Lecture 4: Measurement scales and functions that can be applied to scales

Measurement scales and functions that can be applied to scales

Mapping

- Attribute values $->$ numbers or symbols
- Attribute value domain $->$ range
- Empirical relation $->$ mathematical relation

Scales

Measurement Scales

- A measurement scale is a class of mapping that links empirical and number relations with specific properties

Measurement Scales

- Best possible numerical relation system?
- Representation of an empirical relation in a numerical system?
- Choosing a unique (and best) number system?

Measurement Scales

- Qualitative Scales
  - Nominal (gender)
  - Ordinal (arrival order)
- Numeric/Continuous Scales
  - Interval (temperatures in F)
  - Ratio (height)
  - Absolute (the actual count)

Measurement Scales

- Language(Program) = 1, if Program is written in Pascal
- Language(Program) = 2, if Program is written in C
- Language(Program) = 3, if Program is written in Fortran

Few mathematical operations are applicable (mode, histograms, . . .)

Measurement Scales

- Difficult(Program) = 1, if Program is easy to read
- Difficult(Program) = 2, if Program is not hard to read
- Difficult(Program) = 3, if Program is hard to read

We can have the median here...

Measurement Scales

- Nominal measure label variables without any quantitative value. Ex., Eye color.
- Ordinal measure categorize data in natural order. Size of steps between items is unknown. Ex., Customer satisfaction
- Interval measures preserve differences but not ratios. Ex., The absolute time when an event occurred.
- Ratio measures preserve also the ratio between entities. Ex., LOC in a program. *All math operations are applicable.*
- Absolute measures are counts. Ex., the number of if statements in a program.

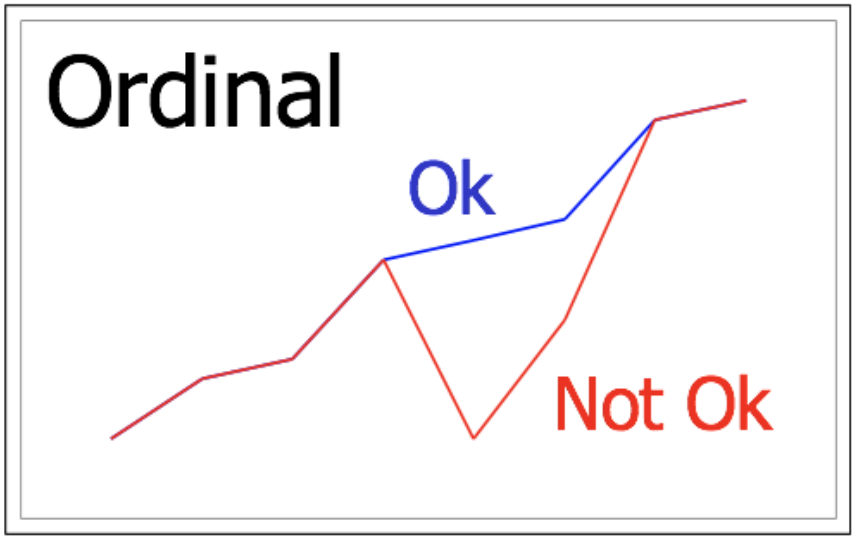
Table 2.8: Summary of measurement scales and statistics relevant to each (Siegel and Castellan, 1988

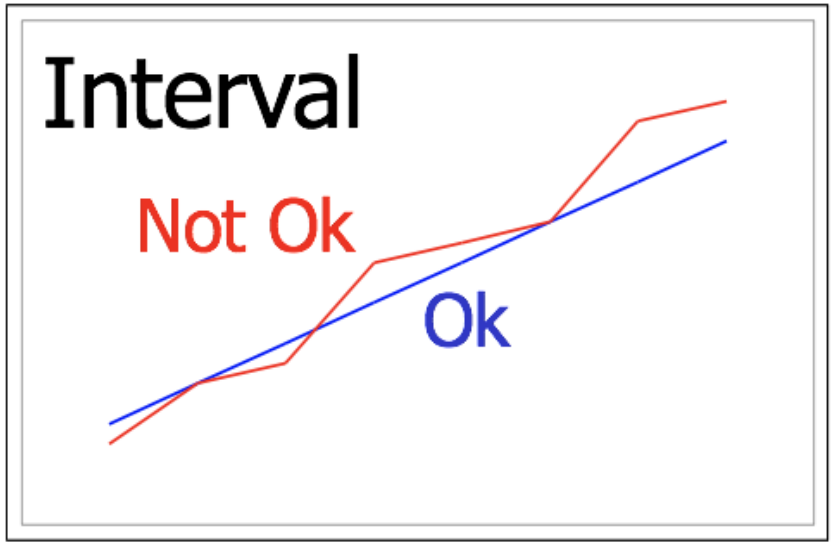
Scale type	Defining relations	Examples of appropriate statistics	Appropriate statistical tests
Nominal	Equivalence	Mode Frequency	Non-parametric
Ordinal	Equivalence Greater than	Median Percentile Spearman r Kendall τ Kendall W	Non-parametric
Interval	Equivalence Greater than Known ratio of any intervals	Mean Standard deviation Pearson product-moment correlation Multiple product-moment correlation	Non-parametric
Ratio	Equivalence Greater than Known ratio of any intervals Known ratio of any two scale values	Geometric mean Coefficient of variation	Non-parametric and parametric

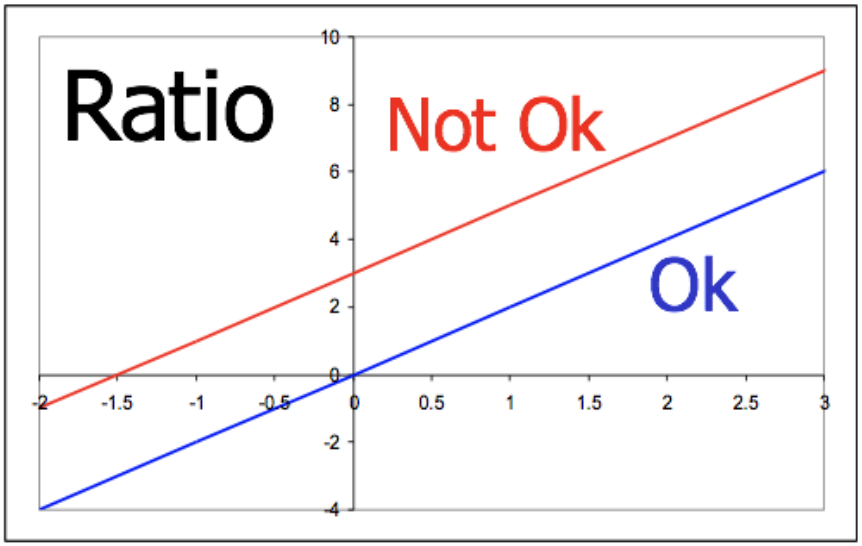
Acceptable Mappings

- For nominal, any 1:1 mapping is OK
- For ordinal, the mapping needs to be strictly increasing
- For interval, the mapping must have the form $Y = aX + b$, with $a > 0$
- For ratio, the mapping must have the form $Y = aX$, with $a > 0$
- For absolute, the only acceptable mapping is $Y = X$

Examples of Mappings







Meaningful Measures

- Measures are said to be meaningful if their truth value does not change when the measure is subject to transformation
- That is, they are defined on the appropriate scale. Mapping is used to verify the appropriateness of the scale.

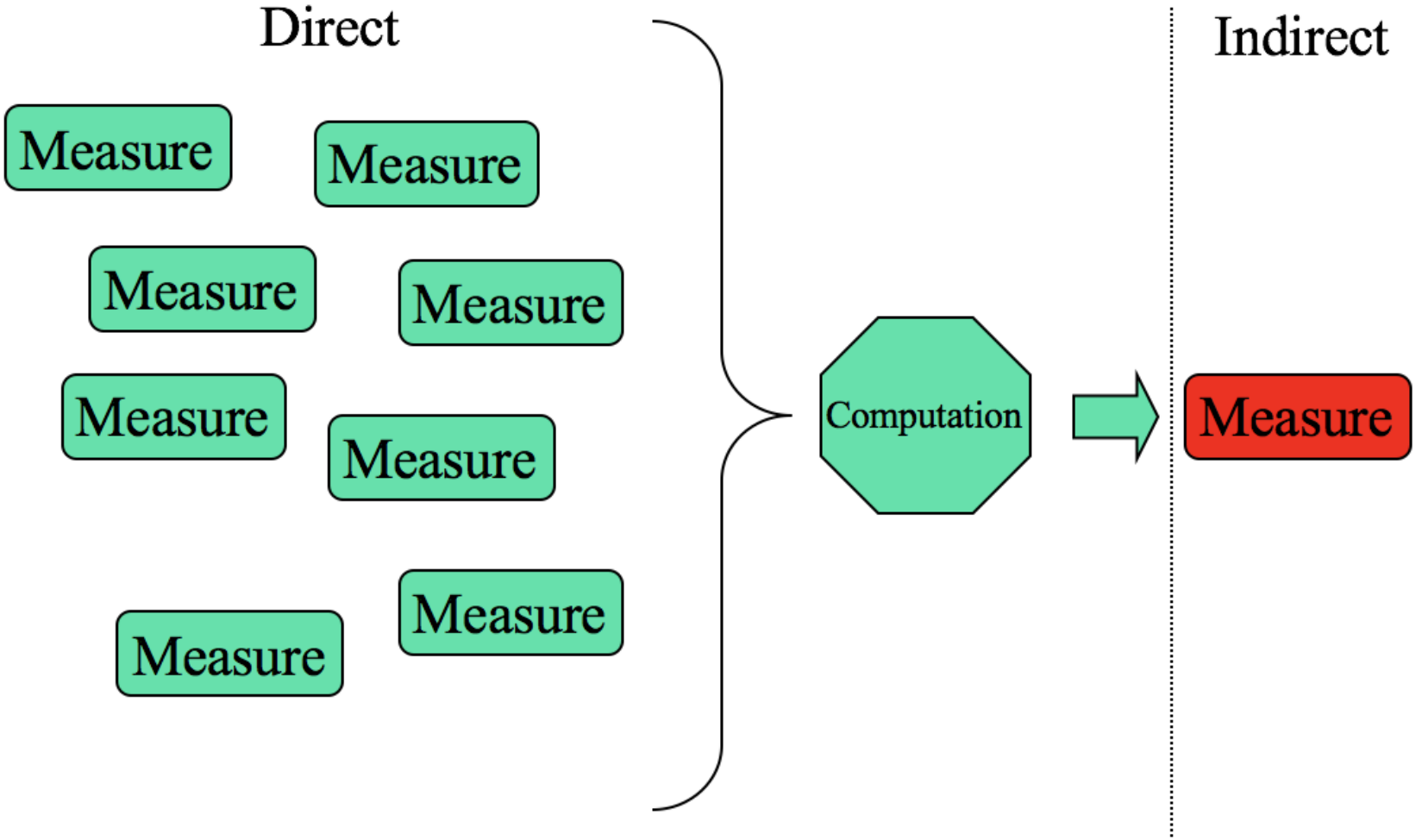
Examples

Meaningful	**Not meaningful**
• The number of atoms in solid A is double the number of atoms in solid B	• The color of solid A is twice as black as the color of solid B
• The number of people who agreed was double the number of people who disagreed	• People agreed twice as much as they disagreed

Kinds of metrics

- A metric is objective if it can be taken by an automated device; it is subjective otherwise
  - *LOC are objective metrics, Function Points are subjective*
- A metric is direct if it can be directly detected, indirect if it is the result of mathematical elaboration on other metrics
  - *LOC, number of errors, and FP are direct*
  - *Number of errors per LOC (Error density) is indirect*

Direct and Indirect Measurement



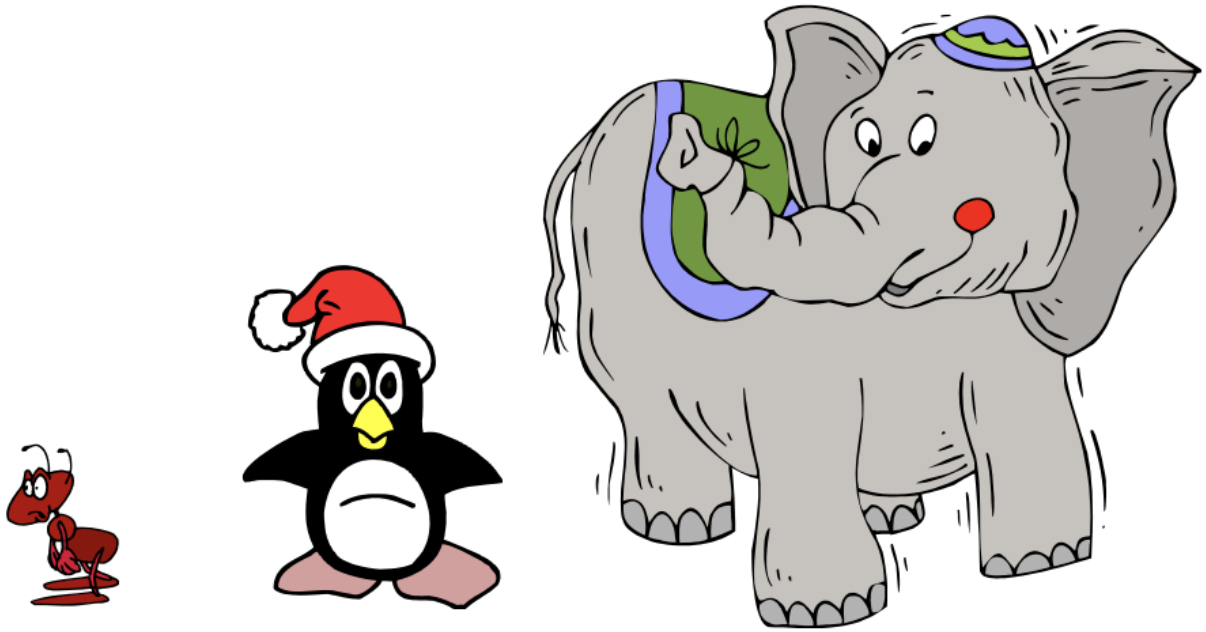
Direct or Indirect

- Immediately definable on one single calculation. Example: LOC, number of people in classroom, number of customer complaints
- Derived from a varied set of values. Example: ROI, number of tennis balls by weight, customer satisfaction

Measurements, Statistics and Scales

- Measurement scales limit the type of operations on measure - e.g., central tendency
- Objective or subjective measurement may limit the type of operations on measures
- Indirect measure depend on other measures' scales and thus are limited in meaningfulness and operations

Exercise: Measure of Mass



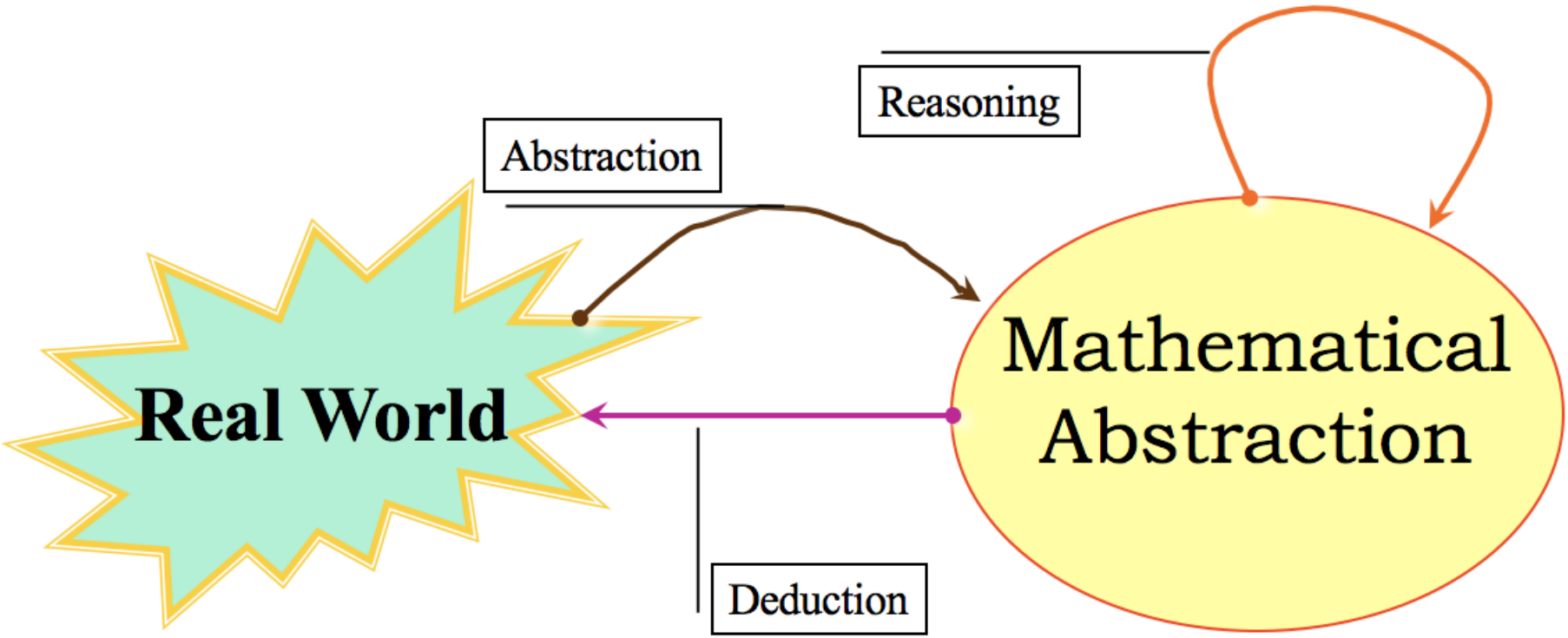
- What are the relations between their masses?
- Which of these are valid mappings?
  - $M_1(A) = 1$, $M_1(P) = 130$, $M_1(E) = 1400$
  - $M_2(A) = 3$, $M_2(P) = 4$, $M_2(E) = 5$
  - $M_3(A) = 24$, $M_3(P) = 51$, $M_3(E) = 49$
- Can we tell how intelligent they are from these mappings?

Questions

- Is it wrong to assert that “lines of code” is a bad software measure?
- What scale is used in “lines of code” measurement?
- Discuss the notion of “distance” in a vector space and its meaningfulness as a measure
- What kind of measure would you use for “program quality?”

Building Models out of Metrics

- A baby should double its weight at the age of month 6.



Model

- Mathematical abstraction
  - Indirect measurement
  - Control measurement
  - Prediction measurement
- **Prediction system** couples a model with procedures that allow forecasting

Risks while building models

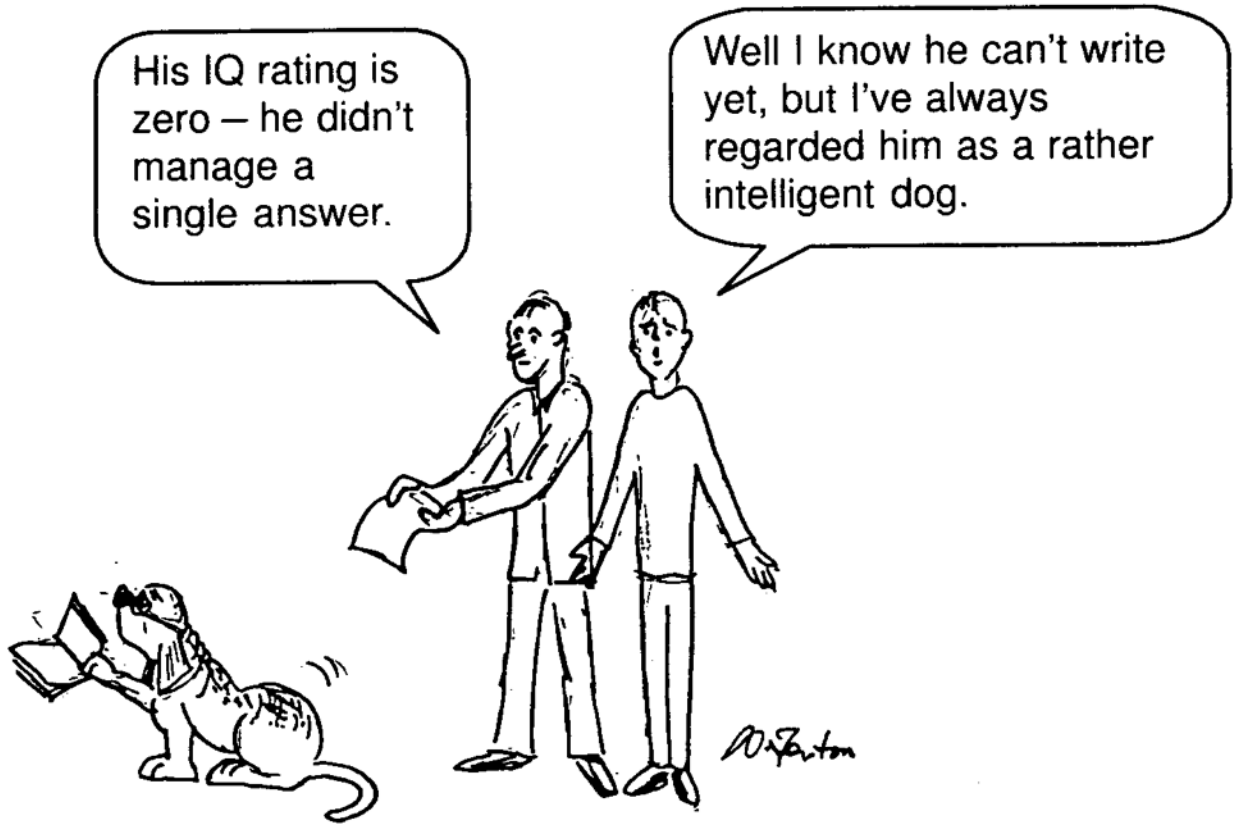


Figure 2.8: Using a suspect definition

from Fenton pp. 38

Metrics to assess personal productivity

From: https://www.analyticsinhr.com/blog/employee-performance-metrics/

The work

- We now analyse how people are evaluating quantitatively the personal productivity.
- The full document is available at the website above.
- We can review it using our approach to metrics.
- We adopt a simplified GQM.

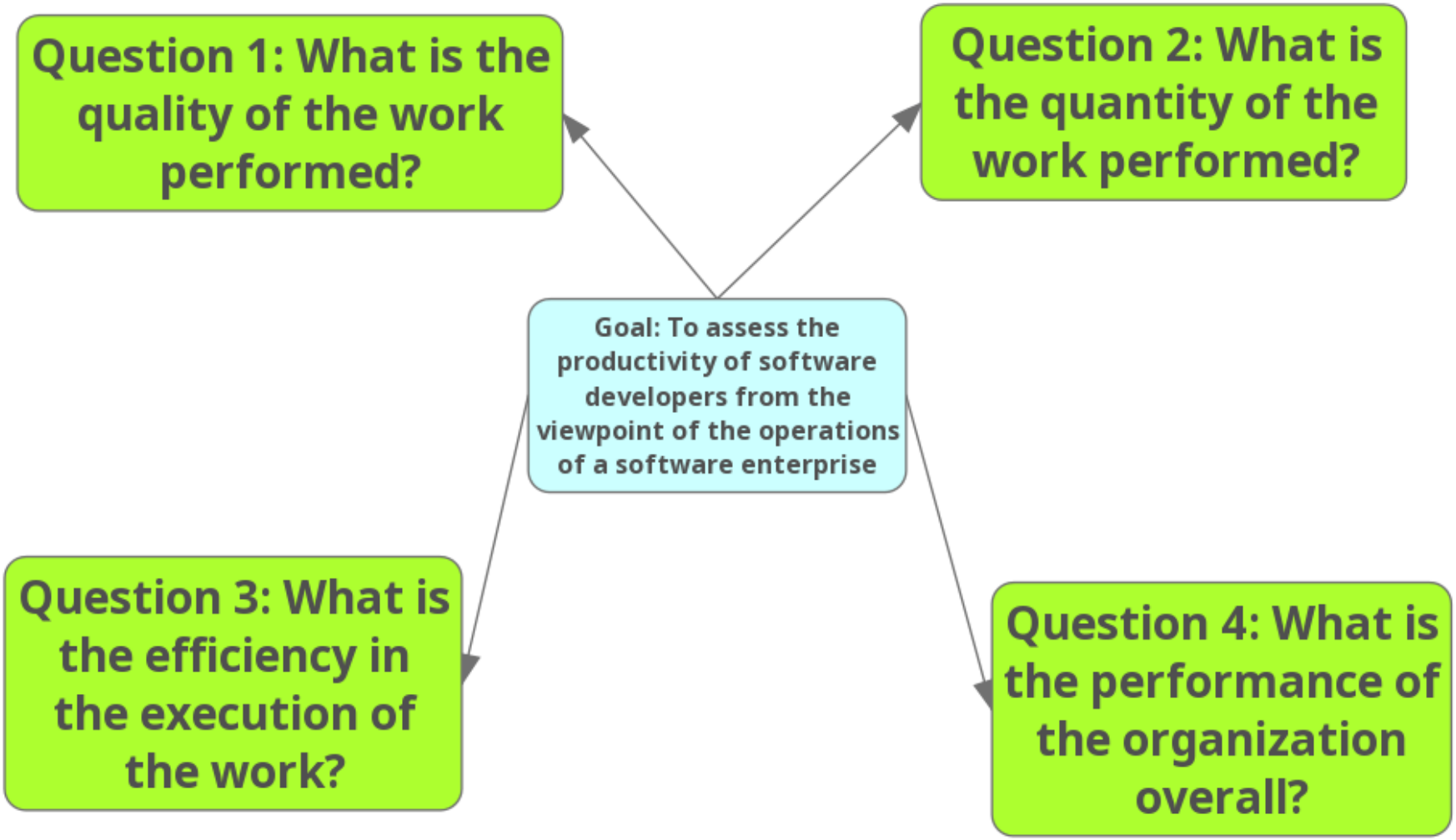
Goal

Goal: To assess the productivity of software developers from the viewpoint of the operations of a software enterprise

The text of this and the following slides comes from:

`https://www.analyticsinhr.com/blog/employee-performance-metrics/`

Questions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Goal: To assess the productivity of software developers from the viewpoint of the operations of a software enterprise
Question 3: What is the efficiency in the execution of the work?
Question 4: What is the performance of the organization overall?

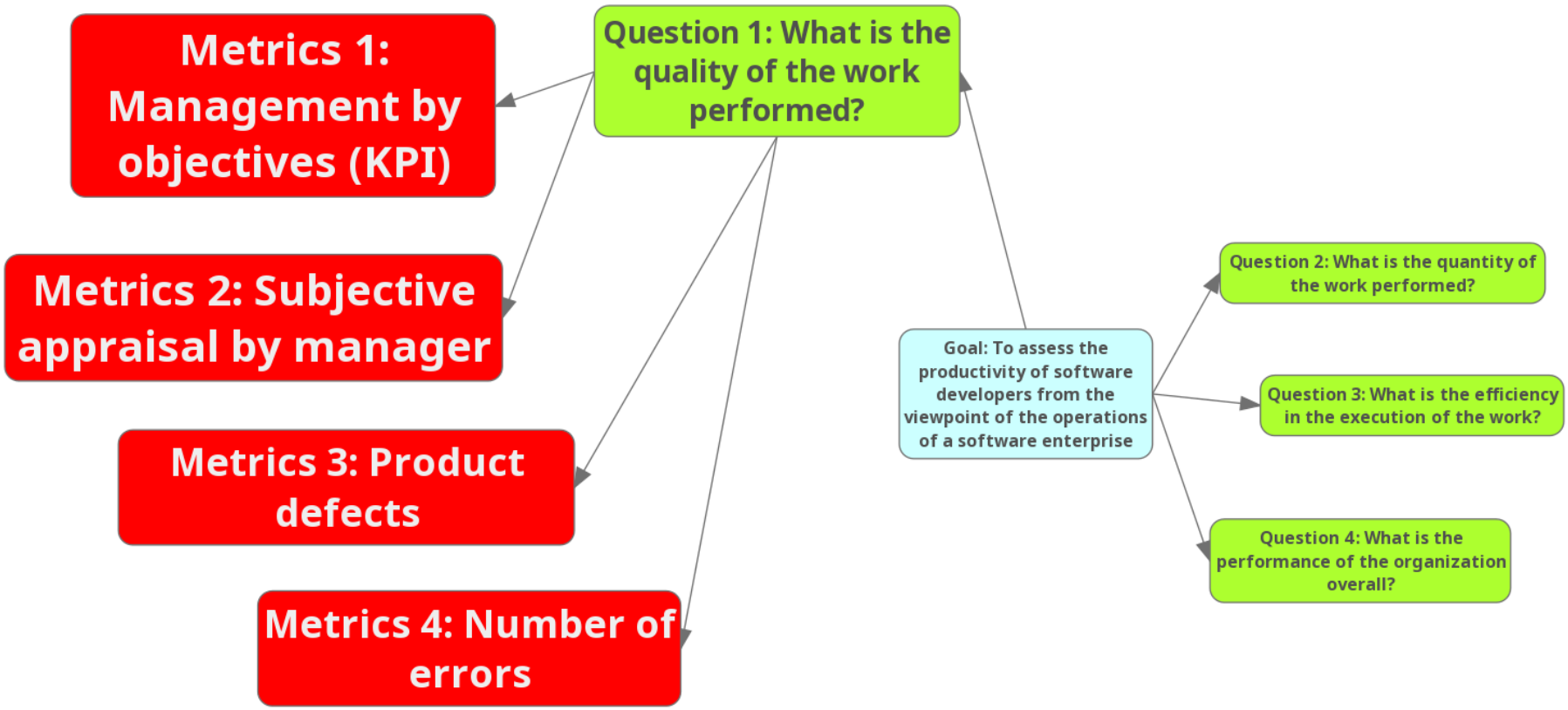
Proposed exercise (1/2)

- Create a mix team of 3 people of which at least one DS and one SE
- Complete the GQM with the metrics
- For every metrics determine:
  - if it direct or indirect
  - if it is subjective or objective
  - its measurement scale
- Provide a significant subset of the model that you would use to evaluate yourself
- Write the results on `http://tiny.cc/IU_EM_F20_L3`, tab: `EmployeesProductivity`
  - Organize every cell as follows:
    - Referred Goal and Question as number, e.g., G1Q2
    - Metrics, newline
    - Direct or indirect, newline
    - Subjective or objective, newline
    - Measurement scale

Proposed exercise (2/2)

`http://tiny.cc/IU_EM_F20_L3`, tab: `EmployeesProductivity`

Q1 Metrics (1)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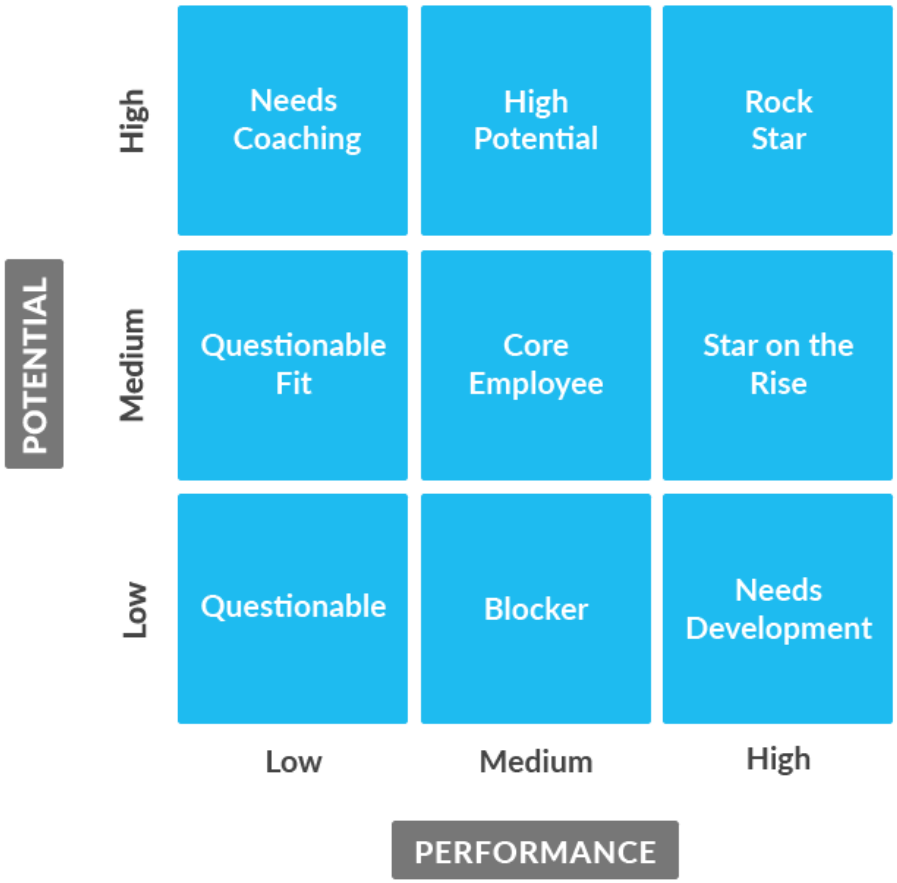
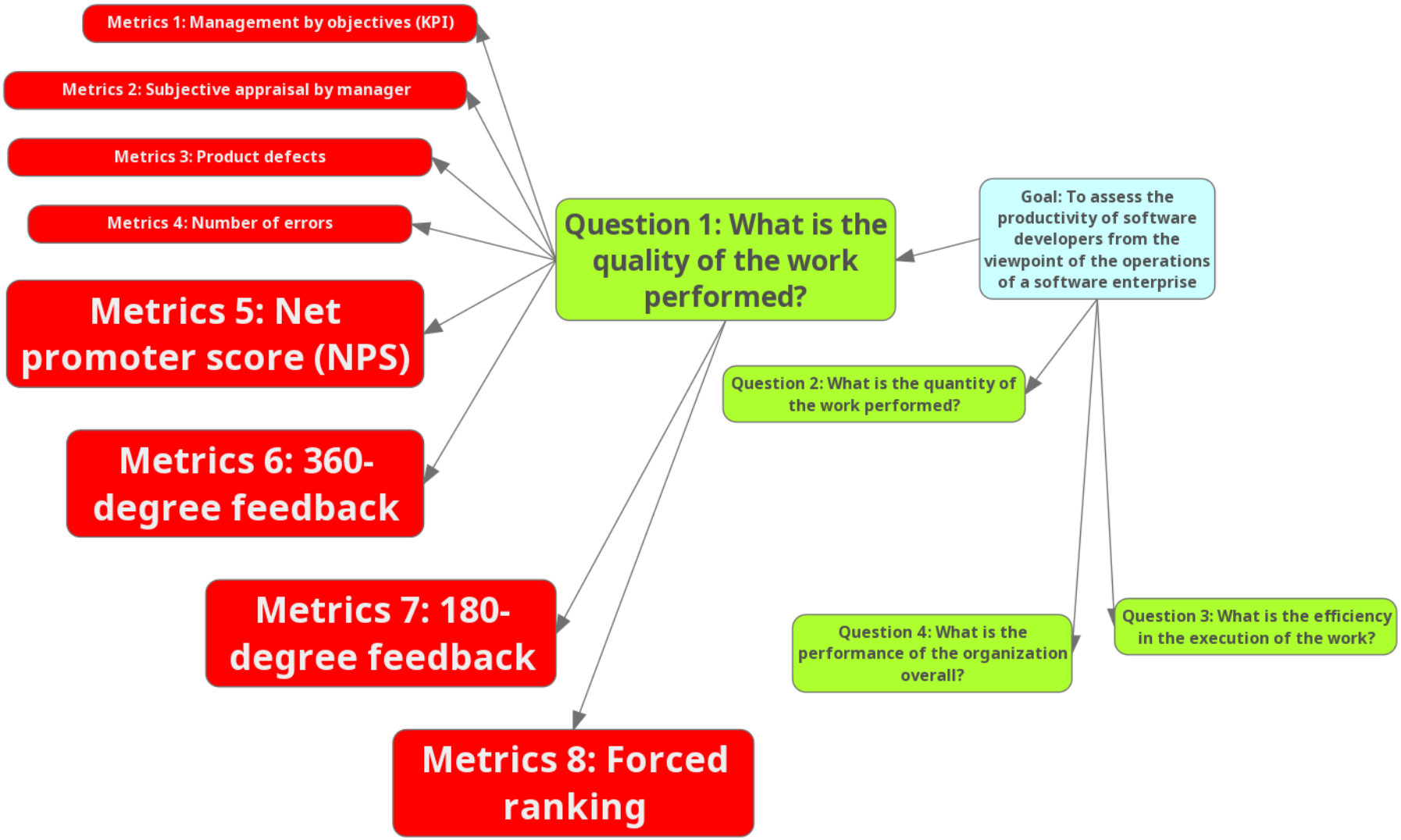
Focus on Q1 M2



Q1 Metrics (2)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Metrics 7: 180-degree feedback
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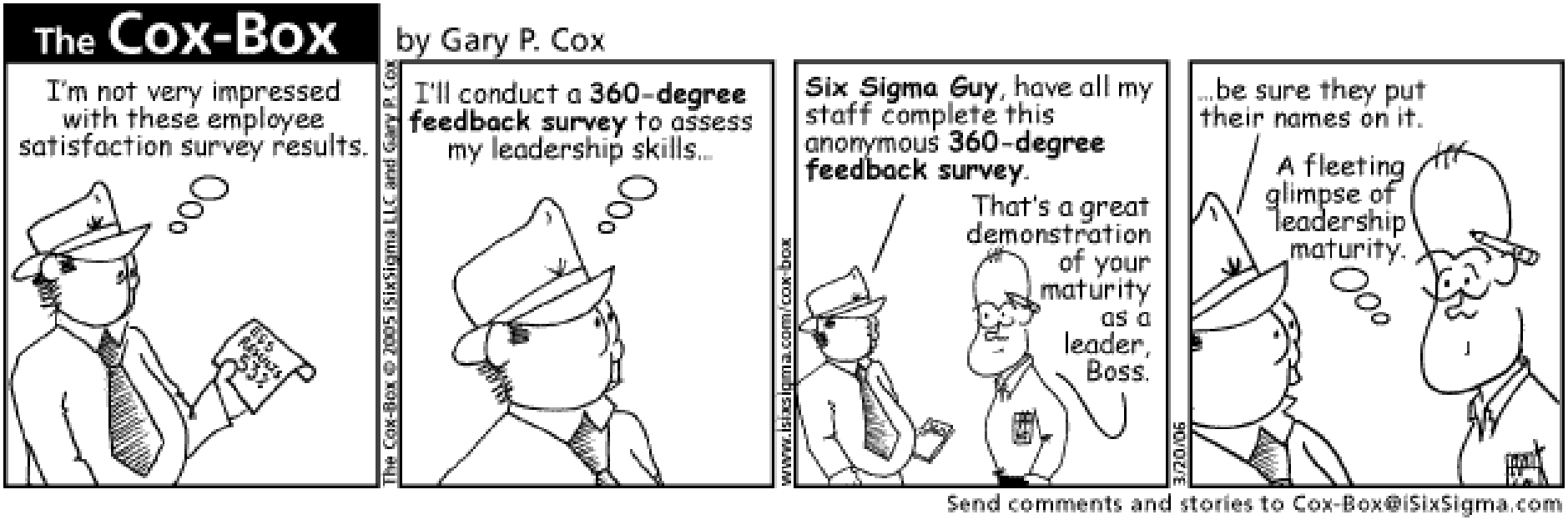
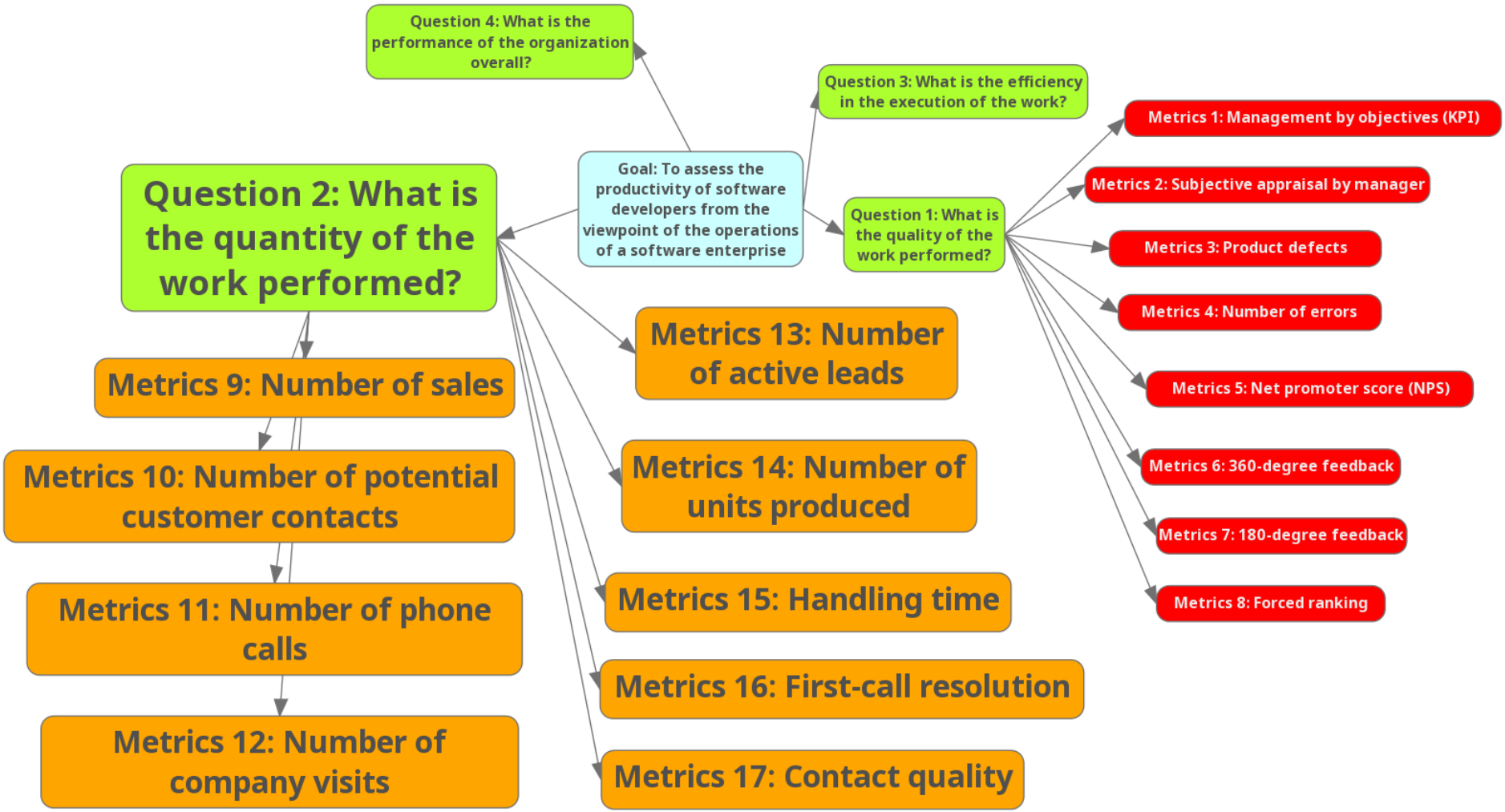
Focus on Q1 M6



Q2 Metrics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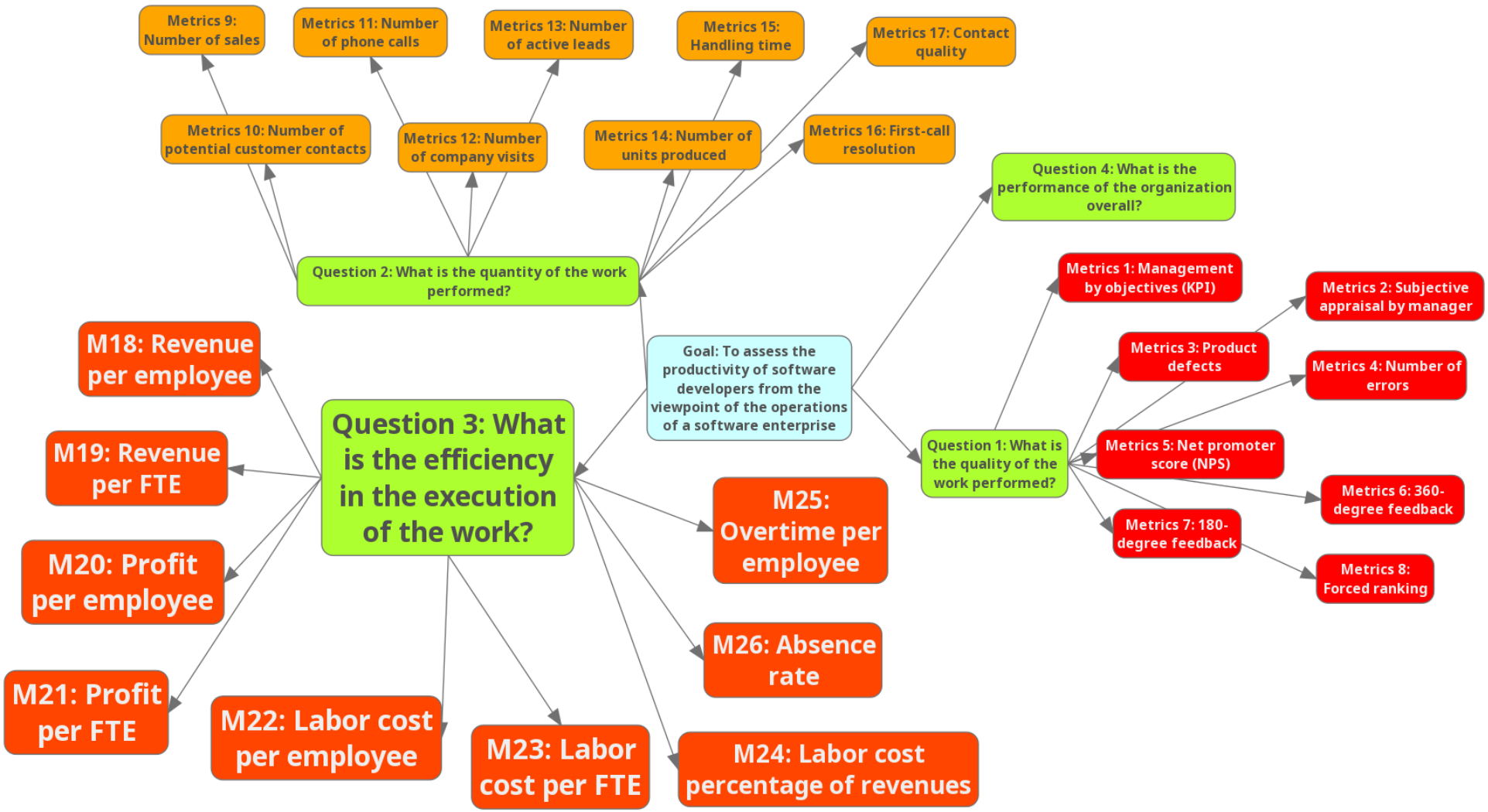
Metrics 9: Number of sales
Metrics 10: Number of potential customer contacts
Metrics 11: Number of phone calls
Metrics 12: Number of company visits
Metrics 13: Number of active leads
Metrics 14: Number of units produced
Metrics 15: Handling time
Metrics 16: First-call resolution
Metrics 17: Contact quality

Q3 Metrics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M18: Revenue per employee
M19: Revenue per FTE
M20: Profit per employee
M21: Profit per FTE
Question 3: What is the efficiency in the execution of the work?
M22: Labor cost per employee
M23: Labor cost per FTE
M24: Labor cost percentage of revenues
M25: Overtime per employee
M26: Absence rate

Questions ?

End of Lecture 4