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

- communication bandwidth
  - GigaBits/s
  - storage
    - GigaBytes
  - processing power
    - GigaOps/s
  - smart(?)
    - software
  - micro-size sensors
  - actuators displays

= infinite(?)
  = embedded opportunities

Opportunities and challenges in embedded systems

version: 1.0
September 9, 2018
ESOopportunities
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
- weight, cost, performance
- emerging behavior, future vs legacy
- heterogeneous vendors
- complexity
- heterogeneity
- privacy, DRM
- versus usability
- engineers involved

Opportunities and challenges in embedded systems
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DYOFCchallenges
Value Chain in Consumer Electronics

Consumers

Providers

System Integrators

Component and Platform Suppliers

Retailers

Providers

UPC
Canal+
AOL
AT&T

System Integrators

Component and Platform Suppliers

Retailers

Consumers

Providers

Value Chain in Consumer Electronics

Opportunities and challenges in embedded systems

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LWAvalueChain
Trend: convergence

Telecom

Consumer

Computer
Integration and Diversity

GSM phone

firewall

dvd

audio

microset

pda

set top box

headphone

pen

garment

headphone

Garment

cable

modem

car

speech

GSM phone

camera

speech

set top box

headphone

television

flat display

Communicator

Ambient Intelligence

living room

car

sailboat
System Integrator Problem Space - Business

- **Time to Market**
  - Infrastructure: 100 months
  - Application: 10 months
  - TV: 1 month

- **Volume**
  - GSM: $10^6$ units
  - Personalized (skins, themes): $10^3$ units

- **Effort**
  - Digital TV: 1000 manyears
  - GSM: 100 manyears

Opportunities and challenges in embedded systems

Gerrit Muller
Is reuse the solution to effort?

**Trends**
- Features
- Performance expectations
- Number of products
- Release cycle time (years ➔ months)
- Openness
- 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
- Network Providers
- Service Providers
- Content Providers
- Home Server
- Infotainment appliance
  - Watch video
  - Browse photo's
  - Calendar
  - And much more...

Opportunities and challenges in embedded systems
Interoperability: systems get connected at all levels

Opportunities and challenges in embedded systems

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DYOF: scope of interoperability
Multi dimensional interoperability

integrating multiple applications
clinical analysis
clinical support
administrative
financial
workflow

in multiple languages
USA, UK,
China, India,
Japan, Korea
France, Germany
Italy, Mexico

delivered by multiple vendors
Philips
GE
Siemens

based on multiple media, networks
DVD+RW
memory stick
memory cards
bluetooth
11a/b/g
UTMS

and multiple standards
Dicom
HL7
XML

and multiple releases
R5
R6.2
R7.1
SW increase in televisions

From: COPA tutorial, Rob van Ommering

Moore's law

En dat wordt perfect. Alzat het m'n prins is.

From COPA tutorial, Rob van Ommering
Increase of software threatens Reliability

Based on average 3 errors/kloc

Opportunities and challenges in embedded systems
Power consumption and dissipation

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

3G phone
standby time
operational time
wireless video

Examples

MRI gradients: 66 mT/m

kwatts: cost, noise, heat

desktop
silent fanless

Data centers
insufficient power in Amsterdam

Opportunities and challenges in embedded systems

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DYOFpower
System Integrator Problem Space - Technology

Operations/s

Watt

Byte

home server

digital TV

GSM

performance

power

storage

10^12

10^9

10^6

10^3

10^9

10^6

10^{-3}

10^{-3}

10^12

10^9

10^6

Opportunities and challenges in embedded systems

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LWAproblemSpaceTechnology
Profile of Digital TV and GSM

Problem space

- months
- units
- manyear
- Operations/s
- Watt
- Byte

- time to market
- volume
- effort
- performance
- power
- storage

- months
- units
- manyear
- Operations/s
- Watt
- Byte

- time to market
- volume
- effort
- performance
- power
- storage
Security conflicting interests

- company
- government
- security
- restrictive
- intrusive

- content
- industry
- digital rights
- restrictive
- paranoia

- consumers
- privacy
- usability
- freedom
- protection

- dictators
- terrorists
- thieves
- pirates
- threats
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

Ambition level

Time

from: Ad Huijser Philips Software Conference 2001
How to create embedded systems which satisfy the functionality, and quality needs and which fit in the limiting constraints

methods to:
specify, design, test and verify; f.i. modeling

Opportunities and challenges in embedded systems

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ESOcapabilities