Workshop @ ECOFAC 2014
Consortium

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23 Mai 2014
Open-PEOPLE tutorial @ ECOFAC 2014
AGENDA

• Introduction

• Characterizing the Power Consumption of Embedded Systems

• Developing Power Consumption Models

• Modeling and Analyzing Embedded Systems
Objective

- A platform for estimating and optimizing the power and energy consumption of complex electronic systems
- Open: internet access, new partnerships (Open-PEOPLE club)
- Extensible: online measurements and model development

Outcomes

- Hardware platform with automatic measurements to develop new models
- Software platform via internet portal or local client
- Methods and tools for consumption estimation and optimization
- A library of standardized software and hardware components models
  - Models for complete platforms
  - Models for operating systems services
- Demonstrators
  - Video (analytic + compression)
  - Telecommunications (SDR)
Requirements for Open-PEOPLE

- Precise power measurement for power consumption optimization on a rack equipped with up to date HW components
- Fast power estimation for new product definition with an updated model library
- Models that have been confronted to experimental results, real industrial use cases and tests ... and users feedback
- A large community of users for Open-PEOPLE: including our clients, suppliers and potential new suppliers
- Benchmarks
- Ergonomics: an easy and ready to use interface with standard tools (scientific community AND industry): components and architecture descriptions should be quick, reusable, upgradable
- Secured access: lightweight client as well as a local version
Consumption measurements: the Open-PEOPLE platform

- **POWER ANALYZER**
  - N6705A

- **CONSOLE**

- **BOARDS**
  - + custom measurement boards

- **PXI CHASSIS**
  - NI PXIe 1062Q
  - Acquisition boards
  - Multiplexers

- **SERVER**
  - DELL T5500

- **SWITCHED PDU**
  - APC AP7921
• Introduction

• Characterizing the Power Consumption of Embedded Systems

• Developing Power Consumption Models

• Modeling and Analyzing Embedded Systems
FLPA : Functional Level Power Analysis

- Three steps
- Complex architectures
- Simple models
- Precise estimation
- For processors
  - DSP & GPP
  - SoftExplorer tool
- For FPGA
- For memories
- For OS services
- For complete systems

- A set of equations
- A multi-entry table

1. Functional Analysis
   - Algorithmic parameters
   - Architectural parameters

2. Characterization
   - Scenario: $\alpha = 0 \ldots 1$
   - Architecture: $F = 20 \ldots 200$ MHz

3. Model determination
   - Algorithmic parameters
   - Architectural parameters
CHARACTERIZING THE POWER CONSUMPTION

Example: The GStreamer power consumption model for the OMAP 3530 MPSoC

- GStreamer: Open-Source Multi-media Framework
- Characterize the power consumption due to decoding a video.
- Power consumption measurements for various fps values.
CHARACTERIZING THE POWER CONSUMPTION

Energy Decomposition
Consumption measurements: the Open-PEOPLE platform

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CHARACTERIZING THE POWER CONSUMPTION

Network Topology

- Loria
- Lab-STICC
  - AJP13 8009
  - Linux Debian Etch
  - Apache 2
  - Tomcat Connector
  - TLS module
  - DMZ
- Windows 7
  - Tomcat 6
  - Axis 2
  - EclipseLink
  - JavaDB
- Hardware Platform
- LAN

HTTPS
CHARACTERIZING THE POWER CONSUMPTION

Demo

- The OPHWP Remote Control: https://dev.open-people.fr/wiki/OPSWP-Release
- Logon the hardware platform
- Choose one optc (the gstreamer demo)
- Schedule and run the test
- Refresh the screen in the current tests window
- Archive test (data from the measurements are downloaded)
- Export .optr file (create an optr file on disk)
CHARACTERIZING THE POWER CONSUMPTION

Gstreamer Power Consumption Model

\[ P_{os\_idle} = 497 \text{mW} \]
Creating model from measurements

Launch the Open-PEOPLE Software Platform (OPSWP)

Import optr in a Look Up Table lut

- Create OP project
- file > new > project > openpeople/openpeople project
- OK to associate OP perspective

In the OP project : RightClick > import > OP/optr into lut

- select data to import …
- for gstreamer with digitizer.csv → measurements points versus time …
- summary.csv is to be taken when several tests in the same optr

Exemple with FPGA consumption modeling …
CHARACTERIZING THE POWER CONSUMPTION

A Power Consumption Model for the ML550 Xilinx Virtex 5 FPGA

- Model parameters:
  - Clock frequency
  - Surface occupied by the design
    - Number of Configurable Logic Elements (CLE)
  - Toggle Rate
    - Defined as the rate at which the output signal of a basic logical element commutes when its input commutes.

- Perform measurements for several designs for which the model parameter values are known and vary.

- The synthesized designs consist of a variable number of counters
  - Number of counters \( \rightarrow \) surface
  - Number of bits of a counter \( \rightarrow \) toggle rate
  - Clock frequency given to EDK.
Creating model from measurements

Exemple : FPGA consumption modelling demo

Run the optc on the OPHWP Remote Control

Import result in the OPSW

- import fr-labsticc-ml550-surface-frequency-togglerate.optr in a LUT
  - In the OP project : RightClick > import > OP/optr into lut
  - select data to import …
  - choose summary.csv (to be taken when several tests in the same optr)

add columns : add

- import data from column = 2
- in a variable ("key") of the new lut
- variable number = 1
- quantity kind = usage rate of configurable element
- Unit = centi (car c'est des pourcentages)
Creating model from measurements

Do the same for the frequency

- import data from column = 3
- in a variable ("key") of the new lut
- variable number = 2
- quantity kind = clock freq
- Unit = mega

Once again for the toggle rate ...

Then the power (output of the model)

Then « finish » ➔ the ex_lut.lut model is created

Select the model, then you have acces to

- Properties thumbnail to redefine units and dimension for the inputs and outputs
- Together with the interpolation method
- Values thumbnail shows different values in the table depending on the inputs
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FLPA: The Big Picture…

- Question:
  - How are we going to use the FLPA models?

- Answer:
  - Integrate them in CAD analysis tools.

- FLPA:
  - Fast and accurate estimations. ☺
  - Reduced model applicability. ☹
    - To the specific component (or component model) on which measurements were taken.

- ➞ There are many models…

- ➞ CAD tools must be updated very often (every time a new model becomes available).
Models integrated in tools are often expressed with general programming languages such as Java, C++, etc.

Needs:
- A dedicated formalism to represent our models.
  - No restriction to power consumption.
- User-friendly editors for designers to manipulate the models.
- Means to integrate these models in CAD analysis tools.
- Means to compute the models to produce the analysis results.
- Means to represent the system we are designing.
  - Architecture Description Languages (ADLs)
DEVELOPING POWER CONSUMPTION MODELS

Quantitative Analysis Modeling Language (QAML)

- Multi-paradigm Modeling / separation of concerns / one DSML for each domain.
- Reuse existing standards as much as we can.
Quantity Kinds and Units Definition

\[ P_{\text{statSubcompo}} = \sum_{\text{subcomponents}} P_{\text{statTot}} \]

\[ P_{\text{statTot}} = P_{\text{statSubcompo}} + P_{\text{stat}} \]
DEVELOPING POWER CONSUMPTION MODELS

QEML Model Definition

EQML

Quantitative Evaluations

Java External Tools

LUTML Lookup Tables

QUAV

Quantities, Units, Dimensions, Values

MathML Mathematics

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DEVELOPING POWER CONSUMPTION MODELS

Demo: Creating a QEML Model

- Launching the Open-PEOPLE Software Platform (OPSWP)
  - The Eclipse Workbench Help System
  - Preferences

- window > preferences > open-people main preference page > units
  - define a new base unit and derived unit

- window > preferences > open-people main preference page > quantities
  - define a new quantity expressed in base or derived unit
    - remark « bug » : a fictive quantity base unit must be defined

Creating a QEML model:

- file > new > law > estimation law
- define targeted project (ex_stockage_model) et the law name
- Enter the law (click in "law") ... (0.2 * Fclock + 0.879) * (1+0.000001*Tc)
- domain of validity ... (Tc>-20)&&(Tc<125)
- Possible to add another validity domain
  - form scratch (add piece)
  - from the preceeding (duplicate)
Demo: Open-PEOPLE Model Library

- Share the ML550 FPGA LUT model.
- Export a model from the project where it has been created:
  - export > OP shared models > consumption model > ex_stockage_de_model
  - (project to export) >
  - directory where to export > ...
- Connect to the shared mode library web site …
- Import the model in the OPSWP:
  - import > op shared models ...
  - Remark: If the project is already in the workspace, drag & drop (dup) from the project origin to the destination project
Components are becoming more and more complex.

There is a strong need for more accurate data sheets of components.

This implies that characteristics of components are more complex to express.

A standard formalism to represent the data sheets would be nice.

QEML could be a candidate for that.
Project progress and planning

**Specification**

- Hardware platform dev
  - HWPF version 1.0
  - HWPF version 0.1

- Software platform dev
  - Support platform
  - Remote control v0
  - PCA0 v0.9
  - SW PF v1.0

- Models and methodologies
  - OMAP / GPP
  - OMAP / DSP
  - Domain Specific Languages
  - FPGA
  - Operating System
  - Global methodology
  - GPP / SoftCores
  - Model transformations

**Validation**

- H264 / software radio → model accuracy (global)
  - Measurements
  - Comparison of modeling level
  - Application / Platform mapping
  - Hardware and software exploration

**Management - Dissemination**

- PCMD v0

**Integration**

- Global methodology

**Date**

11 April 2013

Open-PEOPLE tutorial @ Aalborg University - 2013
Open-PEOPLE architecture

Hardware Platform

Software Platform

Portal GUI (remote control of hardware platform)

Modelling UI

Power Analysis & Optimisation GUI

Power Analysis & Optimisation Services

System Description

Power & Energy Analysis

Locale or Remote

Public

P&E Model Library Components & Component Platforms

Private

P&E Model Library Components & Component Platforms

Hardware Platform Control Functionalities

Power Consumption Model Development

Automatic measurements

Power and Energy Measurements

BenchMarks

Users

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Modeling the system using AADL
Remote control portal

Tab displaying tests processing

<table>
<thead>
<tr>
<th>ID</th>
<th>Owner</th>
<th>Status</th>
<th>Visibility</th>
<th>Priority</th>
<th>Scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
<td>ERROR</td>
<td>private</td>
<td>low</td>
<td>/ Duration: 0.0s</td>
</tr>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
<td>COMPLETED</td>
<td>private</td>
<td>low</td>
<td>Start date: 11 janv. 2012 17:04:04 / Duration: 372.0s</td>
</tr>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
<td>CANCELED</td>
<td>private</td>
<td>low</td>
<td>Start date: 12 janv. 2012 10:46:20 / Duration: 375.0s</td>
</tr>
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<td>test</td>
<td>COMPLETED</td>
<td>private</td>
<td>low</td>
<td>Start date: 12 janv. 2012 14:10:32 / Duration: 366.0s</td>
</tr>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
<td>ERROR</td>
<td>private</td>
<td>low</td>
<td>/ Duration: 0.0s</td>
</tr>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
<td>ERROR</td>
<td>private</td>
<td>low</td>
<td>/ Duration: 0.0s</td>
</tr>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
<td>ERROR</td>
<td>private</td>
<td>low</td>
<td>/ Duration: 0.0s</td>
</tr>
<tr>
<td>fr:labstick:tmdevm3530.jpeg;201105203</td>
<td>test</td>
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<td>private</td>
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<td>COMPLETED</td>
<td>public</td>
<td>medium</td>
<td>Start date: 19 janv. 2012 15:52:19 / Duration: 368.0s</td>
</tr>
</tbody>
</table>
Power Consumption Model Definition

Lookup Table editor

Creation of new quantities

Mathematical laws editor
Tracability: number of requirements satisfied by the AADL architecture spec

Natural language

Constraint language choice

Formal language

Selected requirement

RDAL Editor (Requirements Definition and Analysis Language)
Power Consumption Analysis and Optimization

Allow to associate AADL components and laws

Properties can be associated with law parameters

Start evaluation