Opportunities and challenges in embedded systems

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Abstract

The technological advances in processing, communication, storage, actuating and sensing enables a large amount of applications of embedded systems. The challenges of today to realize these opportunities are discussed, addressing six main issues: market dynamics, interoperability, reliability, power, security, and creativity.

The capabilities of the Embedded Systems Institute are discussed briefly.
Giga embedded opportunities

opportunities

communication
bandwidth
GigaBits/s

processing
power
GigaOps/s

storage
GigaBytes

smart(?)
software

micro-size
sensors

actuators
displays

infinite(?)
embedded opportunities
Hit list of challenges

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

creativity
market dynamics
security
interoperability
power consumption
reliability

privacy, DRM
versus usability

emerging behavior, future vs legacy
heterogeneous vendors

weight, cost, performance

complexity
heterogeneity
#engineers involved

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DYOFContents
Value Chain in Consumer Electronics

Providers
UPC
Canal+
AOL
AT&T

Retailers
Fry's
Dixon

System Integrators
Philips CE-TV
Loewe
Sony
Nokia
Philips CE-DN
Philips CE-PCC

Component and Platform Suppliers
Philips Components
Intel
Microsoft
Micron
Philips Semiconductors
Liberate
Samsung

Consumers
Boonstra
Peper
Kok
Chirac
Blair
Pietersen
Smith
Jones
Jansen
Muller
Kleisterlee
Clinton
Koch
d'Oliviera

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LWAvalueChain
Trend: convergence

Telecom

Consumer

Computer
Integration and Diversity

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LWAIntegrationAndDiversity
System Integrator Problem Space - Business

- time to market
  - infrastructure: 100 months
  - application: 10 months
  - volume: 1000 units

- volume
  - personalization (skins, themes)

- effort
  - digital TV: 1000 manyears
  - GSM: 10 manyears
Is reuse the solution to effort?

Trends:
- Features
- Performance expectations
- Number of products
- Release cycle time (years → months)
- Openness and interoperability

Consequences:
- Feature interaction
- Complexity
- Amount of software
- Integration effort
- Reliability

Solutions:
- New methods
- New tools
- Hardware performance
- New software technology
- New standards
- Reuse
Applications depend on chain of systems

Users

Home Server
Network Providers
Service Providers
Content Providers

Infotainment Appliance
- Watch video
- Browse photo's
- Calendar
- And much more...
Interoperability: systems get connected at all levels

- MR scanner
- Workstation
- Storage
- RIS
- Printer
- PC
- Beamer
- Other examination rooms
- Other clinical departments
- Clinicians at home
- Clinicians away
- Clinical experts
- Suppliers
- Patients away
- Patients at home

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DYOFscopeOfInteroperability

Embedded Systems Institute
Multi dimensional interoperability

<table>
<thead>
<tr>
<th>integrating multiple applications</th>
<th>in multiple languages</th>
<th>delivered by multiple vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td>clinical analysis</td>
<td>clinical cultures</td>
<td>Philips GE Siemens</td>
</tr>
<tr>
<td>clinical support</td>
<td>USA, UK, China, India, Japan, Korea France, Germany Italy, Mexico</td>
<td></td>
</tr>
<tr>
<td>administrative workflow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>based on multiple media, networks</th>
<th>and multiple standards</th>
<th>and multiple releases</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVD+RW, memory stick, memory cards, bluetooth, 11a/b/g, UTMS</td>
<td>Dicom, HL7, XML</td>
<td>R5, R6.2, R7.1</td>
</tr>
</tbody>
</table>
SW increase in televisions

1965

1979

1 kB

2000

1990

2 MB

64 kB

Moore's law

From: COPA tutorial, Rob van Ommering

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LWAmooresLawRvO
Increase of software threatens Reliability

Based on average 3 errors/kloc

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Power consumption and dissipation

- heat dissipation
- stand-by time
- operational time
- acoustic noise
- power supply cost

**Examples**

- 3G phone
  - standby time
  - operational time
  - wireless video
- Desktop
  - silent fanless
- Data centers
  - insufficient power in Amsterdam
- MRI gradients: 66 mT/m
- kWatts: cost, noise, heat
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Profile of Digital TV and GSM
Security conflicting interests

- company
- government
- security
- restrictive
- intrusive
- content
- industry
- digital rights
- restrictive
- paranoia
- consumers
- privacy
- usability
- freedom
- protection
- dictators
- terrorists
- thieves
- pirates
- threats

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DYOFsecurity
Creativity as limiting factor

Can we do it?
Can we make it?
Can we organize it?
Can we conceive it?

Performance
Cost, Power, Size
People, Process
Imagination

from: Ad Huijser Philips Software Conference 2001

Time
Ambition level

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How to create embedded systems which satisfy the functionality, and quality needs and which fit in the limiting constraints.

- Specify, design, test and verify; f.i. modeling.
- Performance, interoperability, productivity, reliability.
- Power, cost, economy, skills, legislation.

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ESI capabilities