Module 37, Architectural Reasoning Threads and Integration

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Abstract

This module provides methods and techniques to integrate insights across views. Lines and Threads of reasoning form the main framework.
Abstract

Many stakeholder concerns can be specified in terms of qualities. These qualities can be viewed from all 5 “CAFCR” viewpoints. In this way qualities can be used to relate the views to each other.

The meaning of qualities for the different views is described. A checklist of qualities is provided as a means for architecting. All qualities in the checklist are described briefly.
Quality needs as generic integrating concepts

<table>
<thead>
<tr>
<th>Customer objectives</th>
<th>Application</th>
<th>Functional</th>
<th>Conceptual</th>
<th>Realization</th>
</tr>
</thead>
<tbody>
<tr>
<td>safety</td>
<td>usability</td>
<td>evolvability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Qualities as Integrating Needles

Gerrit Muller

version: 1.3
February 3, 2015
QNneedles
Security as example through all views

<table>
<thead>
<tr>
<th>Customer objectives</th>
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<th>Realization</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensitive information</td>
<td>selection, classification, authentication</td>
<td>functions for administration, authentication, intrusion detection, logging, quantification</td>
<td>cryptography, firewall, security zones, authentication, registry, logging</td>
<td>specific algorithms, interfaces, libraries, servers, storage, protocols</td>
</tr>
<tr>
<td>trusted people, information, badges, passwords, locks / walls, guards, administrators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>desired characteristics, specifications &amp; mechanisms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>not trusted</td>
<td>social contacts, open passwords, blackmail, burglary, fraud</td>
<td>missing functionality, wrong quantification</td>
<td>holes between concepts</td>
<td>bugs: buffer overflow, non encrypted storage, poor exception handling</td>
</tr>
<tr>
<td></td>
<td>unworkable procedures</td>
<td></td>
<td></td>
<td>threats</td>
</tr>
</tbody>
</table>

Qualities as Integrating Needles

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QNsecurityExample
### Quality Checklist

**usable**
- usability
- attractiveness
- responsiveness
- image quality
- wearability
- storability
- transportability

**dependable**
- safety
- security
- reliability
- robustness
- integrity
- availability

**effective**
- throughput or productivity

**interoperable**
- connectivity
- 3rd party extendible

**liable**
- liability
- testability
- traceability
- standards compliance

**efficient**
- resource utilization
- cost of ownership

**serviceable**
- serviceability
- configurability
- installability

**ecological**
- ecological footprint
- contamination
- noise
- disposability

**future proof**
- evolvability
- portability
- upgradeability
- extendibility
- maintainability

**down to earth attributes**
- cost price
- power consumption
- consumption rate
- (water, air, chemicals, et cetera)
- size, weight
- accuracy

**consistent**
- reproducibility
- predictability

**logistics friendly**
- manufacturability
- logistics flexibility
- lead time

**qualities as integrating needles**

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**version:** 1.3  
**February 3, 2015**  
**QNchecklist**
Abstract

A method of reasoning is described, which addresses cross-cutting issues. The basis is fast iteration in the problem and solution space. A thread of reasoning is a set of highly relevant related issues, which are addressed by articulating the problem in terms of tension and analyzing it in the CAFCR framework.
Overview of the reasoning approach

1. select starting point:
   - actual dominant need or problem

2. create insight:
   - submethod in one of CAFCR views
   - qualities checklist

3. deepen insight via facts:
   - via tests, measurements, simulations
   - story telling

4. broaden insight via questions:
   - why
   - what
   - how

5. define and extend the thread:
   - what is the most important / valuable
   - what is the most critical / sensitive
   - look for the conflicts and tension

continuously
consolidate in simple models
communicate to stakeholders
refactor documentation
From starting point to insight

step 1 starting point

C - Customer objectives
A - Application
F - Functional
C - Conceptual
R - Realization

slow response
Creating Insight

step 2 creating insight

Customer
Application
Functional
Conceptual
Realization

performance
response
time model
Deepening Insight

Customer objectives

Application

Functional

Conceptual

Realization

specific needs

step 3 deepening insight

simulations, test, measurements

specific facts
Broadening Insight

**Threads of Reasoning**

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TORbroadeningInsight
Problem identification and articulation

Customer objectives
Application
Functional
Conceptual
Realization

important
critical
valuable
difficult
sensitive
vulnerable

need and problem selection criterions

throughput
cost

high performance sensor
high speed moves

definition in terms of tension
Iteration during the analysis

- **Solution**: improve solution
- **Problem**: improved problem understanding
- **Criteria**: improve criteria
- **Intuition**: adjust intuition
- **Mismatch**: detect mismatch

**Threads of Reasoning**
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TORanalysis/iteration
Thread of related issues

Customer objectives
Application
Functional
Conceptual
Realization

Threads of Reasoning
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Documentation and communication structure

- **Customer objectives**
  - key drivers

- **Application**
  - context
  - case

- **Functional**
  - zap
  - store
  - IQ spec
  - target
  - response time

- **Conceptual**
  - functional model
  - pipeline design
  - cost budget
  - time budget

- **Realization**
  - processing library
  - micro benchmarks
Threads of reasoning illustrated by medical imaging case

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Abstract

The medical imaging workstation case is introduced. An architecting method based on the CAFCR viewpoints is explained, consisting of 4 elements:

- the CAFCR viewpoints
- qualities as integrating needles
- story telling
- threads of reasoning

A thread of reasoning is build up in steps, based on this case. The underlying reasoning is explained.

Distribution

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Easyvision serving three URF examination rooms

URF-systems

EasyVision: Medical Imaging Workstation

typical clinical image (intestines)
X-ray rooms from examination to reading around 1990

Examination Room

Control Room

Corridor or closet

Examination Room

Control Room

Reading Room

Threads of reasoning illustrated by medical imaging case

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XRayRoomsOld
X-ray rooms with Easyvision applied as printserver

- Examination Room
- Control Room
- Corridor or closet
- Reading Room

- X-ray source
- Detector
- Console
- Printer
- Light box

Threads of reasoning illustrated by medical imaging case

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XRayRoomsPlusPrintServer
Comparison screen copy versus optimized film

old: screen copy

new: SW formatting

20 to 50% less film needed
Challenges for product creation

- **product policy:**
  - standard HW
  - SW "only"
  - 40 MHz CPU
  - 64 MByte memory
  - 10 MBit/s ethernet
  - 1 GByte disk

- **print throughput**
- **view response time**
- **image quality**
- **image processing**
- **tension**
- **product policy:**
- ca 1 film / minute
  - film = 4k*5k pixels
- subsecond retrieve
  - screen = 1k*1k
- print throughput
- view response time
- image quality
- image processing
- tension
- product policy:
  - standard HW
  - SW "only"
  - 40 MHz CPU
  - 64 MByte memory
  - 10 MBit/s ethernet
  - 1 GByte disk

Threads of reasoning illustrated by medical imaging case

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IMIchallenge
Top level decomposition

Threads of reasoning illustrated by medical imaging case

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IMI decomposition
CAFCR viewpoints

What does Customer need in Product and Why?

Customer What

Customer How

Product What

Product How

Customer objectives

Application

Functional

Conceptual

Realization

drives, justifies, needs

enables, supports

Threads of reasoning illustrated by medical imaging case

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CAFCRannotated

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Quality needles as generic integrating concepts

Threads of reasoning illustrated by medical imaging case

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QNneedles
From story to design

**What** does Customer need in Product and **Why**?

Customer **What**

Customer **How**

Product **What**

Product **How**

**C**ustomer objectives

**A**pplication

**F**unctional

**C**onceptual

**R**ealization

**story**

market vision

a priori solution knowledge

analyze design

design	analyze design	case

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SHTfromStoryToDesign
Chronology of Easyvision RF R1 development

1991
- Basic application toolboxes
- 100 kloc
- Interactive viewing

Marketing opinion:
"All the functionality is available, we only have to provide a clinical UI"

1992
- Performance problems
- IQ problems

1993
- Easyvision RF integrated product
- 360 kloc
- Print server + communication + interactive viewing

Threads of reasoning illustrated by medical imaging case
Thread of reasoning based on efficiency-quality tension

**Customer objectives**
- time efficient
- diagnostic quality
- safety (liability)

**Specification issues**
- system response
- system throughput

**Concepts**
- resource management
- processor, memory
- internal logistics
- concurrency, processes
- image processing
- algorithms

**Applications**
- functional
- conceptual
- realization

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[Diagram showing the relationship between different aspects of system design and implementation]
Technology innovations

- standard UNIX based workstation
- full SW implementation, more flexible
- object oriented design and implementation (Objective-C)
- graphical User Interface, with windows, mouse etcetera
- call back scheduling, fine-grained notification
- data base engine, fast, reliable and robust
- extensive set of toolboxes
- property based configuration
- multiple coordinate spaces

Performance vs. Cost

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Introvert view: cost and impact of new technologies
Memory usage half way R1

**Graphical Representation:**

- **Total Measured Memory Usage:**
  - OS
  - Code
  - Data
  - Bulk Data
  - Fragmentation

- **Performance:**
  - Physical Memory
  - Paging to Disk

- **Memory Usage:**
  - 0 MB
  - 64 MB
  - 200 MB

Threads of reasoning illustrated by medical imaging case

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MSmemoryZeroMeasurement
Solution of memory performance problem

200 MB measured

anti-fragmenting

budget based awareness, measurement

DLLs tuning

budget

bulk data

data

code

OS

74 MB
Visualization memory use per process

-measured (left column)
-budget per process (right column)

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MSmemoryBudget
Typical case URF examination

3 examination rooms connected to 1 medical imaging workstation + printer

examination room: average 4 interleaved examinations / hour

image production: 20 $1024^2$ 8 bit images per examination

film production: 3 films of 4k*5k pixels each

high quality output (bi-cubic interpolation)
Thread of reasoning; phase 2

Philips operational view
(manufacturing, service, sales)

Application Realization
M'U Functional Conceptual Realization

How to measure memory, how much is needed?
from introvert to extrovert
Radiologist workspots and activities

supervision of the examination

view and diagnose, dictate report

verify and authorise report

activities of the radiologist
Diagnosis in tens of seconds

- Films loaded by clinical personnel during the day
- Looks at images
- Moves head forward/backward
- Moves head or eyes left/right/up/down
- Zooms in
- Overview
- Image selection, panning
- Presses next button
- Mumbles a few Latin words or clinical codes in recorder
- New films
- Old films
- Light-box
- Auto-loader

Threads of reasoning illustrated by medical imaging case

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MISdiagnosis
Rendered images at different destinations

**Screen:**
- low resolution
- fast response

**Film:**
- high resolution
- high throughput

**Network:**
- medium resolution
- high throughput

Figures illustrating the comparison of different imaging techniques in terms of resolution and response time.
Threads of reasoning illustrated by medical imaging case

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MITORswLayers1991
Print server is based on banding

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MICVbanding
Server CPU load

- remote systems and users
- communication
- data base
- print

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MiCVserverCPUload
Radiologists diagnose from film, throughput is important. Extrovert view shows conceptual and realization gaps!
Image quality and safety problem

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Presentation pipeline for X-ray images

- Image from database
- Spatial enhancement
- Interpolate (bi-linear, bi-cubic)
- Look up table (invert, contrast / brightness)
- Graphics merge
- Colour LUT
- Monitor

Legend:
- SW
- HW
Image Quality expectation WYSIWYG

What you see at one work-spot is what you get at another work-spot.

X-ray system

Image generation

Presentation

Monitor

Film

Network, storage

3rd party workstation

Application processing

Presentation

Easyvision

Monitor

Film

Network, storage

Threads of reasoning illustrated by medical imaging case

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MICVwysiwyg
Safety problem

for user readability the font-size was determined "intelligently"; causing a dangerous mismatch between text and image

URF monitor output: fixed size letters at fixed grid

EV output: scaleable fonts in graphics overlay
from extrovert diagnostic quality, via image quality, algorithms and load, to extrovert throughput
cost revisited in context of clinical needs and realization constraints; note: original threads are significantly simplified
Overview of architecting method

**method outline**

**framework**
- Customer objectives
- Application
- Functional
- Conceptual
- Realization

**submethods**
- Customer objectives
  - + key drivers
  - + value chain
  - + business models
  - + supplier map
- Application
  - + stakeholders and concerns
  - + context diagram
  - + entity relationship models
  - + dynamic models
- Functional
  - + use case
  - + commercial, logistics decompositions
  - + mapping technical functions and several more
- Conceptual
  - + construction decomposition
  - + functional decomposition
  - + information model and many more
- Realization
  - + budget
  - + benchmarking
  - + performance analysis
  - + safety analysis and many more

**integration**
via qualities

**explore**
specific details

**reasoning**

Threads of reasoning illustrated by medical imaging case

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AMOoverview
Exercise Threads of Reasoning

- **Customer objectives**
  - 1. Select 3..5 most important needs and concerns

- **Application**
  - 2. Select 3..5 most important specification issues

- **Functional**
  - 3. Select 3..5 most critical design aspects

- **Conceptual**
  - 4. Select 3..5 most critical life cycle issues

- **Realization**
  - 5. Show relations positive negative

- **Life cycle**
  - 6. Transform into elevator pitch

Integration via Qualities

Qualities Connect all Views

Look Positive and Negative

Many, Many Qualities

Summary Module Architectural Reasoning Threads and Integration

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## Threads of Reasoning

### Diverge, Converge, Zoom-in, Zoom-out

1. Select starting point:
   - actual dominant need or problem

2. Create insight:
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5. Define and extend the thread:
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### Identify Most Relevant Issues

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<td>critical</td>
<td>valuable</td>
<td>critical</td>
<td></td>
</tr>
<tr>
<td>valuable</td>
<td>difficult</td>
<td>sensitive</td>
<td>vulnerable</td>
<td></td>
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### All Issues are Interrelated

- **Customer Objectives**
- **Application**
- **Functional**
- **Conceptual**
- **Realization**

### Reconstruct the “Big Picture”

- Useable
- Effective
- Efficient
- Operational constraints
- Profit margin
- Standard workstation
- Philips operational view

- **Customer Objectives**
- **Application**
- **Functional**
- **Conceptual**
- **Realization**

- Cost revisited in context of clinical needs and realization constraints; note: original threads are significantly simplified

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Summary Module Architectural Reasoning Threads and Integration

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