GQM: Goal Question Metrics

Introduction

Main reference

"Understanding Measurement and Practical Implementation of GQM", V. R. Basili, C. B. Seaman, 2010

Leveraging Measurement

- Many organizations collect a lot of data
  - Effort spent on a project or task
  - Lines of code written
  - Expertise of people involved in a project or task
  - Defects in the product at a given development phase
  - ...
- Collecting data is expensive
  - Need to plan measurement, produce procedures, train people, instrument production environments, analyze and elaborate data..
- Measurement must not be a goal per se
- Measurement must be the means to an end
  - Characterize and Understand (e.g. descriptive and analysis models)
  - Evaluate and Predict (Evaluation and prediction models)
  - Improve (prescriptive models)

Leveraging Measurement

- Why do organizations measure?
  - Gain insight in their business
    - Build baselines
    - Find correlations
    - Identify critical factors
  - Manage and control based on evidence
    - Plan and estimate
    - Track and monitor
    - Make runtime decisions
  - Improve and Optimize
    - Prioritize
    - Assess
    - Package experience for future reuse

Leveraging Measurement

- Some questions that measurement should answer
  - How much is this going to cost?
  - Is everything going fine?
  - Is this issue common?
  - What should I do now to mitigate the issue?
  - Is the product going to meet the expected non functional requirements?

Leveraging Measurement

- What can we model and measure?
  - Resources
    - E.g. Resource allocation models...
  - Changes/Defects
    - E.g. Defect prediction models, requirements change rate...
  - Product
    - E.g. Actual vs expected product size, number of components...
  - Processes
    - E.g. Waterfall...
  - Quality
    - E.g. Reliability models...
  - ...

GQM: Goal Question Metrics

- An Approach to Software Measurement
  - Goal-driven measurement
    - Define your goals (objectives) first
    - Derive questions to refine the goal and address the goal
    - Define metrics that, when collected, can answer the questions
  - Evidence-based
    - Build interpretation models to check the achievement of goals against collected measures
  - Context-aware
    - Make assumptions and context factors explicit

GQM Template: Definition of Goals

- Mechanism for defining and interpreting measurable goals
  - Object of study
    - E.g. A process (unit testing), a product (requirements artifact)...
  - Focus
    - E.g. Performance, number of detected defects, cost
  - Point of view (perspective)
    - E.g. Developer, project manager, researcher...
  - Purpose
    - E.g. Characterize, predict...
  - Context
    - E.g. Environmental constraints, project characterization...

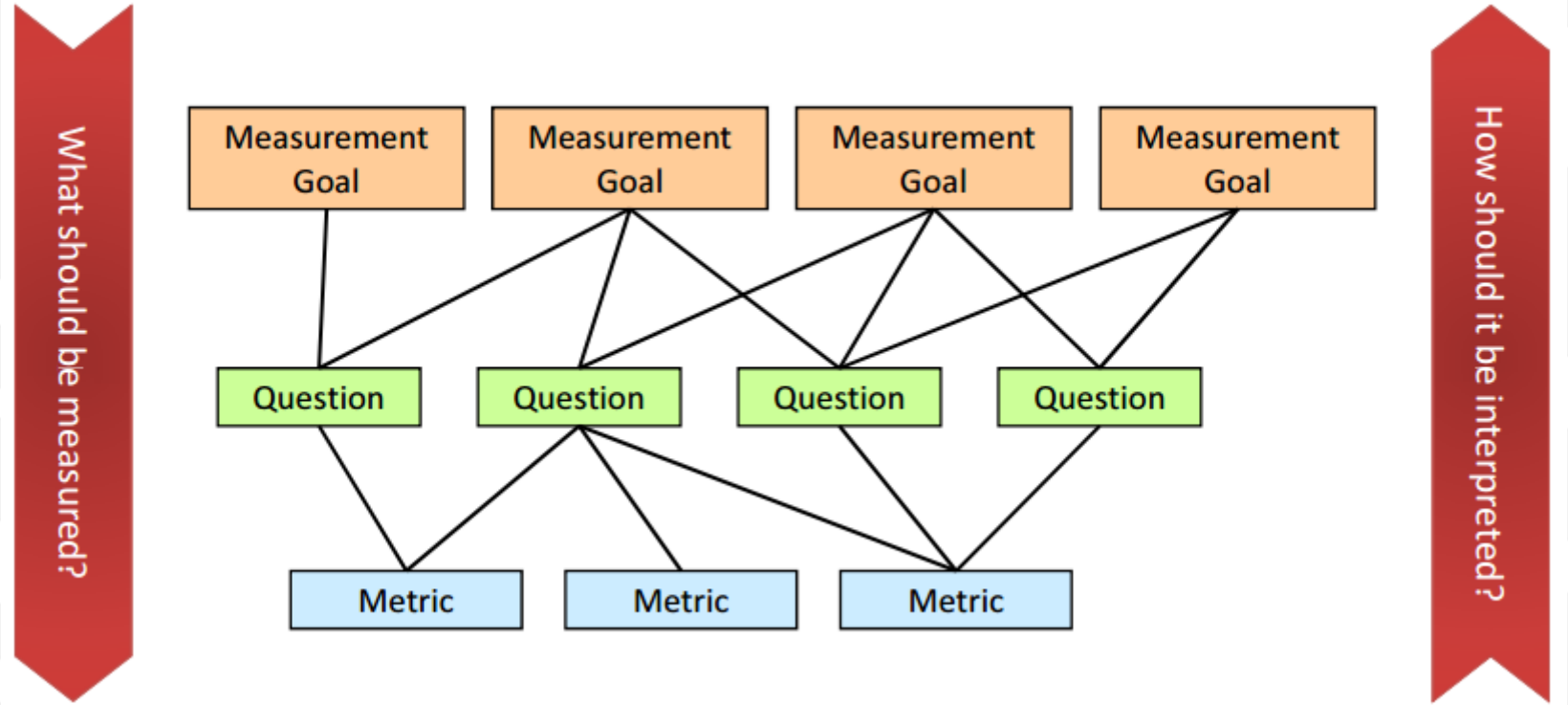
GQM Questions

- Specify the required information that help to achieve the goal
  - Natural language
- Questions should refine the goal to such an extent that it is completely specified and quantifiable
  - Need understanding of the problem and of the context
    - The “point of view” is relevant to the definition of questions
  - Interviews with experts can be a way to build questions
    - Questions can be used to build a baseline for improvement

GQM Metrics

- Answer the questions
- Easy to collect
  - Collecting is a cost
    - May require changes in the current process
- Can be reused to answer multiple questions or to satisfy multiple goals

GQM in a Nutshell



GQM Abstraction Sheet

- Tool for
  - Refining and structuring goals and identify metrics
  - Eliciting information during interviews

Object of study	Purpose	Focus	Point of view
Quality Focus		**Variation factors**	
What are the possible metrics for measuring a goal object?		*Which factors influence the possible metrics?*	
Baseline hypotheses		**Impact of variation factors on baseline hypotheses**	
What's the current knowledge or expectations about metrics?		*How could variation factors influence the metrics?*	

An Example: Product Measurement

- A company C is about to develop a new product
- C wants to create a repository for it
  - C needs to characterize such product with respect to a variety of attributes
    - Logical, Physical, Cost, Changes, Defects, Customer satisfaction
- C will deliver the product to a variety of customers with different “profiles”
- C wants to know each class of customers’ satisfaction
- C wants to predict the reliability of the product for each customer class

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Examples of GQM Template

1. Analyze the final product for the purpose of characterizing it with respect to logical, physical, cost, changes and defects from the point of view of C

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1. Analyze the final product for the purpose of characterizing it with respect to logical, physical, cost, changes and defects from the point of view of C
2. Analyze the final product for the purpose of evaluation with respect to customer's satisfaction from the point of view of various customer classes

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Examples of GQM Template

1. Analyze the final product for the purpose of characterizing it with respect to logical, physical, cost, changes and defects from the point of view of C
2. Analyze the final product for the purpose of evaluation with respect to customer's satisfaction from the point of view of various customer classes
3. Analyze the final product for the purpose of predicting with respect to reliability from the point of view of various customer classes

Example of GQM Questions (and Metrics)

- Goal 1
  - Analyze the final product for the purpose of characterizing it with respect to **logical, physical**, cost, changes and defects from the point of view of C
- For example
  - What's the size of the product?
    - Pages/lines of user documentation or source code
    - …
  - What's the complexity of the product?
    - Cyclomatic complexity
    - Data complexity
    - …
  - What's the resource consumption of the product?
    - …
  - …

Example of GQM Questions (and Metrics)

- Goal 1
  - Analyze the final product for the purpose of characterizing it with respect to logical, physical, **cost**, changes and defects from the point of view of C
- For example
  - What's the development effort by phase?
  - What's the involved personnel?
  - What's the used machine time?
  - What's the calendar time required to develop?
  - …

Example of GQM Questions (and Metrics)

- Goal 1
  - Analyze the final product for the purpose of characterizing it with respect to logical, physical, cost, **changes** and defects from the point of view of C
- For example
  - What's the number of enhancements?
    - Per unit of time
    - Per phase
    - Per category
      - Type of enhancement
      - Size (number of changed lines of code, number of affected components)
      - …
  - How many customers are affected?
  - …

Example of GQM Questions (and Metrics)

- Goal 1
  - Analyze the final product for the purpose of characterizing it with respect to logical, physical, cost, changes and **defects** from the point of view of C
- For example
  - What's the number of bugs?
    - Per type
    - …
  - What's the frequency of errors?
  - What's the number of failures?
    - By severity
    - Per unit of time
    - Per customer class
    - …
  - …

Example of Context

- And what about the «context» dimension?
- For example, consider:
  - Customer community
    - What classes of customers are expected to use the system?
    - What is the matrix of functional requirements vs. customer classes?
  - Operational profile
    - What percent of the system is expected to be executed by each customer class?

One More Example: Process Measurement

- Analyze the unit test method U for the purpose of evaluating it with respect to **defect slippage** from the point of view of Unit Tester

Object of study	Purpose	Focus	Point of view
Unit test method U	Evaluation	Defect slippage	Unit tester
Quality Focus		**Variation factors**	
DD: Percentage of detected defects *HSSD: Estimated percentage of high severity slipped defects*		*V1: Experience of coders with used technologies* *V2: Experience of unit testers with product domain* *V3: Use of condition coverage criteria*	
Baseline hypotheses		**Impact of variation factors on baseline hypotheses**	
DD = 80% *HSSD = 15%*		*Increase of DD when increasing V1* *Decrease of HSSD when increasing V2* *Increase of DD when V3 is true*	

Interpretation Model

- We defined goals, asked questions and identified metrics.
- Next step: collect measures
  - Now that you have measures, what do they mean?
  - Hypothesis: you wanted to reduce cost by 10%
  - Some actions were taken by leveraging the GQM approach
  - Three cases
    - Cost reduction is 7%
    - Cost reduction is 11%
    - Cost reduction is 4%
  - So what?
  - Without an interpretation model, measures do not objectively indicate whether the goal was met

Interpretation Model

- An interpretation model defines the expected mathematical bounds on the metric and the interpretation of the values of the metrics in order to answer the targe question
- For each metric
  - Estimate the expected value
    - Historical data
    - Prior data on the current project
    - Proxy estimate (indicators)
    - Expert estimate
  - Identifies ranges of acceptance
    - Use known distributions (e.g. normal)
    - Use some form of regression or computation on proxy data
    - Expert estimate

Example of Interpretation Model

- Evaluate unit test method U
  - Expected DD_{new}: 80%
  - Current DD_{old} without U: 70%
  - Interpretation model:
    - If $DD_{new} = DD_{old} \pm 5\%$ then U should be better investigated
    - Else if $DD_{old} < DD_{new}$ then U should be institutionalized
    - Else if $DD_{old} > DD_{new}$ then U should be rejected