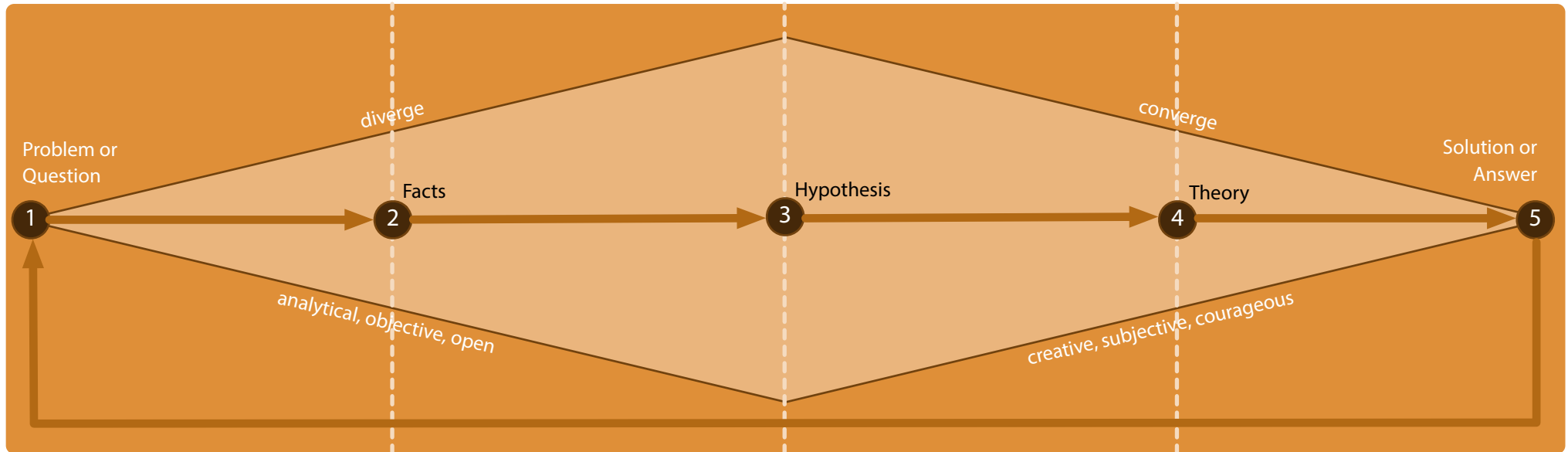




Software Engineering in Industrial Practice (SEIP)

Dr. Ralf S. Engelschall



INVESTIGATE & RESEARCH

1. Reflecting

(find facts via own knowledge/experience)

2. Searching

(find facts via body of knowledge)

3. Verification

(cross-check facts according to sources)

4. Tagging

(classify facts with tags)

STRUCTURE & SORT

1. Typing

(split/aggregate facts according to type)

2. Clustering

(hierarchically group facts by tags)

3. Relating

(link source to target facts)

4. Ordering

(order facts in each cluster)

REDUCE & COMPLEMENT

1. Substituting

(substitute/rename facts)

2. Extending

(add still missing facts)

3. Priorization

(priorize facts according to criterias)

4. Rejecting

(reject non-relevant/redundant facts)

INTEGRATE & PRESENT

1. Specialization

(specialize too general facts)

2. Generalization

(generalise too specific facts)

3. Integration
















(aggregate/link facts)

4. Presentation

(convert facts into target form)

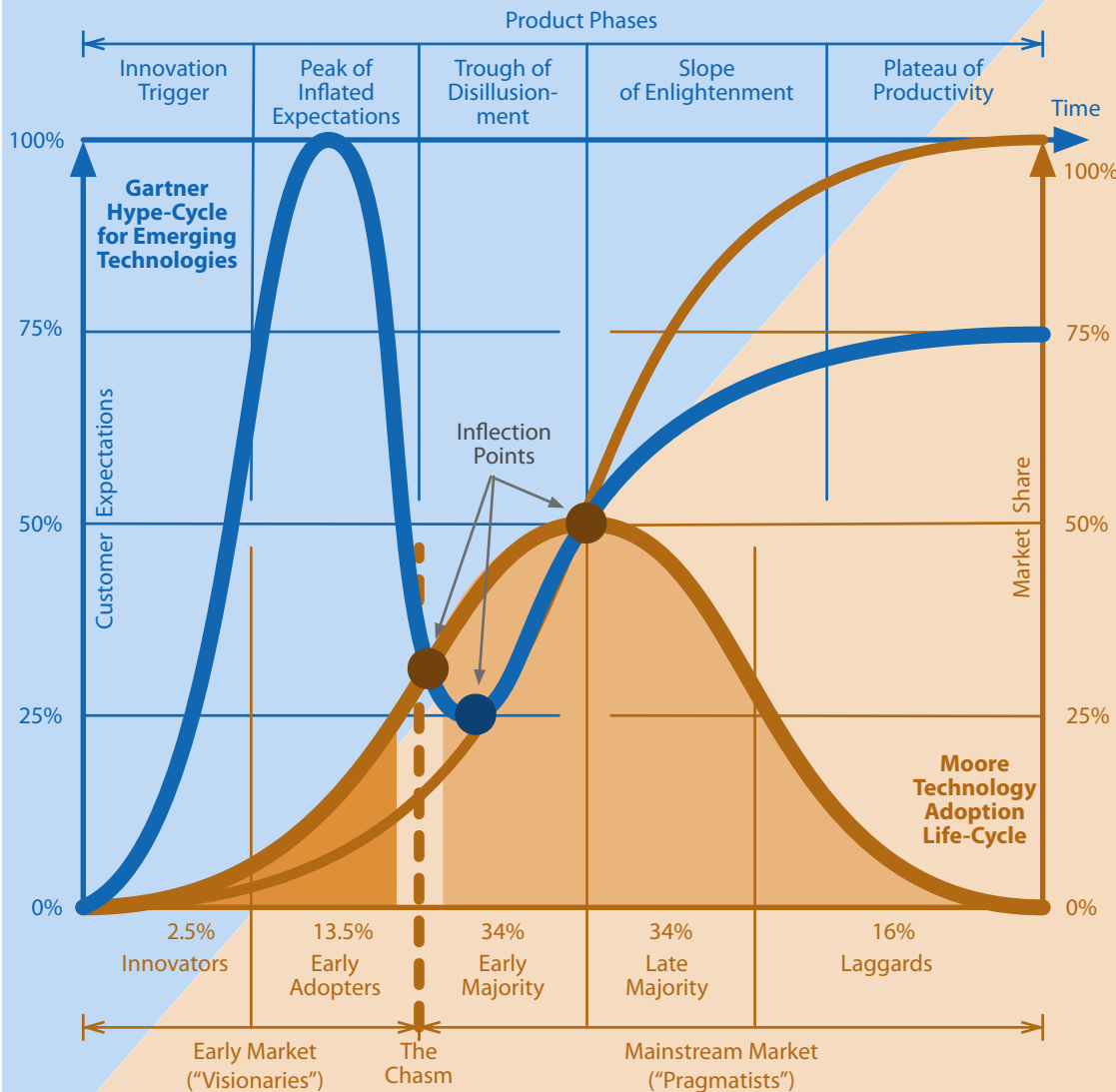
(primary step)

(secondary step)

| | | | | | | | |
|--|--|---|---|---|--|---|--|
| Research Crawling the problem domain's body of knowledge to find starting points. | RE  | Abstraction Solving the problem in a model of the problem before applying it to the real problem to get a better understanding. | AB  | Lateral Thinking Approaching the problem indirectly and creatively to find a not obvious solving lever. | LT  | Backward Search Looking at the expected results and determine which operations could bring you to them. | BS  |
| Brainstorming Suggesting larger number of solution ideas for further combination and development. | BR  | Generalization Thinking about the problem more abstract to get rid of special cases. | GE  | Hypothesis Proof Assuming a possible solution and trying to prove (or disprove) the assumption to find starting points. | HP Q.E.D. | Backtracking Remembering path towards the solution and on failure tracking back and choosing a new path. | BT  |
| Analogy Thinking in terms of similar problems for which solutions are known to get inspired. | AN  | Specialization Solving a special case first to get an impression towards the full solution. | SP  | Root Cause Asking "Why?" five times in sequence to explore the cause-and-effect relationships underlying the problem. | RC  | Divide & Conquer Breaking down the large complex problem into smaller, easier solvable partial problems. | DC  |
| Reduction Transform the problem into another one for which a solutions already exists to reduce solving efforts. | RD  | Variation Changing the problem context or expressing the problem differently to find a not obvious solving lever. | VA  | Means End Choosing an action from scratch just at each step to move closer and closer to the solution. | ME  | Trial & Error As a last resort, brute-force testing all potential solutions in case of a small enough total solution space. | TE  |

Definition: **Heuristic** — fallible experience-based technique or strategy for problem solving in case *Rule of Thumb* *Guessing*, *Intuitive Judgement*, *Common Sense* and *Stereotyping* are either not sufficient or not appropriate.

Gartner Hype-Cycle for Emerging Technologies



Moore Technology Adoption Life-Cycle

Gartner Hype-Cycle for Emerging Technologies

According to [1], provides "a graphic representation of the maturity and adoption of technologies and applications, and how they are potentially relevant to solving real business problems and exploiting new opportunities." It gives "a view of how a technology or application will evolve over time." The five product phases are:

"Innovation Trigger: A potential technology breakthrough kicks things off. Early proof-of-concept stories and media interest trigger significant publicity. Often no usable products exist and commercial viability is unproven.

Peak of Inflated Expectations: Early publicity produces a number of success stories — often accompanied by scores of failures. Some companies take action; many do not. The peak can be also considered a direct result of the *Dunning-Kruger Effect*, a "cognitive bias in which people mistakenly assess their cognitive ability as greater than it is" [2] and hence exaggerate in their expectations.

Trough of Disillusionment: Interest wanes as experiments and implementations fail to deliver. Producers of the technology shake out or fail. Investments continue only if the surviving providers improve their products to the satisfaction of early adopters.

Slope of Enlightenment: More instances of how the technology can benefit the enterprise start to crystallize and become more widely understood. Second- and third-generation products appear from technology providers. More enterprises fund pilots; conservative companies remain cautious.

Plateau of Productivity: Mainstream adoption starts to take off. Criteria for assessing provider viability are more clearly defined. The technology's broad market applicability and relevance are clearly paying off."

Moore Technology Adoption Life-Cycle

According to [3], describes "the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups." The five distinct adopter groups are:

"Innovators: had larger" business, "were more educated, more prosperous and more risk-oriented.

Early Adopters: younger, more educated, tended to be community leaders, less prosperous.

Early Majority: more conservative but open to new ideas, active in community and influence to neighbours.

Late Majority: older, less educated, fairly conservative and less socially active.

Laggards: very conservative, had small" business "and capital, oldest and least educated."

According to [4], there is also a "chasm between the early adopters of the product (the technology enthusiasts and visionaries) and the early majority (the pragmatists)," because "visionaries and pragmatists have very different expectations," and technology is usually switched, at last at the Inflection Points.

Crossing The Chasm [4] is related to the *Innovator's Dilemma* [5], where "new entry next generation products" usually "find niches away from the incumbent customer set to build the new product."

[1] <https://gtmr.it/36rBT4X>
[2] <https://bit.ly/2qZ4Lkx>
[3] <https://bit.ly/2N3fB1t>
[4] <https://bit.ly/2NuRNT7>
[5] <https://bit.ly/34IMkEW>

Open Source Definition

Distribution terms (license) of Open Source Software must be compliant with the following criterias:

- Free **Redistribution**
- (Original) **Source Code** (Availability)
- **Derived Works** (Allowance)
- **Integrity** of the Author's **Source Code**
- **No Discrimination** Against Persons or Groups
- **No Discrimination** Against Fields of Endeavor
- **Distribution** of (Non-Exclusive) **License**
- License Must **Not Be Specific** to a **Product**
- License Must **Not Restrict** Other Software
- License Must Be **Technology-Neutral**

Open Source Personality Streams

§ **Software Sharing**

Dogmatism
Social Equity
Politics

@ **Software Hacking**

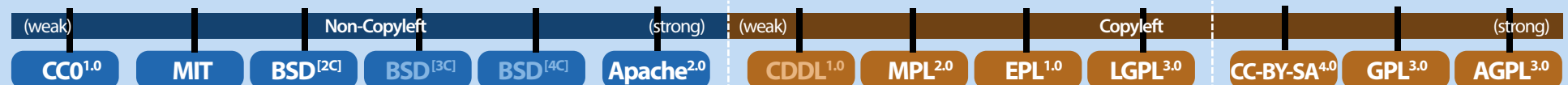
Fundamentalism
Art
Hacking

€ **Software Engineering**

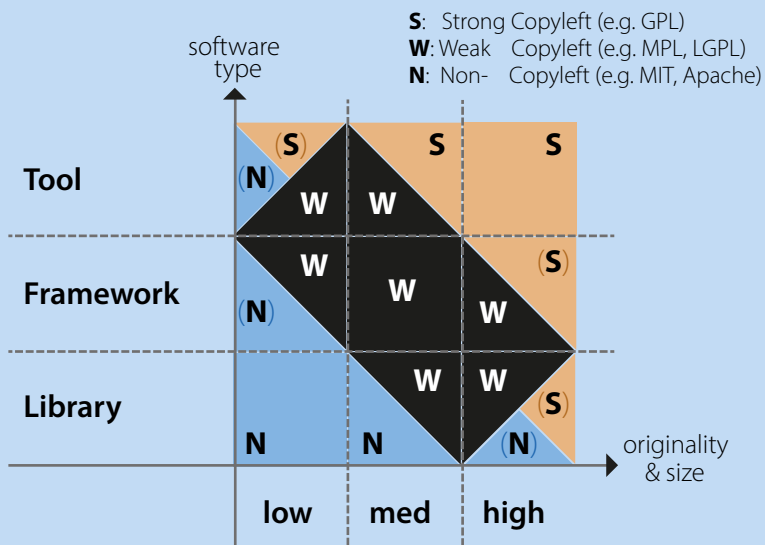
Pragmatism
Business
Engineering

Industry
Private
Science

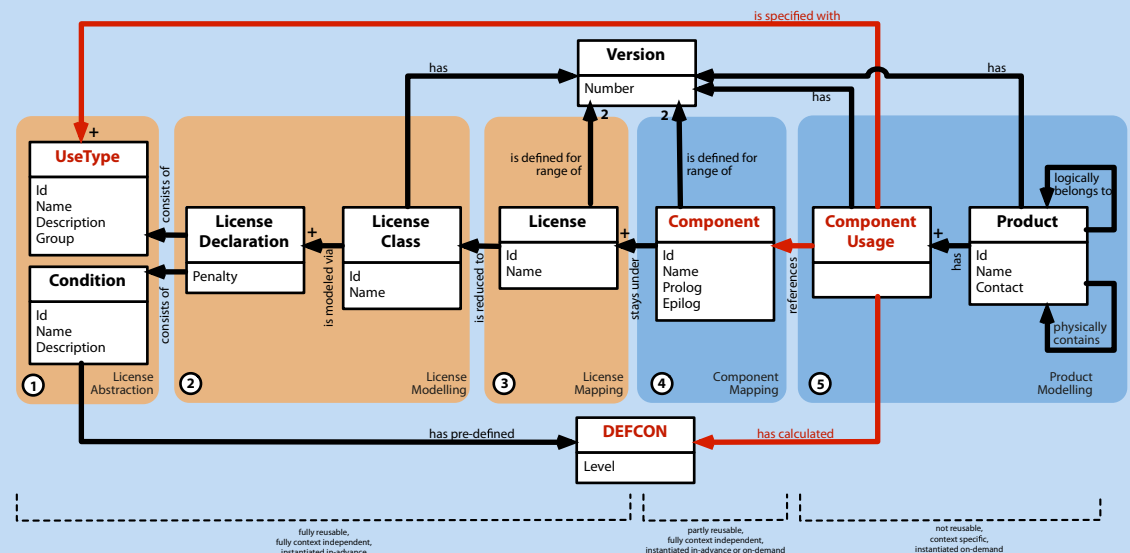
Most Popular Open Source Licenses



Choosing an Open Source License



License Compliance Checking Meta-Model



Specification (Example)

Customer: Twitter Inc.

Business: MicroBlogging

Use-Cases 1/3 (profile):

- user can register an account
- user can "follow" other users
- user can create lists of users he follows

Use Cases 2/3 (send):

- user can send tweets
- tweets are based on words, each either a text "example", tag "#example", user reference "@example" or URL <http://example.com>
- tweets are either public broadcast or personal/direct messages
- user can re-tweet a message of others

Use Cases 3/3 (query):

- user can view timeline
(chronological tweets of others he follows)
- user can search for tweets
(by keyword "foo", tag "#foo", or user "@foo")
- user can view tag cloud

Frontends/Clients:

- mobile app (iOS, Android)
- desktop app (Windows, Mac OS X)
- web app
- embedded web widget (query use cases only)

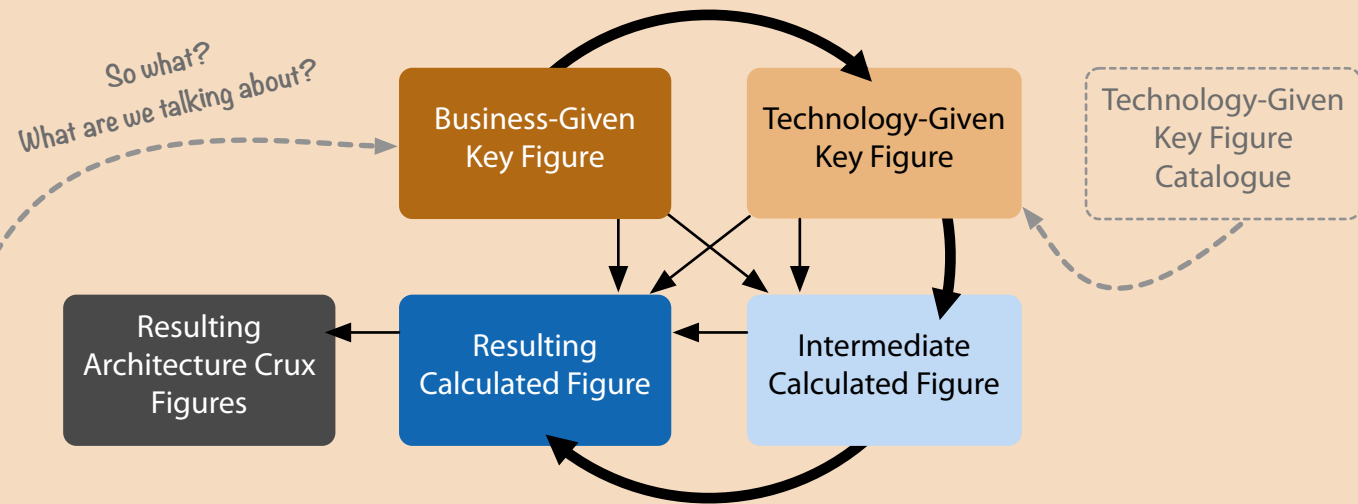
Current Demand (as of 2012):

- 140M user profiles
- 400M tweets/day
- 6393 tweets/second peak
- 140 characters/tweet
- 30K queries/second
- 300 GB/hour data in total
- 4,4 tweets/day/user on average
- 103,4 follower/user
- < 5s tweet-write-to-read-delay

Future Demand:

- quadratic user and traffic growth

Conversion & Normalization



Calculation (Example)

| Twitter Information | | Traffic Bandwidth | |
|----------------------------------|--|---|-----------|
| 6.393 tweets/second peak | 140 chars/tweet | 350% overhead HTTP+TCP+IP+Ethernet | |
| 400.000.000 tweets/day (write) | 4.630 tweets/second (write) | 2,2 MB/s (write) | |
| 2.592.000.000 queries/day (read) | 30.000 queries/second (read) | 140,2 MB/s (read) | |
| 6,5 factor read/writes | 10 tweets/query | 142,4 MB/s | |
| | 4,4 tweets/day/user | 10000 Mbps | 1250 MB/s |
| | 2,4 tweets/day (M. Fowler) | 1000 Mbps | 125 MB/s |
| | 0,8 tweets/day (R. Engelschall) | 100 Mbps | 12,5 MB/s |
| | 621.880.000 tweets/day (average) total | 10 Mbps | 1,25 MB/s |
| | 64,3% users are active at all | | |
| | 277.778 users/minute active | | |
| Storage Requirements (static) | | Computing Hardware Requirements | |
| 140.000.000 user profiles | 300 GB/hour data in total | 2000 requests/sec (read) AS performance | |
| 52.000 chars/users for profile | 214 TB/month data in total | 100 requests/sec (write) As performance | |
| 6,62 TB profile (total) | | 15,0 servers for writes | |
| | 200% overhead storage | 46,3 servers for reads | |
| 103,4 follower/user | 1265,9 KB/s tweets | | |
| 14.474.600.000 user follow links | 104,3 GB/day tweets | | |
| 32 bytes/link | 3,1 TB/month tweets | | |
| 0,42 TB links (total) | | | |
| Storage Hardware Requirements | | | |
| 0,3 TB/disk (15K rpm) | 200 chars/log entry | | |
| 8,0 disks/server | 6763,6 KB/s log | | |
| 2,4 TB/server | 557,3 GB/day log | | |
| 8,2 server/month (new) | 16,6 TB/month log | | |
| | 9,2% ratio business data | | |
| | 90,8% ratio infrastructure data | | |

Weighted Decision Matrix

| | | A ₁ | A ₂ | ... | A _n |
|----------------|----------------|------------------|------------------|-----|------------------|
| C ₁ | w ₁ | E _{1,1} | E _{1,2} | ... | E _{1,n} |
| C ₂ | w ₂ | E _{2,1} | E _{2,2} | ... | E _{2,n} |
| ... | ... | ... | ... | ... | ... |
| C _m | w _m | E _{m,1} | E _{m,2} | ... | E _{m,n} |
| | | R ₁ | R ₂ | ... | R _n |

C_{i=1..m}: Criteria i

A_{j=1..n}: Alternative j

w_{i=1..m}: in [1/4, 1/2, 1, 2, 4]: Weighting i

E_{i,j} in { -2, -1, 0, +1, +2 }: Evaluation i,j

R_{j=1..n} = SUM_{i=1..m} (w_i * E_{i,j}): Rating j

R_{best} = MAX_{j=1..n} (R_j): Best Rating

Light-Weight Alternative:
qualitatively cherry-picking major
positive/negative backing criterias

| Ranking criteria | A ₁ | | | A ₂ | | | ... | A _n | | |
|--------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|-----|----------------|----------------|----------------|
| + | c ₁ | c ₄ | c ₈ | c ₁ | c ₂ | c ₇ | ... | c ₂ | c ₉ | c ₈ |
| - | c ₂ | c ₃ | | c ₄ | | | ... | c ₇ | c ₅ | |
| Decision for A _{best} | | | | | | | | | | |

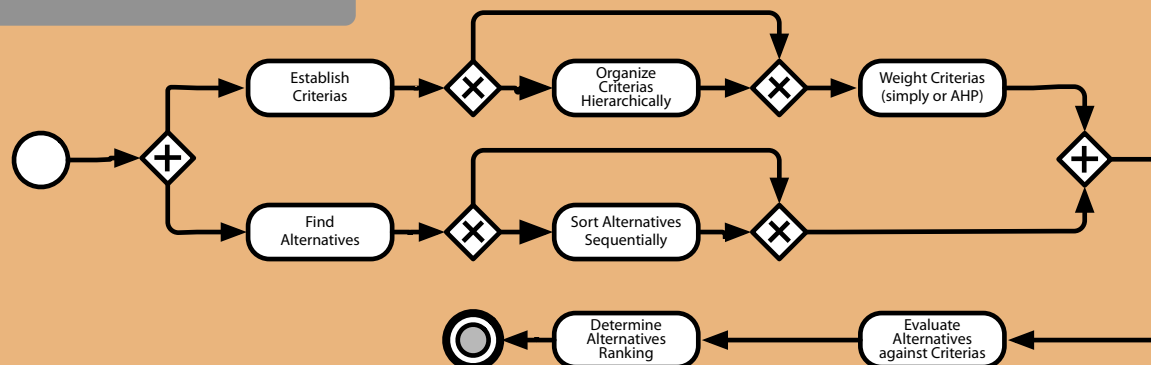
Best Practice Rules

- Rule 1: the alternatives have to be really **reasonably comparable**.
- Rule 2: the **best** rating should be at least **10% above** the **second** best rating.
- Rule 3: the **best** rating should cover at least **80% of the requirements**.
- Rule 4: the Weighted Decision Matrices should cover at least all **grand decisions**.

Notice

It's about **subjective** decision **transparency**,
not about **objective** decision **making**!

Decision Making Process



Standard Criteria Catalogs

Software Selection:

- Suitable Functionality
- Available Usage Examples
- Reasonable Documentation
- Reasonable Support
- Permissive License
- Long-Term Release Track Record
- Current Market Momentum

Software Selection (Open Source):

- + Clean Source Code
- + Clean Build Process
- + Open Source License

Software Selection (Library):

- + Non-Invasive Programming Model
- + Orthogonal Application Programming Interface
- + Minimum/No Dependencies
- + Non-Copyleft Open Source License

Software Selection (Framework):

- + Orthogonal Application Programming Interface
- + Adequate Dependencies
- + Non-Overlapping Scope
- + Non-Copyleft Open Source License

Software Selection (Tool):

- + Clean Deployment Procedure
- + Pleasant Command-Line Interface

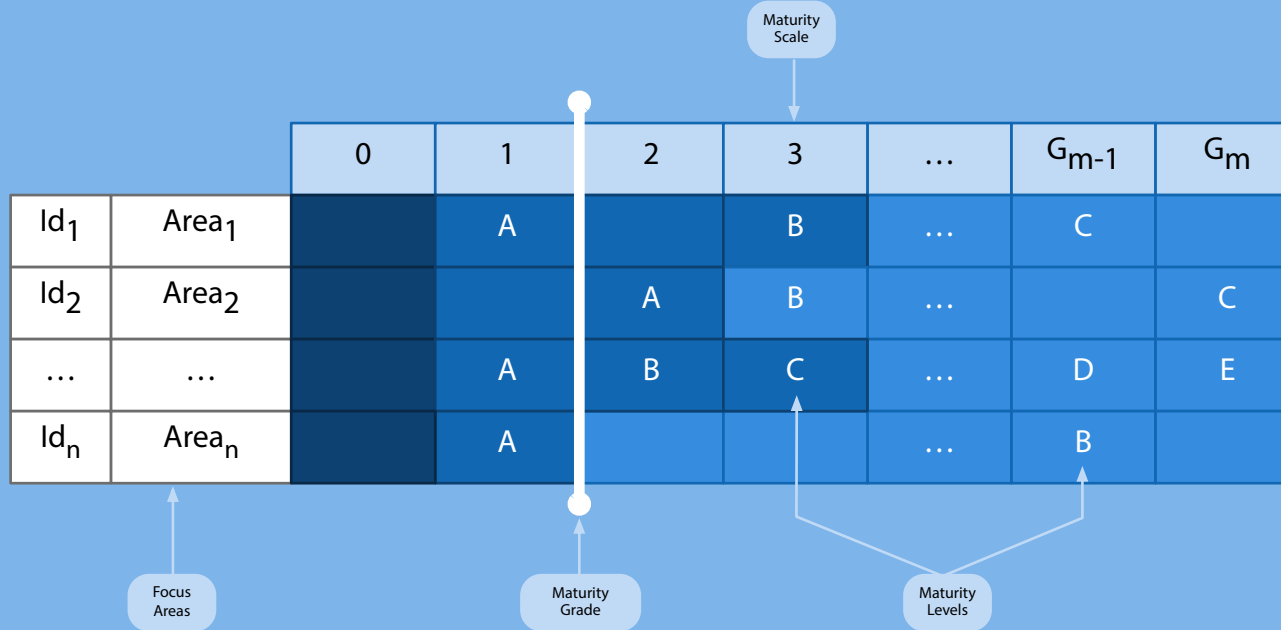
Software Selection (Application):

- + Clean Deployment Procedure
- + Pleasant Graphical User Interface

Software Architecture Evaluation:

- Meets Functional Requirements
- Meets Non-Functional Requirements
- Adequate Technology Overhead
- Single Dependency Direction
- Distance to State of the Art ("modern")
- Distance to Most Simple Approach ("adequate")
- Distance to Mainstream Approach ("mainstream")
- Documented Architecture Decisions ("rationales")
- Documented Architecture Views
- Documented Architecture Perspectives (NFR)

Matrix Structure



Focus Area Definition

Id: <unique id of focus area>
Name: <unique name of focus area>

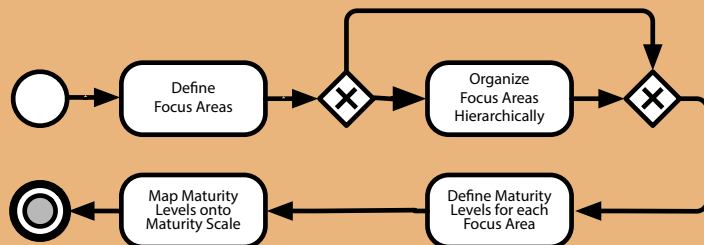
Maturity Level Definition

Id: <unique id of focus area>
Level: <unique letter of maturity level>
Name: <unique name of capability>
Goal: <purpose the capability serves>
Action: <steps how to meet the capability>
Prerequisites: <optional references to Id/Level>
References: <optional external references>

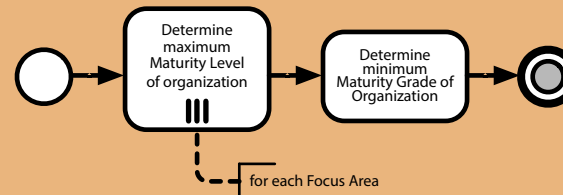
Maturity Level Prerequisites

Notice: Maturity Levels are inherently ordered within their Focus Area, but optionally also form a dependency graph by cross-referencing Maturity Levels of other Focus Areas.

Matrix Design Process



Maturity Decision Process



Maturity Grade Zero

Notice: the Maturity Scale always starts with 0, because an organization might not be able to fulfil a Focus Area at all, i.e., it might not even be on Maturity Level A.

Maturity Grade Determination

Determine minimum Maturity Level fulfilled by an organization and project from Maturity Level onto Maturity Scale.

Vote is a portable mobile-first designed application for easily performing anonymous online votings within a small group of people to figure out their opinions or moods.

Votings are created in advance, executed at a certain time, conducted by the users, and then finally reported.

| Actor Role | Use-Case |
|------------|---|
| User | Register Account Recover Account Configure Account Login Account Logout Account |
| Author | Create Voting Grant Voting Access |
| Supervisor | Execute Voting Enable Question Display Result |
| Voter | Vote Question Display Result |

| Quality | Expectation |
|--------------------------------------|-------------|
| Cross-Platform Client | yes |
| Non-Cleartext Password Storage | yes |
| Minimum Concurrent Voters (people) | 50 |
| Maximum Display Result Latency (sec) | 1 |

| Aspect | Amount | Size | Total Size | Unit |
|------------------|--------|-------|------------|------|
| Account Data | 10.000 | 256 | 2.560.000 | B |
| Voting Data | 10.000 | 1.024 | 10.240.000 | B |
| Server RAM Usage | 200 | 20 | 4.000 | MB |

(Example)

1 Elevator Pitch

RE D

Name, Purpose, Motivation, Actors, Devices.



Rationale: Roughly describe the purpose and primary motivation.

Format: Prose Abstract

3 Customer Journey

UX D

Actor Roles, Use-Cases.



Rationale: Sketch the customer journey through major use-cases.

Format: 2xN Table or UML UC Diag.

5 Quality Requirements

RE T

Qualities, Expectations.



Rationale: List requirements on the major non-functional qualities.

Format: 2xN Table

8 Sizing Sketch

SW T

Aspects, Amounts, Sizes, Total Sizes, Units.



Rationale: Sketch the sizing of major entities and system parts.

Format: 5xN Table

(Method)

2 Crux Flash

RE D

Functionality, Cruxes.



Rationale: Roughly describe the functionality and the cruxes.

Format: Prose Abstract

4 Dialog Storyboard

UX D

Dialogs, Interaction, Control Flow.



Rationale: Illustrate the major user interface dialogs (or dialog types).

Format: Wireframe Graph Diagram

6 System Architecture

SY T

Actors, Systems, Zones, Programs.



Rationale: Illustrate the major system architecture components.

Format: Boxes'n'Lines Diagram

7 Data Model

SW T

Entities, Relationships.

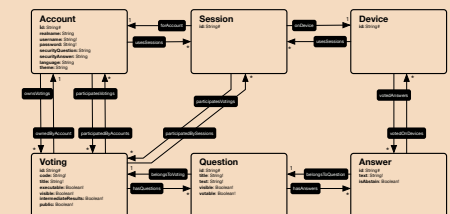
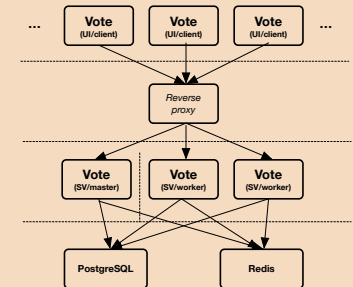
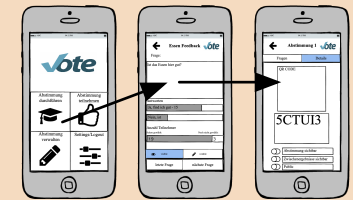


Rationale: Model major data entities and their relationships.

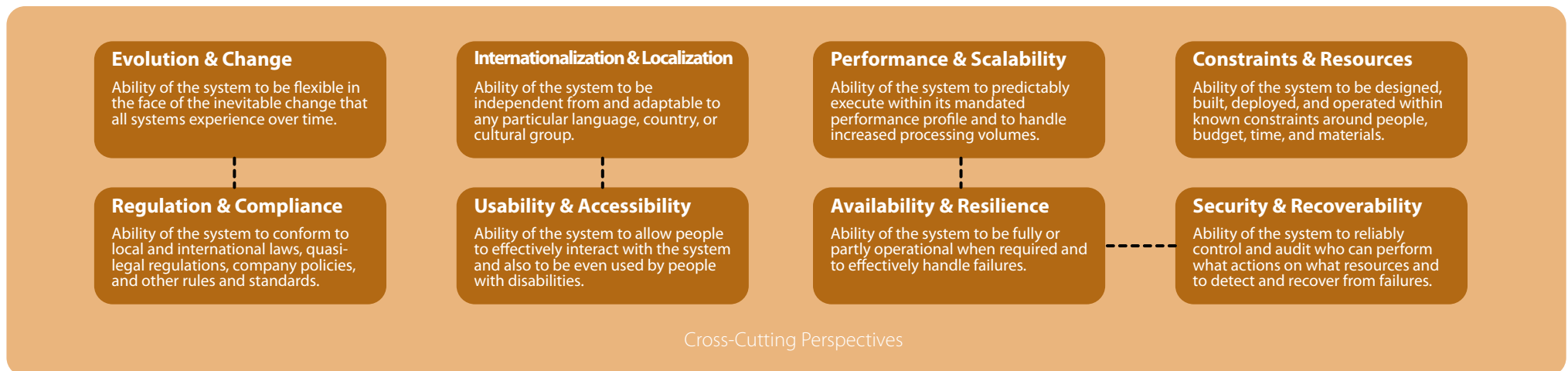
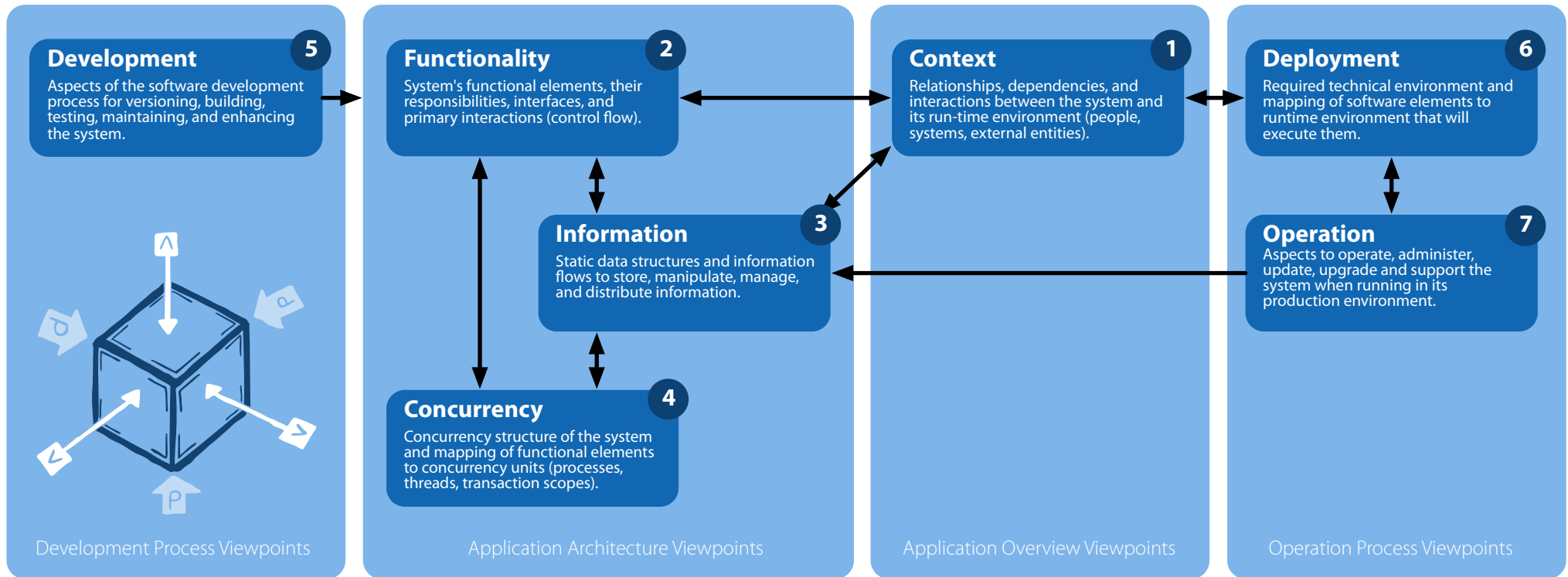
Format: UML Class Diagram

Votings can be quickly accessed by QR-code or URL and are based on one or more questions and corresponding multiple-choice-based answers.

Votings are interactively conducted, and answers are received and reported either asynchronously in batches (offline voting) or even synchronously in real-time (online voting).



(Example)



Cross-Cutting Perspectives