1.3 Ambient Intelligence: the Next Paradigm for Consumer Electronics: How Will it Affect Silicon?

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Ambient Intelligence refers to an environment where the user experience is what matters. People want to have fun, feel free, enjoy life, feel secure, be in control and be productive. This experience is not linked to one particular device but is realized by a network of devices present in the environment that will provide us these experiences in an intelligent way.

Ambient Intelligence is introduced as a new paradigm in consumer electronics. Some of the technologies required for Ambient Intelligence are covered, with a focus on IC consequences. Ongoing work in three fields is described: ubiquitous radio, intuitive user/system interfaces and three-dimensional visual displays. These three fields highlight the diverse nature of Ambient Intelligence technologies as well as the resulting requirements for ICs. Considerations with respect to an introduction timeline of Ambient Intelligence are given.

Contents
- The changing landscape of consumer electronics
- Ambient Intelligence, the concept
- Challenges for silicon
- Topics
  - Ubiquitous radio concept
  - Easy access to audio content
  - Towards an enhanced visual experience
- A likely timeline of introduction
- Conclusions

Television now
The inside story

Television in the sixties

Ambient Intelligence, the concept
- An environment that is sensitive, adaptive and responsive to the presence of people or objects
- An environment where technology is embedded, hidden in the background
- An environment that augments activities through smart, non-explicit assistance
- An environment that will preserve security, privacy and trustworthiness while utilizing information when needed and appropriate.
Ambient Intelligence
Domains & Drivers

- Domains:
  - Home [focus of this presentation]
  - Car
  - Office

- Drivers
  - Ubiquitous communications
  - Distributed computing
  - Intelligent interfaces

50 years of semiconductor industry

Trend = +17% / Year

Process technology drives progress

Process Technology

- Storage
- BW
- LAN, WAN
- Internet
- Digital TV
- CPU power
- Processor
- DSP
- ASICs
- I/O
- LCD
- CCD
- Silicon on anything
- Wearables
- Plastic electronics

Home connected to the world

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Conclusions

- Bit growth will keep increasing exponentially.
- Memory architecture diversification will continue.
  - High Density, High Speed, Low Power, Solution Memory
- Bit growth rate will increase rapidly from ~2005.
  - Digital Convergence for Virtually All Electronics
  - New Platforms Will Keep Being Introduced:
    - Internet Appliances + Network + Mobile + Consumer
- Rapid Bit Cost Reduction will Generate New Platforms

First generation IT-systems

Second generation IT-systems

Third generation IT-systems

Interfaces to computing machinery

The Evolution of Computers and Networks

Room size
Mainframe
Mini-computer
Desktop PC
Notebook PC
PDA
Networked appliance

The Evolution of User Interfaces

Personalised anticipatory multi-modal UI

Assembly and machine code

High-level languages

VUI

GUI

High-level languages

Assembly and machine code
Challenges for Silicon

- A multitude of environment / system interfaces
  - Bitrates from 1 bit/s to 5Gbit/s
- Large variation in computational complexity
  - 1 KOPS [control] to 1 TOPS [synthetic video]
- Large variation in power requirements
  - < 100 µW [no battery] to > 1W [mains operated]
- Ubiquity presumes ultra low cost
  - < 10 ct [tagging]
- Design time & effort must be limited

Wireless Data Transfer Market

Wireless Data Transfer Market

ZigBee

The aim of ZigBee is to bring about a low cost, low bit rate, low power, short range RF data link aimed at consumer products in and around the home as well as industrial sensor applications.

ZigBee characteristics

- 10kbps - 115.2kbps data throughput
- 10-75m coverage range (home/garden)
- Support for up to 255 nodes
- Support for up to 100 co-located networks
- Support for 4 time-critical devices
- 0.5-2 year battery life (2 x AA)
- Up to 5ms⁻¹ permitted mobility
- Module cost: $1.5-$2.5 in 2003/4

Network Topology

Master manages the network
- Forwards messages
- Keeps address book up-to-date

Between Radios and Tags...

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Ultimate Miniaturization!

Existing ZigBee based active tag

Ubiquitous radio?
IC objectives:
- Small size (~ few mm²)
- Low power design ~ 100µW
- Integrated antenna + matching circuits
- No external frequency reference
- No external ‘glue’ components
- Small / integrated battery (+ power coupling)
- Power optimised protocol

Easy Access
- Problem statement
  - Storage capacity doubling every two years
  - Compression technologies rapidly improving
    • High quality audio coding now possible @ 40Kb/s
    • 3000 songs on a DVD; 60000 songs on a HDD [100GB]

So, you can store anything you want……..

But will you ever find it back?

Easy Access
- What is Easy Access?
  - Innovative user interface options that support different user strategies for handling large collections of media content in CE devices.
- Necessary ingredients
  - Knowledge on the user- and technology related issues for implementing multi-modal and personalised user interfaces.
  - Methods and tools for the specification and validation of multi-modal user interface solutions.

Concept demonstrator
- Multi modal & personalized internet audio jukebox:
  - Control through touch and phoneme based speech recognition
  - Feedback through graphics and audio (with text-to-speech)
  - Access to “unknown” content through Query by Humming
  - Personalized access based on Speaker Identification and Automatic Collaborative Filtering

Multimodal interaction
- Query by Humming

Query by Humming is a novel way to access music by producing a ‘hook-line’ of a song while the system seeks the song containing that melody.

For those occasions in which:
- you have only some knowledge of the melody
- you don’t want to browse, hoping you will recognize the title
- you want to find songs with similar ‘hook-lines’

Signal Processing steps

Computational load [1]
- Processing steps being cascaded:
  - Pitch extraction, event detection, note quantization, melody encoding, approximate pattern matching
- Complexity mainly determined by approximate pattern matching:
  - O (n.m) where
    • n = number of notes sung
    • m = number of notes of the melody in the database

Computational load [2]
- Realistic system:
  - N=12, M=300, 20000 songs, T<0.5 second
- Approximate pattern matching takes 3 GOPS
Towards an enhanced visual experience

Reconstruction from 2D video

A 3D TV chain

Depth estimation (2.5D) from 2D video

Different ways of representing 3D

Combining depth maps to a 3D model

Key requirements

Results: Dionysios sequence

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Computational load

- Most demanding processing steps:
  - Segment-based motion estimation [5 GOPS]
  - Rendering:
    - Multi-view auto-stereoscopic display, 3000*2000, allowing multiple SD [720*576] images
    - Nearest neighbor interpolation: 4 GOPS
    - Bi-linear interpolation: 20 GOPS

Embedded Systems: Design objective

Communication in a Multiprocessor Architecture

Types of Embedded Cores

- weakly-programmable (parametrizable) functions (FSMD) e.g. video functions
- application specific and programmable cores (ASIP) e.g. Tensilica, A/RT VLIW
- programmable DSP cores: e.g. R.E.A.L., Palm, Oak...
- programmable general purpose CPU cores e.g. ARM, MIPS, TM...

Current platforms: DVP example

Networks-on-Silicon

- Multistage network = graph construct with routers & links
- From global to segmented interconnect
- Similarity with telecom networks
- NOS must be more predictable to avoid time-consuming design iterations

Networks-on-Silicon: OSI Protocols

- Application layer
- Presentation layer
- Session layer
- Transport layer
- Network layer
- Data link layer
- Physical layer

DVP example: Viper (PNX8500)

- ASB and DTV
- 0.18 μm / 8M
- 1.8V / 4.5W
- 35 M transistors
- 75 clock domains
A likely timeline of introduction

- Not a "Big Bang" but rather a gradual blending into daily life
- Ubiquitous communications will further develop to cover the whole spectrum
- Intelligent interfaces will be enabled step-by-step through exploitation of Moore's law
- Natural- and synthetic image processing is very compute-cycle demanding and needs progress in novel architectures and algorithms. A new paradigm for on-chip communications is needed.

Conclusions

- Ambient Intelligence has been presented
- Challenges for IC design are many-fold:
  - Ultra low cost [ubiquity]
  - Ultra low power [5 year battery life; off the environment]
  - Ultra high-speed [100 GOPS ... ! TOPS]
  - Novel architectural approaches on silicon needed
- Applications in various domains
  - Car, office, home
- Convergence of computing, communications and consumer electronics means business

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