatives identified as sufficiently mature to be analyzed:
    - 2 services based on older (ad-hoc) technology
    - The pilot project developed on the new platform
    - 2 new services developed on the new platform
  - Trade-off: multiplicity of services analysed guarantees that the results are representative vs. cost of analysis
- Time period:
  - From the beginning of the analysis to date
  - Plus, projection of costs and benefits in the future (3 years)

Context: definition of the characteristics of the analysis

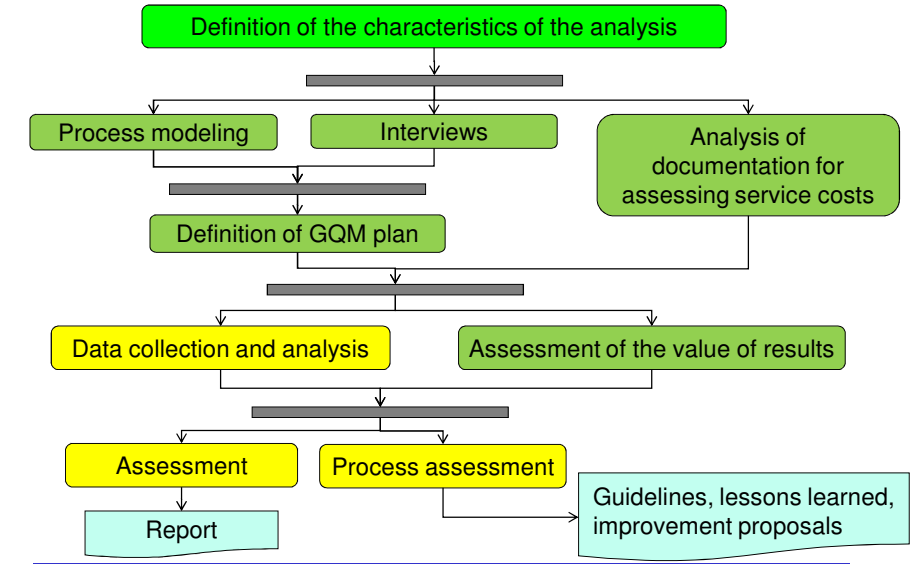
- Strategic goals to be evaluated:
  - Efficiency
  - Trasparence
  - Simplification
  - Resource usage and savings
- Point of view:
  - Internal (i.e., the potential benefits to the public were not to be considered)

Context: object of the analysis

	XXX	YYY	ZZZ	WWW	Pilot projects
diffusion					
Application	*Ad hoc*	*Ad hoc*	*Platform based*	*Platform based*	*Service platf. based*
Stakeholders	PA, diretorates	PA, diretorates, Accounting dept., Finance dept., Banks, suppliers	diretorates	diretorates, president secretary, Accounting dept.	Directorates, Citizens, Companies, PA, other external actors



Whole process



Goal 1

- Object: (introduction of) the five selected services
- Purpose: evaluation
- Quality: (increase of) efficiency
- Viewpoint: management
- Environment: PA

Goal 2

- Object: (introduction of) the five selected services
- Purpose: evaluation
- Quality: (increase of) transparency
- Viewpoint: management
- Environment: PA

Goal 3

- Object: (introduction of) the five selected services
- Purpose: evaluation
- Quality: (increase of) simplification
- Viewpoint: management
- Environment: PA

Goal 4

- Object: (introduction of) the five selected services
- Purpose: evaluation
- Quality: resource usage and savings
- Viewpoint: management
- Environment: PA

Goal 1: Questions

- How many processes per month are completed?
- What is the duration of each process?
- What is the percentage of processes whose execution involved problems?
  - Problems can explain longer processes
- How long do processes remain in states that are necessarily executed manually (i.e., that cannot be automated)?
  - This explains to what extent a process duration can be shortened.
- These questions must be answered before and after the introduction of dematarialization.

Goal 1: Metrics

- Number of processes completed per month
- Duration of each process state, i.e., how long did each process instance remain in a given state.
  - If a process instance enters twice the same state (because of an iteration), the durations must be recorded separately
- Classification of process states in manual or automated
  - or eliminated, after the introduction of dematarialization.
- From the above data we can derive:
  - Number and duration of seamless processes
  - Number and duration of processes involving one or more iterations
  - Time spent in “manual” states

Descriptive statistics

- Usual descriptive statistics are used to present the data in a comprehensible form:
  - Mean and variance
  - Median, min, max, and quartiles
    - Tipically represented via a boxplot
  - ...

Goal 2: Questions

- To what extent are processes observable? I.e., to what extent it is known in which state is currently a process?
- What is the delay between a change in state and the observability of the new state?
- To what extent is the information produced within the process available?
- What is the delay between the production of information and its availability?
- What is the level of detail of the available information (with respect to user needs and expectations)?
- *Note: it could have been possible to define transparency via different questions. These are the ones that appeared most suitable for the specific case.*

- These questions must be answered before and after the introduction of dematarialization.

Goal 2: Metrics

- The metrics of goal 2 are very close to the questions:
  - Evidence of process state
  - Delay of new state observability
  - % of interesting information that is made available
  - Delay of new information availability
  - Level of detail of the available information
- All the metrics are evaluated subjectively. In fact, here it is the point of view of the user that is relevant.
  - E.g., if an information is produced but not actually made accessible to the user, it cannot be considered “available”
- In most cases, it is necessary to collect samples
  - Samples of process instances
  - Samples of users

Goal 3: Questions

- How much activity has been automated?
- How much paper document have been made useless or converted into electronic information?
- How many paper document transfers have been eliminated?
- How many documents have been made available to satisfy user needs simply and immediately?
- To what extent have processes been standardized?

Goal 3: Metrics

- Number and mean duration of automated activities
- Number and mean duration of activities that are no longer needed
  - E.g., photocopying paper documents
- Number, type and volume of paper documents no longer needed
- Number of electronic data transfers
- Number and type of documents that are made available immediately and simply to users
  - E.g., certified receipt at the conclusion of a payment process
- Number of standardized activities
- Number of standardized documents

Goal 4: Questions

- How many person hours (per role) are required to carry out the processes?
- What is the amount of paper used?
- What is the amount and cost of devices used in the processes?

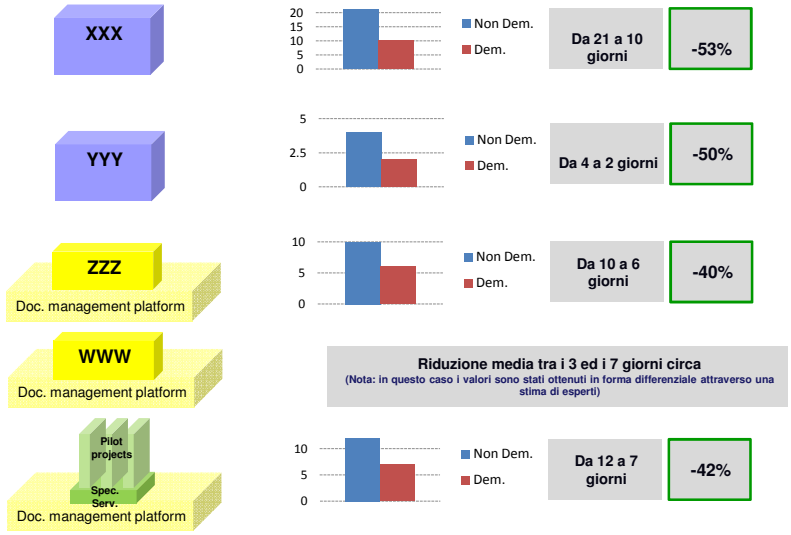
Goal 4: Metrics

- FTE involved, per role
- For each process instance: effort required, per role
  - Classifying the process instance as: “smooth”, “problematic”, “anomalous” (it required an ad-hoc manual solution)
- For each process instance: how many paper sheets are used
- Number, type, and cost characterization of employed devices
  - E.g., printers, copiers, scanners, ...

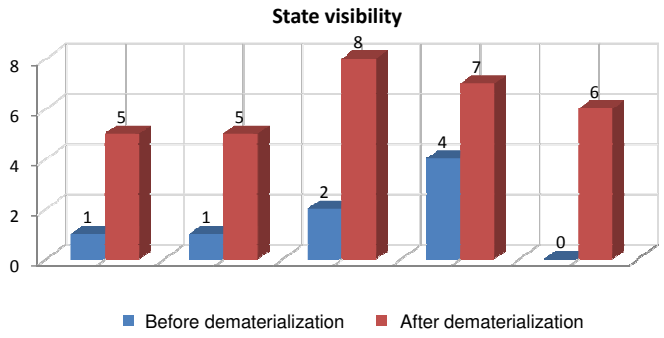
Observation

- It is easy to observe that many questions and metrics can be used:
  - To evaluate the improvement (measures after dematerialization wrt measure before the dematerialization)
  - To perform continuous monitoring of the process
    - For timely identification of problems
    - For the computation of trends
    - In general, for quantitative (evidence-based) management

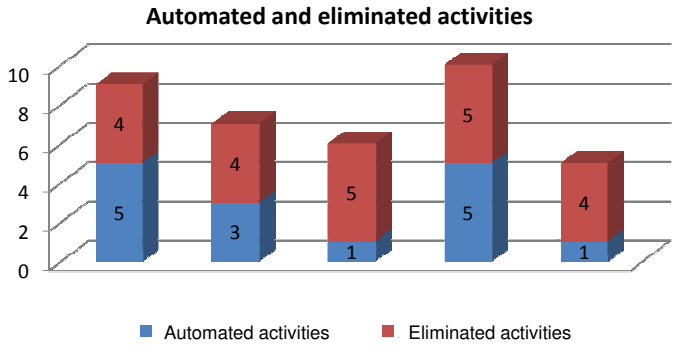
Goal 1 (efficiency): results



Goal 2 (transparency): results



Goal 3 (simplification): results



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Warning

- The case study is much simpler than the example discussed above
- To make the tool explanation manageable, we need a small example ...

Case study definition

- Context: A software development organization
- Process being considered: estimation of the development effort
- Current practice:
  - Usage of COCOMO-like estimation methods, based on size only.
    - Measure of size used: UFP (unadjusted function points)
- Problem:
  - The precision of the estimation (actual-estimated) is too big.
  - This leads to the creation of unrealistic plans, which –in their turn- lead to problematic project management

Estimation error

- According to COCOMO, the estimate of the development effort can be obtained by means of the following formula:

$$Effort = a\ Size^{b}$$

- However, the estimate you get is always affected by some error:

$$Effort = a\ Size^{b}\ (1+ REffortErr)$$

where REffortErr is the relative effort estimation error.

  - For COCOMO-like methods, we can safely assume REffortErr = 20% or more, on average.

Case study: overall objective

$$Effort = a\ Size^{b}\ (1+ REffortErr)$$

We want to reduce this error

This “error” accounts for the fact that there are other factors –beside size- that affect the development effort

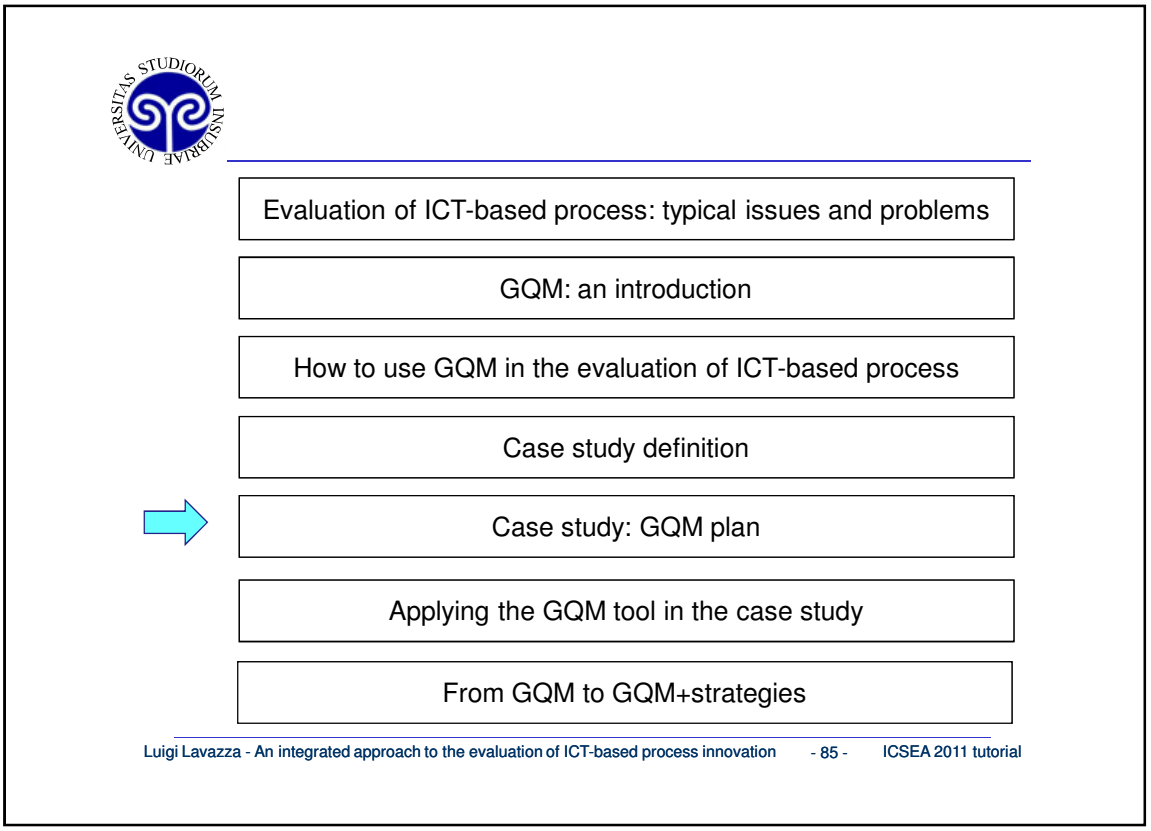
How?

We assume that the following holds:

$$Effort = a\ Size^{b}\ (1+ REffortErr) =$$
$$Effort = a\ Size^{b}\ Complexity^{c}\ (1+ REffortErr')$$

If complexity actually affects development effort, then this term is closer to actual effort ...

... and REttortErr’ < REffortErr



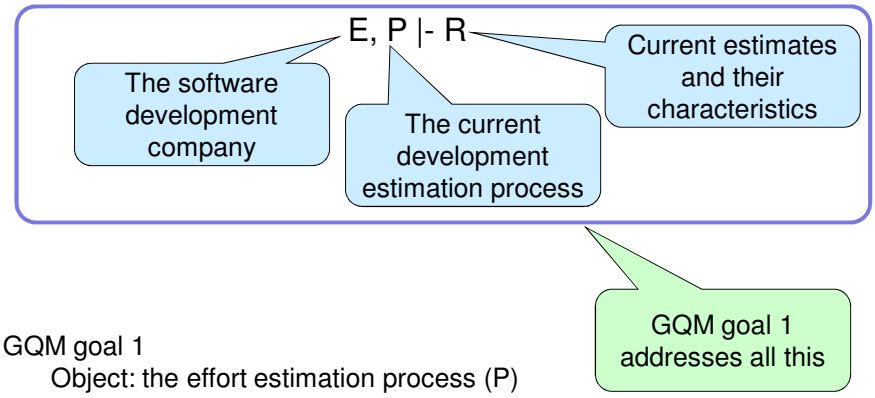
First goal

- In general, REffortErr is not known *precisely* in advance.
  - It may be known that it is too big: that is the starting point of the process improvement initiative.
- So, it is reasonable that a first goal of the company concerns evaluating the actual precision of effort estimates as obtained through the current estimation procedures.
- GQM goal 1
  - Object: the effort estimation process
  - Quality: precision of estimates
  - Purpose: quantitative evaluation
  - Viewpoint: software development managers
  - Environment: the SW development company

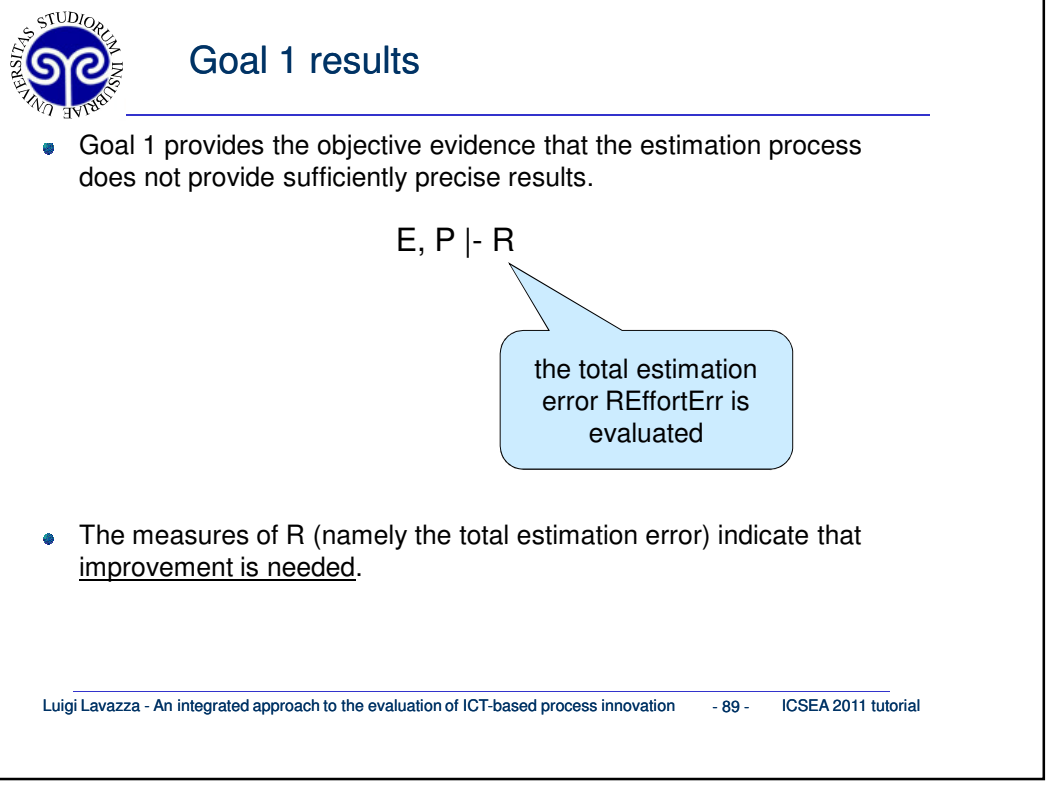
Note

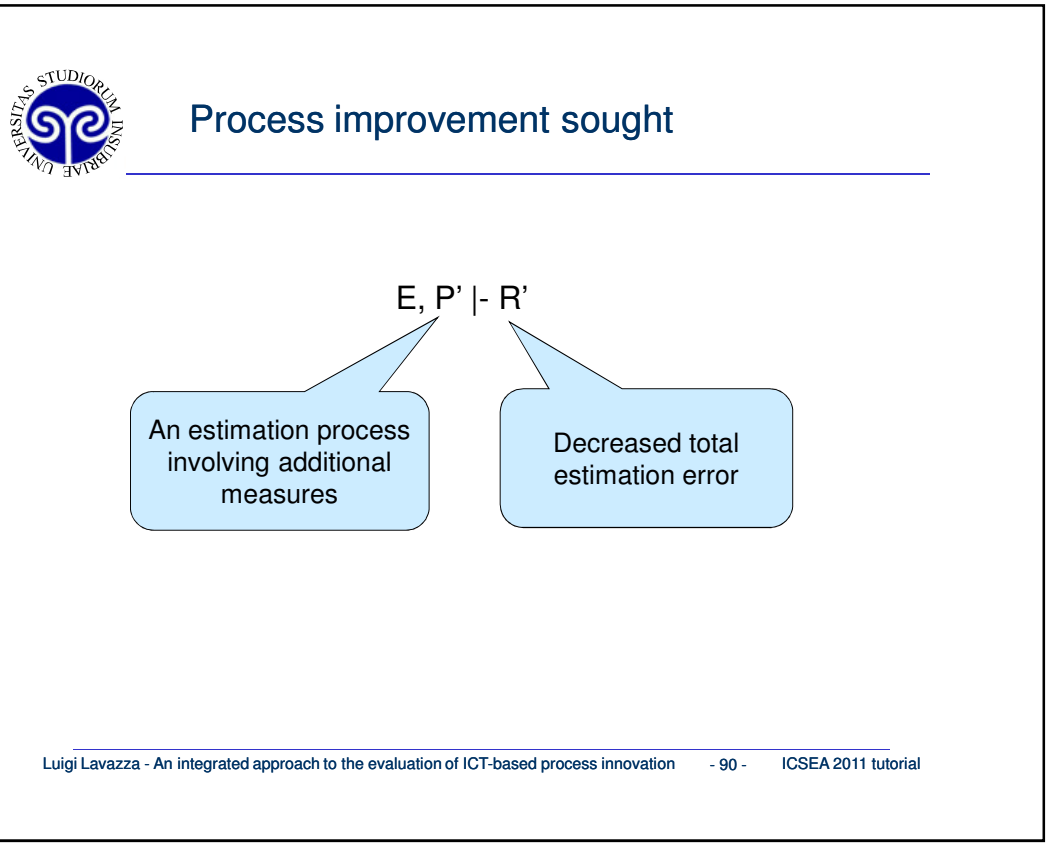
- It is quite common to have a goal exclusively devoted to evaluation before proceeding to improvement.
- The objective is twofold:
  - To be sure that the problem exist and that it is relevant enough to deserve specific process improvement actions.
  - To provide data about the situation to be improved. In fact, in general we need to prove that the process has actually improved by comparing the performance after the change with the original performance.

Formal statement of objectives



GQM goal 1
Object: the effort estimation process (P)
Quality: precision of estimates (R)
Purpose: quantitative evaluation
Viewpoint: software development managers
Environment: the SW development company (E)


Goal 1 results
Goal 1 provides the objective evidence that the estimation process does not provide sufficiently precise results.
E, P |- R
the total estimation error REffortErr is evaluated
The measures of R (namely the total estimation error) indicate that improvement is needed.
Luigi Lavazza - An integrated approach to the evaluation of ICT-based process innovation - 89 - ICSEA 2011 tutorial


Process improvement sought
E, P' |- R'
An estimation process involving additional measures
Decreased total estimation error
Luigi Lavazza - An integrated approach to the evaluation of ICT-based process innovation - 90 - ICSEA 2011 tutorial

Defining a new process

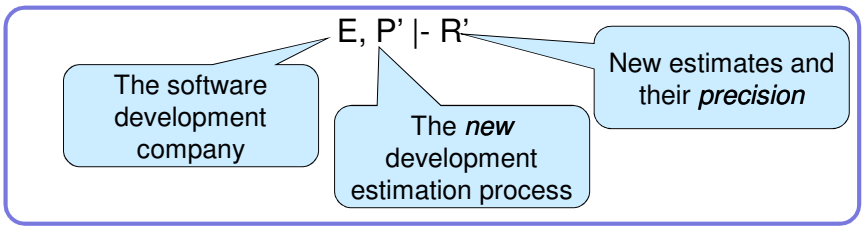
- A new estimation process that satisfies the given objectives involves measuring the size *and complexity* of requirements:

$$\text{Effort} = a\ \text{Size}^b\ \text{Complexity}^c$$

- Note: other factors could be considered, in principle.

Second GQM goal

- Evaluate improvement in estimation error due to new estimation process



Other possible goals

- Meta-goals:
  - How much does the new process cost?
  - How long does it take?
  - How many employees can carry out the estimation?
  - How long does it take to learn the new estimation process?
  - …
- Meta-goals are important because results are reliable only when the new process is fully and correctly implemented.
- However, in our example we do not include GQM goals addressing meta-goals.

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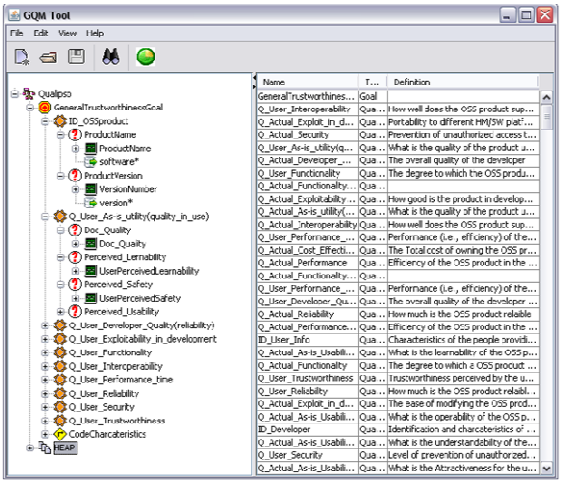
The GQM tool

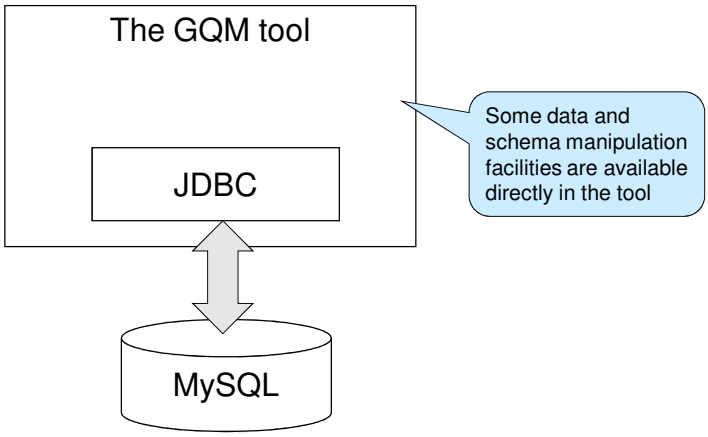
- An open-source, multi-platform tool



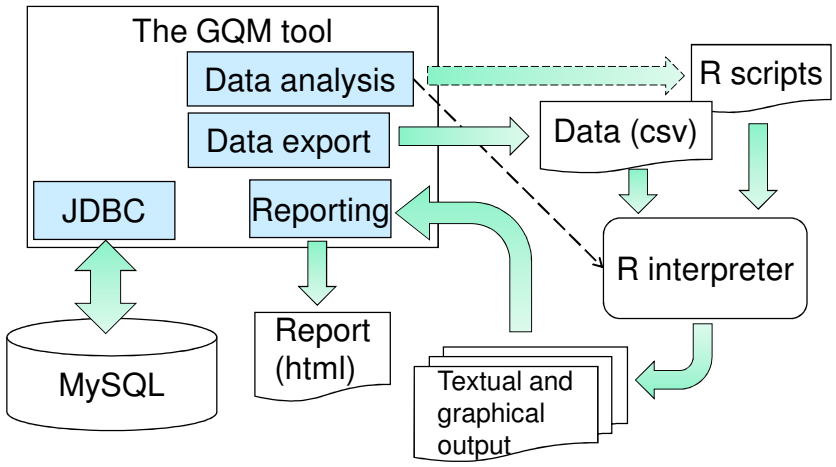
Technologies used

- Java
- MySQL
- JDBC
- R
- OpenCSV

DB integration



Data analysis integration



Live tool demo

Evaluation of ICT-based process: typical issues and problems

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GQM+strategies: foundations

- The GQM + Strategies methodology moves from the observation that E, P |- R provides a relatively narrow representation of improvement problems and programmes, which often involve strategic initiatives.
  - For instance, the changes to P may involve just a single activity carried out by a single role, or the whole process.

Strategies

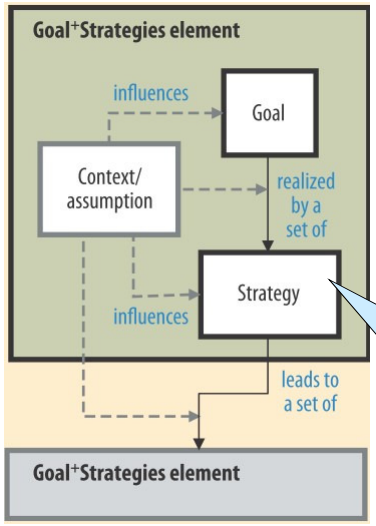
- A strategy allows achieving a given goal in a given context:

  Context, Strategy |- Goal

- Given a context and a goal, the strategy is the “solution” that –in the given context and under some assumptions– satisfies the goal.
  - However, implementing the strategy can itself be considered a goal of a lower level strategic action …
  - It is thus possible to create a hierarchy: a solution strategy becomes a goal to be satisfied in a different context (maybe the same context, but refined to take into consideration “lower level” details).
    - Complex improvement initiatives are better modelled hierarchically:

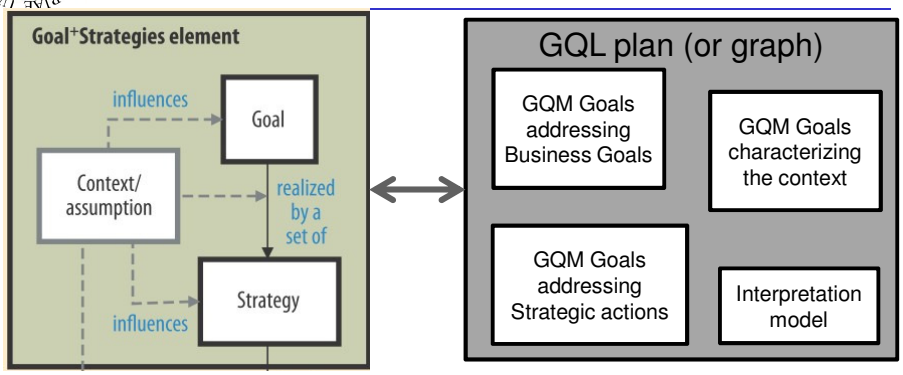
      E, P1 |- R
      E, P2 |- P1
      E, P3 |- P2
      …

GQM + strategies



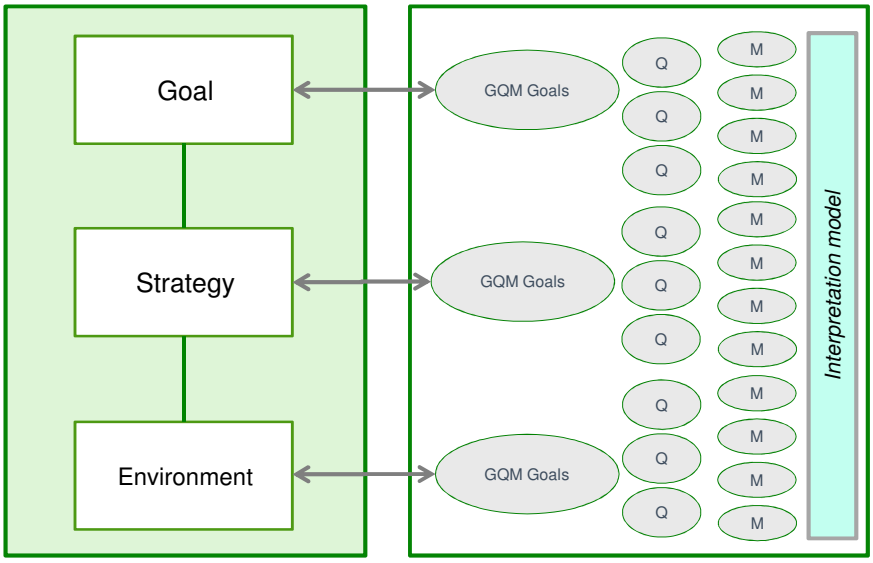
Unlike in software development, in a strategy definition, implementation details can be given

GQM+strategies: here come the measures



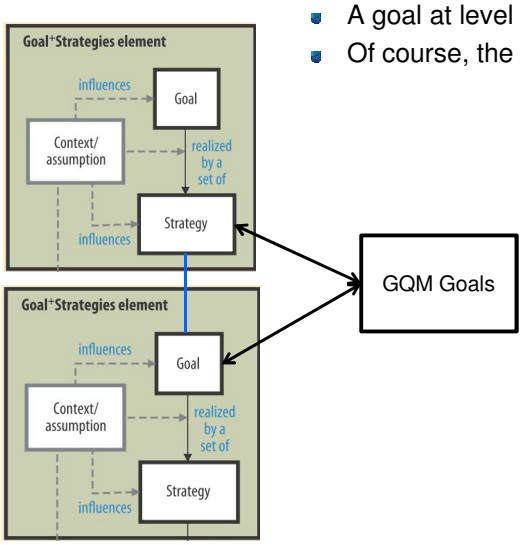
- Differences with respect to Basili et al.:
  - A GQM goal for each component of the Goal+Strategies element, instead of "a single GQM goal that measures a Goal+Strategies element and its corresponding questions, metrics, and interpretation models."
  - Rationale: it is interesting to know a) if the strategic actions were performed; b) if the context worked as expected (did some condition affect the usual cause-effect relationships that should make the strategy work?); c) if the business goal was achieved, and to what extent.

GQM + Strategies



Hierarchical goals and measures

- A goal at level n can be a strategy at level n-1.
- Of course, the measure is the same!



Some economy of scale

- The nodes are related semi-hierarchically. A goal can have several associated measurement goals, each of which is the basis for an entire GQM graph.
- However, *different GQM structures are likely to use some of the same questions and metrics*, and interpretation models might combine data from different GQM structures, thus optimizing metrics collection.
- The results of the lower-level interpretation models feed into the higher-level ones to provide feedback on lower-level goal achievement.

Dealing with uncertainty

- The context includes
  - Factors (known with certainty)
    - These are mainly cause-effect relations that are known to hold in the environment
  - Assumption (uncertain)
    - Almost everything, from manager intuitions to urban legends
- Accordingly, we could say that

$$Context_F, Context_A, Strategy \vdash Goal$$

- Of course, assumptions need to be verified. Thus, we need GQM goals to check that assumptions are true.
  - A good strategy may be well implemented and fail because of wrong assumptions …

GQM+Strategies: references

- Basili, V., Lindvall, M., Regardie, M., Seaman, C., Heidrich, J., Munch, J., Rombach, D. and Trendowicz, A. (2010) "Linking Software Development and Business Strategy Through Measurement" *Computer*, vol. 43, no. 4, pp. 57-65.
- Victor Basili, Jens Heidrich, Mikael Lindvall, Jürgen Münch, Carolyn Seaman, Myrna Regardie, Adam Trendowicz, "Determining the Impact of Business Strategies Using Principles from Goal-oriented Measurement", *Business Services: Konzepte, Technologien, Anwendungen. 9. Internationale Tagung Wirtschaftsinformatik*. Books OCG. Vienna, Austria: Österreichische Computer Gesellschaft.
- Victor Basili, Jens Heidrich, Mikael Lindvall, Jürgen Münch, Myrna Regardie, Adam Trendowicz, "GQM + Strategies – Aligning Business Strategies with Software Measurement ", ESEM '07 - First International Symposium on Empirical Software Engineering and Measurement.
- Vladimir Mandic and Markku Oivo, "SAS: A Tool for the GQM+Strategies Grid Derivation Process", PROFES 2010, Springer-Verlag LNCS 6156, 2010.

GQM+Strategies in our case study

- Nobody wants to improve the precision of development effort estimates just to prove that he/she is good at it!
- There must be some important* reasons behind such need.

  * usually, "important" means "related to earning or saving money"
- In our case, it is easy to imagine a hierarchy like the following:
  - High-level goal: reduce cost of development
  - Strategy: use more effectively the available resources
  - Second level goal: improve resource allocation planning
  - Second level strategy: achieve a better understanding (estimation) of how many resources will be needed, and when.
  - Third level goal: decrease effort estimation error
  - Third level strategy: base effort estimation on both size and complexity of requirements.

The goal hierarchy

Goal: reduce cost of development

Strategy: use available resources more effectively

Development cost is increased by bad resource allocation. E.g., the need for more resources is discovered during project execution.

Plans based on reliable estimates of resource needs lead to more effective usage of resources

Goal: improve resource allocation planning

Strategy: better estimation of how many resources will be needed, and when

Planning depends heavily on the estimation of resource needs

Better estimates can be achieved in various ways. In our case we are constrained to use current models, but with smaller error.

Goal: decrease effort estimation error

Strategy: base effort estimation on size and complexity measures of reqs

Estimates based on size and complexity measures of requirements are affected by smaller errors than those based on SW product size.

Thanks for your attention!

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