Abstract
A short general introduction to Architecting, CAFCR framework and Architectural Reasoning is given. We explore the creation of an ATM case with the CAFCR framework. We start with existing requirements and then we explore customer and future needs.
What is Architecting?

- Articulated
- Structured

Problem and solution know-how

Vague notion of the problem

Vague notion of potential solutions

Architecting

Basic methods:
- Framework
- Submethods
- Integration methods

Architecting method:

Architecture description:
- Articulated
- Structured

Report
Spec
Design

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AMOmethod
The “CAFCR” model

What does Customer need in Product and Why?

Customer What drives, justifies, needs enables, supports Product How

Customer objectives Application Functional Conceptual Realization

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CAFCRannotated
Integrating CAFCR

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

Customer

- **What** (Customer objectives)
- **How** (Application)
- **Opportunities** (context understanding)

Product

- **What** (Functional)
- **Why** (intention)
- **Objective** (objective driven)

Conceptual

- **Knowledge** (constraint awareness)

Realization

- **Product** (knowledge based)
CAFCR can be applied recursively

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Example of a small buying organization

Who is the customer?

cFO  CIO
cMO  CEO  CTO
decision maker(s)
purchaser

department head

user

maintainer

operator

CEO: Chief Executive Officer
CFO: Chief Financial Officer
CIO: Chief Information Officer
CMO: Chief Marketing Officer
CTO: Chief Technology Officer
Connecting System Design to Detailed Design

- 10^0
- 10^1
- 10^2
- 10^3
- 10^4
- 10^5
- 10^6
- 10^7
- 10^8

number of details

- system requirements
- design decisions
- parts
- connections
- lines of code

and growing every year....

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RATWpyramid
Organizational Problem: Disconnect

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

- **C**ustomer objectives
- **A**pplication
- **F**unctional
- **C**onceptual

How can the product be realized

- **R**ealisation

What are the critical decisions

- system requirements
- design decisions
- parts
- connections
- lines of code

and growing every year....
Architect: Connecting Problem and Technical Solution

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

**How** can the product be realized?

**What** are the critical decisions?

- What does Customer need in Product and **Why**?
- How can the product be realized?
- What are the critical decisions?

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**Architectural Reasoning Illustrated by an ATM Example**

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RATWbreadthAndDepth
Major Bottleneck: Mental Dynamic Range

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RATWmentalDynamicRange
1. ATM Specification and Design Status Quo

   Exercise: Identify Critical Design Decisions

   Exercise: What is the Minimal Cost of the Controller

2. Customer and Life Cycle Perspective

   Exercise: What are Important Future Customer Concerns

3. The Big (Complicated) Picture

4. Thread of Reasoning

   Exercise: What did You Learn?
Step 1, Status Quo

number of details

understanding the status quo

mono-disciplinary system

multi-disciplinary system

essence of problem

original input

critical details

original input

critical details

mono-disciplinary

multi-disciplinary

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5.0 Operational Phase Requirements (partial)

5.1 Input/Output Requirements

5.1.1 Input Requirements

5.1.1.1 The ATM system shall accept a general ID from the customer.
5.1.1.2 The ATM system shall accept a unique ID from the customer.
5.1.1.3 The ATM system shall accept customer requests, including requests for deposits and requests for withdrawals.
5.1.1.4 The ATM system shall accept customer input, including account type (i.e., savings, checking, and bank credit), amount of deposit, deposit type (cash vs. check), and amount of withdrawal (credit).
5.1.1.5 The ATM system shall accept a cash/check deposit from the customer.
5.1.1.6 The ATM system shall accept the amount of available funds from the bank computer. (Fmax).
5.1.1.7 The ATM system shall accept an employee code from a bank employee.
5.1.1.8 The ATM System shall accept a request to open from the bank employee.
5.1.1.9 The ATM System shall accept cash from the bank employee.
5.1.1.10 The ATM system shall accept blank receipts from a bank employee.
5.1.1.11 The ATM system shall accept a request to close from the bank employee.
5.1.1.12 The ATM system shall accept an initialization instruction from a bank employee.

5.1.2 Output Requirements:

5.1.2.1 The ATM system shall provide a request for unique ID to the customer.
5.1.2.2 The ATM system shall provide requests for customer input, including activity type, account type, deposit amount, and type of deposit (cash vs. check).
5.1.2.3 The ATM system shall provide a means for the customer to physically insert a deposit (cash/check).
5.1.2.4 The ATM system shall provide a record of a transaction to the bank computer.
5.1.2.5 The ATM system shall provide a record for the amount of available funds to the bank computer (Fmax).
5.1.2.6 If Fmax ≥ Creq and Cmax ≥ Creq, the ATM shall provide the cash withdrawal to the customer. (Cmax = the maximum withdrawal allowed for the particular ATM.).
5.1.2.7 The ATM system shall provide a receipt for a transaction to the customer.
5.1.2.8 The ATM system shall provide the main menu to the customer.
5.1.2.9 The ATM system shall provide employee access to a valid bank employee.
5.1.2.10 The ATM system shall provide physical access to a valid bank employee.
5.1.2.11 The ATM system shall provide customer deposits and payments to a bank employee.
5.1.2.12 The ATM System shall provide confirmation that it has been locked to the bank employee.

2.0 ATM System Operational Phase Scenarios

1) Customer makes deposits.
- Customer provides valid general identification information.
- ATM requests unique identification information.
- Customer enters unique identification information.
- ATM requests activity selection.
- Customer selects deposit.
- ATM requests account type.
- Customer identifies account type (i.e., savings, checking, and bank credit card).
- ATM requests amount of deposit.
- Customer identifies amount of deposit (Dmax).
- ATM requests type of deposit (cash vs. check).
- Customer identifies type of deposit-cash/check.
- ATM provides a means to physically insert cash/check into ATM.
- Customer enters deposit.
- ATM transmits the transaction to the main bank computer, gives customer receipt, and returns to main menu.

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ARATMoriginalInputs
ATM Typical Function Flow

customer identification and authentication

determine request type and amount deposit or withdrawal

validate amount

transfer money and update account
ATM Hardware Diagram

cabinet
controller
cash handling
card reader
display
keyboard
network interface
cash handling
power
cabinet

card reader

display

controller

network interface

power
Objectives

from SYS 650 System Architecture and Design
ATM Case Study
Copyright Michael Pennotti, PhD. and
Stevens Institute of Technology
Adapted from a case study by Dennis Buede, Ph.D.
Impact of ATM introduction

old situation

main office

branch office

new situation

main office

ATM

branch office
Exercise: Identify Critical Design Decisions

Identify critical design decisions

Critical: high risks, sensitive or vulnerable, high impact on objectives

What decisions are critical?

Why are these decisions critical?

How do you decrease the risk?
Exercise: What is the Minimal Cost of the Controller

Determine Minimal Cost Controller

Identify multiple controller alternatives.

Estimate cost per alternative.

What is the impact on other design aspects?

What is the impact on the objectives?
Step 2, Customer and Life Cycle Perspective

Customer objectives
Application
Functional
Conceptual
Realization

objectives
requirements
scenarios
critical design decisions

value chain
future concerns
impact on specification and design
Value Chain and Customer Concerns

- **Concerns**
  - ease of use
  - convenience
  - ease of mind

- **Profit / Cost of Operation**
  - smooth operation / availability
  - market share / customer base

- **Security**

**Diagram:**
- Consumers
- Bank Corporation
  - ATM manufacturer
  - Infrastructure and service providers
What are Important Future Customer Concerns?

Describe or visualize these concerns very specific.

What are the consequences of replacing offices with machines?

What is the biggest nightmare of the management and the consumers?

How is the current system prepared for these future concerns?
The following slides provide some answers of the previous exercises.

Continue only after going through the exercises!
Examples of Critical Design Issues

- Security design
- Exception handling
- Operating system
- Controller hardware
- Security
- Availability
- Design size and complexity
- Cost
- Performance
- Functionality
- Development effort
- Cost
- Performance
Examples Controller Alternatives

**minimal cost design**
- HW material cost: 100$
- SW license cost: 0$
- SW size: 20kloc
- performance: HW/network
- constrained

- state table
- state machine engine
- HW handlers
- watchdog
- 8 bit controller

**PC oriented design**
- HW material cost: 500$
- SW license cost: 40$
- SW size: 120kloc
- performance: HW/network
- constrained

- OO based application
- middleware framework
- embedded Windows
- drivers
- interfaces
- industrial PC
Example of Customer Contact Concern

**old situation**

**main office**
- personnel
- counter
- customers

**branch office**
- personnel
- counter
- customers

**new situation**

**main office**
- personnel
- counter
- customers

ATM

**important assets of bank:**
- brand name
- customer base

main point of contact moves from office to ATM!

ATM visit is short opportunity to bind and sell.

promotion offers, new products, via animations and ...?
De belangrijkste feiten:
– PIN gaat over op EMV
– Geen hoge kosten door geleidelijke invoering
– Volledige invoering verwacht rond 2013
– Magneetstrip werkt nog lange tijd

translation:
+ PIN changes into EMV standard
magnet strip replaced by chip
- introduction complete ca 2013

Security relates to all system aspects
from bank management, personnel and processes
down to network medium and hardware drivers.
The bad guys also make lots of progress.
Step 3, The Big (Complicated) Picture

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ARATMgraph

Customer objectives
- cost reduction
- security
- customer contacts
- sales promotion
- brand image

Application
- personnel office reduction
- procedures PIN code

Functional
- ATM
- material cost
- identification authentication
- availability
- animation

Conceptual
- controller design
- exception handling
- state table

Realization
- u controller
- minimal code
- watch dog
- industrial PC
- full fledged OS
- full color display
Step 4, Thread of Reasoning

Customer objectives

Application

Functional

Conceptual

Realization

cost reduction

personnel office reduction

ATM

controller design

u controller

security

procedures

PIN code

material cost

identification authentication

exception handling

state table

minimal code

watch dog

industrial PC

full fledged OS

animation

full color display

customer contacts

sales promotion

brand image

availability

animation
Exercise: What did You Learn?

What did You Learn?

Where did we start?

What are the iterative steps that we took?

What are the new insights?

How SMART is the result?

What do we still have to do?
Warning: Following Slides provide Answers!

The following slides provide some answers of the previous exercises.

Continue only after going through the exercises!
What is next?

We made a very fast iteration over many view points.

Most reasoning has been qualitative.

Fact finding and quantification needed to determine relevant and significant issues.

Keep on iterating and sharpening!