Role of Systems Architecting in Innovation

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Abstract

Distribution

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March 6, 2013
status: preliminary draft
version: 0
The Embedded Systems Domain

- chip
- television
- printer
- waferstepper
- MRI scanner
- cardio X-ray system
- GSM
- television
- printer
- waferstepper
Successful Innovation = Technological + Market

market innovations
segments
needs
applications
services

system

technological innovations
materials
circuits
functions
user interface

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RIItechnologicalAndMarket
System Architect links technology and market

**market innovations**
- segments
- applications
- needs
- services

**technological innovations**
- materials
- circuits
- functions
- user interface

**system**
- engineers
- inventors
- marketeers
- systems architect

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RILcontributes
Example: 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

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Product Innovation: Easyvision applied as printserver

Examination Room
- X ray source
- detector

Control Room
- console

Corridor or closet
- printer

Examination Room

Control Room

Reading Room
- light box

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XRaysRoomsPlusPrintServer
Market innovation: optimized film

old: screen copy

new: SW formatting

20 to 50% less film needed
Technology innovation challenges

print
throughput
view
response time
image quality
image processing
tension

ca 1 film / minute
film = 4k*5k pixels
subsecond retrieve
screen = 1k*1k

product policy:
standard HW
SW "only"

40 MHz CPU
64 MByte memory
10 MBit/s ethernet
1 GByte disk
Typical Growth of a System Architect

- Root technical knowledge
- Generalist technical knowledge
- Business, application insight
- Process insight
- Psychosocial skills
Generalist versus Specialist

- Specialist
- Generalist
- Root knowledge
- Breadth of knowledge
- Depth of knowledge

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MATgeneralistVsSpecialist
Generalists and Specialists are Complementary

- **Generalists** have a breadth of knowledge.
- **Specialists** have a depth of knowledge.

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Spectrum from Specialist to System Architect

- **Specialist**
- **All-round specialist**
- **Aspect architect**
- **Systems architect**

**Depth of knowledge** vs **Breadth of knowledge**

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More innovations in Medical Imaging

1992
RF 1.1
URF basis
RF 1.2
vascular import
RF 1.2
vascular

1993
RF 2.1
cardio
RF 2.1
cardio

1994
RF 2.2
Dicom
RF 2.2
Dicom

1995
RF 2.2
Dicom

1996
X 3.1
spine

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RllexampleMI

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Key success factor 1: innovation by all parties

market innovations
segments
needs
applications
services

system

marketeteers
system architect
engineers
inventors

technological innovations
materials
circuits
functions
user interface

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The "CAFCR" model

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
What does Customer need in Product and Why?

Customer
What

Customer
How

Product
What

Product
How

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

context understanding
intention
objective driven

opportunities
constraint awareness
knowledge based
CAFCR can be applied recursively

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## CAFCR applied on Security

<table>
<thead>
<tr>
<th>Customer objectives</th>
<th>Application</th>
<th>Functional</th>
<th>Conceptual</th>
<th>Realization</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensitive information</td>
<td>selection</td>
<td>functions for administration</td>
<td>cryptography</td>
<td>specific</td>
</tr>
<tr>
<td>trusted</td>
<td>classification</td>
<td>authentication</td>
<td>firewall</td>
<td>algorithms</td>
</tr>
<tr>
<td></td>
<td>people</td>
<td>intrusion detection</td>
<td>security zones</td>
<td>interfaces</td>
</tr>
<tr>
<td></td>
<td>information</td>
<td>logging</td>
<td>authentication</td>
<td>libraries</td>
</tr>
<tr>
<td></td>
<td>authentication</td>
<td>quantification</td>
<td>registry</td>
<td>servers</td>
</tr>
<tr>
<td></td>
<td>badges</td>
<td></td>
<td>logging</td>
<td>storage</td>
</tr>
<tr>
<td></td>
<td>passwords</td>
<td></td>
<td></td>
<td>protocols</td>
</tr>
<tr>
<td></td>
<td>locks / walls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>guards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>administrators</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**desired characteristics, specifications & mechanisms**

<table>
<thead>
<tr>
<th>social contacts</th>
<th>missing</th>
<th>holes between</th>
<th>bugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>open passwords</td>
<td>functionality</td>
<td>concepts</td>
<td>buffer overflow</td>
</tr>
<tr>
<td>blackmail</td>
<td>wrong</td>
<td></td>
<td>non encrypted</td>
</tr>
<tr>
<td>burglary</td>
<td>quantification</td>
<td></td>
<td>storage</td>
</tr>
<tr>
<td>fraud</td>
<td></td>
<td></td>
<td>poor exception</td>
</tr>
<tr>
<td>unworkable procedures</td>
<td></td>
<td></td>
<td>handling</td>
</tr>
</tbody>
</table>

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QNsecurityExample
Deliverables of the System Architect

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Responsibilities of the System Architect

Balance  Consistency  Decomposition  Integration

Overview

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RSAreponsibilities
What does the System Architect do?

- think, analyze
- listen, talk, walk around
- design, brainstorm, explain
- assist project leader with work breakdown, schedule, risks
- present, meet, teach, discuss
- test, integrate
- write, consolidate, browse
- read, review
- travel to customer, supplier, conference
- provide vision and leadership
## From Detail to Overview

<table>
<thead>
<tr>
<th>Details</th>
<th>Quantity per year (order-of-magnitude)</th>
<th>Architect time per item</th>
</tr>
</thead>
<tbody>
<tr>
<td>driving views</td>
<td>10</td>
<td>100 h</td>
</tr>
<tr>
<td>shared issues</td>
<td>$10^2$</td>
<td>1 h</td>
</tr>
<tr>
<td>touched details</td>
<td>$10^4$</td>
<td>0.5 – 10 min</td>
</tr>
<tr>
<td>seen details</td>
<td>$10^5 – 10^6$</td>
<td>0.1 – 1 sec</td>
</tr>
<tr>
<td>product details</td>
<td>$10^7 – 10^{10}$</td>
<td></td>
</tr>
<tr>
<td>real-world facts</td>
<td>infinite</td>
<td></td>
</tr>
</tbody>
</table>

- consolidation in deliverables
- meetings
- informal contacts
- sampling scanning

### Quantity (order-of-magnitude) for:
- Driving views: 10
- Shared issues: $10^2$
- Touched details: $10^4$
- Seen details: $10^5 – 10^6$
- Product details: $10^7 – 10^{10}$
- Real-world facts: infinite

### Architect time per item:
- 100 h
- 1 h
- 0.5 – 10 min
- 0.1 – 1 sec
Key Success Factor 2: highly iterative

Cost revisited in context of clinical needs and realization constraints; note: original threads are significantly simplified.
Key Success Factor 3: Architect as Integrator

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MSmeddlerAndHeroes
Innovation Challenges in Embedded Systems

discover latent needs
enable emergence
where is the business
globalization
hype waves
Moore's law

creativity
market dynamics

security
interoperability
emerging behavior, future vs legacy
heterogeneous vendors

power consumption
reliability
weight, cost, performance
complexity
heterogeneity
#engineers involved

privacy, DRM
versus usability