The challenges of devising next generation automotive benchmarks

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Agenda

Automotive System Trends

Market requirements

Benchmark requirements

Workload characterization

New Benchmark

Summary
Key Market Drivers

- **CO2 Reduction**
  - [Image of fuel pump and globe]

- **Pollution Reduction**
  - [Image of exhaust pipe with HC, CO, NOx, PM text]

- **Safety**
  - [Image of car driving through wet conditions]

- **Fun to Drive**
  - [Image of red car on a race track]
Global CO₂ Targets

It's the law: 35 mpg CAFE
Automotive News Dec. 19th 2007
Cars: 35 mpg by 2020

EU agrees to steep fines to cut car CO₂ from 2012
Automotive News Dec. 20th 2007
Cars: 120gCO₂/km by 2012
+10 g coming from biofuels ...

Conversion table for regular gasoline engine

<table>
<thead>
<tr>
<th>gCO₂/km</th>
<th>155</th>
<th>140</th>
<th>130</th>
<th>120</th>
<th>110</th>
<th>100</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>L / 100km</td>
<td>6.72</td>
<td>6.08</td>
<td>5.65</td>
<td>5.21</td>
<td>4.78</td>
<td>4.34</td>
<td>3.91</td>
</tr>
<tr>
<td>MPG</td>
<td>35.00</td>
<td>38.69</td>
<td>41.66</td>
<td>45.13</td>
<td>49.24</td>
<td>54.16</td>
<td>60.18</td>
</tr>
</tbody>
</table>
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Summary
# General Architectural Trends and Requirements for Semiconductors

<table>
<thead>
<tr>
<th>Trend</th>
<th>Application Examples</th>
<th>IC Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software-enabled functionality</td>
<td>Replacement of dedicated hardware with software algorithms running on µC</td>
<td>Strong microcontroller cores with RT capabilities, broad peripheral set and eFlash</td>
</tr>
<tr>
<td>Decentralization to Centralization</td>
<td>µC-enabled global controls</td>
<td>High performance processors with network connectivity</td>
</tr>
<tr>
<td>Centralization to Decentralization</td>
<td>Smart sensor networks, dedicated board nets</td>
<td>Broad IP portfolio (sensors, µC, power) HVCMOS and advanced packaging technology</td>
</tr>
<tr>
<td>Analog/Digital Tradeoff</td>
<td>Replacement of signal processing and communication from analog to digital</td>
<td>A/D and D/A conversion, signal conditioning and processing</td>
</tr>
<tr>
<td>X-by-Wire</td>
<td>Mechatronical solutions for steering, breaking instead of mechanical systems</td>
<td>RT capabilities, failsafe electronics</td>
</tr>
</tbody>
</table>
Software-Enabled Functionality
Increased Microcontroller Performance

Semiconductor Industry provides a 30% to 60% annual performance increase at same cost

Software platform, reuse of software modules across application and customers

Migration of functions from hardware to software

Hardware independent Software

Wider use of automatic code generation

Software standardization e.g. Operating system, Drivers with application level interfaces (OSEK, AutoSar, IEC61508, ISO26262…)

Robust, transparent software e.g. encapsulation, software self test

µC family concept with performance increase and easy migration path
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Summary
Benchmarks that Predict Performance in Real-world Applications

Not MHz
- Only provides relative performance analysis

Not Dhrystone
- No regulation
- No memory or cache effects
- Optimizes to nothing
Usage Models

- Is a substitute of the real application to model the system performance and memory size utilization
- Analyze, tune, and validate new processor architectures
- Design and analysis of system-level implementation
- Compare and select processors according to more important criteria than MHz
Vision of the benchmark

The vision is to establish this new benchmark as an automotive tool to specify and measure performance between:

1. OEMs
2. Tier1s
3. Silicon vendors
4. 3rd party tool vendors
The relevance of the benchmark

The automotive is more going toward the system benchmark

1. Static Benchmark
   - Test of given algorithm

2. Dynamic Benchmark
   - Test of response, switch context…

3. Functional Benchmark
   - Test of complete function CAN, LIN, PWM, ADC

4. Auto code Benchmark
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Summary
Proposal EEMBC Automotive Suite V2

- Two big needs
  1. Work load extraction
  2. Application Representative Benchmark generator
The end customers like the Application to be at 70% of the capability of the machine at the first SOP of the product / platform.
Embedded Software

To assess performance of a µC for an application is important to have a good knowledge of:

1. Control Algorithm
2. Plant Algorithm
3. Scenario
Work load characterization

At Source Code level

1. This analyses the source code
2. Without care of the use cases

At Trace code level

1. This analyses a given code trace
2. For a given plant and a given scenario
3. E.g. Full load, Idle, Engine Acceleration..
Benchmark Characterization

Multiple parameters:

1. Instruction distribution
2. Inherent instruction-level parallelism (ILP)
3. Branch predictability
4. Inherent floating-point (FU) usage
5. Minimum cache size to minimize misses
Instruction distribution at Application level

At Source Code level

At Trace Code level

- Trace 1
- Trace 2
- Trace n
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Summary
# Algorithm selection

## Arithmetic Fundamentals
- Bit manipulation
- Basic Calculation, Saturation & Rounding
- Polynomial equations and limited dev.
- Table look-up & Interpolation
- Zeros of a 2nd order equation
- Trigonometric
- Logarithmic, Exponential, X Power Y
- Vector and Matrix functions

## Filters
- De-bounces
- Schmidt trigger
- Finite Impulse Response (FIR) Filter
- Infinite Impulse Response (IIR) Filter
- Fast Fourier Transform (FFT)
- Inverse Fast Fourier Transform (iFFT)
- Discrete Cosine Transform (DCT)
- Inverse Discrete Cosine Transform (iDCT)

## Control
- Finite state machine
- PID
- Kalman + LQG

## Statistics
- Autocorrelation
- Convolution
- Mean Value, Variance, Standard deviation
- Linear regression
- Random sequence
Instruction distribution

At Reference Algorithm level

Ref. Algorithm 1
Ref. Algorithm 2
Ref. Algorithm 3
Ref. Algorithm n

Level of definition

Algorithm parameters (Format, dimension..)

Algorithm data set
Instruction distribution

Instruction Distribution for Automotive Benchmarks

- a2time01
- aifref01
- airfr01
- basefo01
- blimnp01
- cachet01
- camrd01
- idcrtn01
- lirfr01
- marinx01
- pmtrch01
- pwmod01
- rspeed01
- tblock01
- ttspk01

Legend:
- Green: Branches
- Blue: Loads
- Light Blue: Stores
- Red: Add
- Orange: Mult
- Yellow: Shift
- Dark Blue: Subtract
- Purple: Compare
- Brown: Moves
- Yellow: Logical Op

EEMBC Automotive V1
Inherent ILP

Inherent instruction-level parallelism

Parallelism for EEMBC Automotive Benchmarks

Instructions Per Cycle (IPC)

EEMBC Automotive V1
Benchmark Fitting / Tuning

Application

Benchmark
Benchmark Fitting / Tuning

Customer Code

Benchmark Code
- Algorithm selection
- Algorithm parameters
- Algorithm data set
- Algorithm blending
- Fitting to application envelop
- Link to OS
Today Fitting / Tuning is a manual process in the future this could be semi-automatic or fully-automatic.
Software architecture
(Static view)

- Neural network
- Statistic
- State Machine
- Filters T.
- Libraries
- ECU Abstraction Layer
- µC Abstraction Layer

- Table Interp.
- Kalman
- Filters F.
- OS services
- C

- Trigo.
- H∞
- Bit Manipul.
- PID

- Log.

- UML
- MS
- C
- ASM
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Summary

- It is possible to create a benchmark to substitute the application code and be representative.

- This benchmark is a tool to share performance information between OEMs, Tier1s, Silicon vendors, SW vendors and Tool suppliers…

- This benchmark is a tool to better architect HW and SW for next generation Automotive Electronics.
Acknowledgement

EEMBC: The Embedded Microcontroller Benchmark Consortium

http://www.eembc.org

Markus Levy
EEMBC President

Shay Gal-On
EEMBC Director of Software Engineering
The challenges of devising next generation automotive benchmarks

Thank you for your attention

Q&A