JAVA FPGA
An Application for Space

Presented by
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Center for Embedded Software Systems

In coorporation with
GOMSpace
Agenda

• The Java stack
• Towards an Java FPGA
• That’s all good, can I buy it?
• Suppliers
• What are the offerings
• JOP
• JOPCMP
• Conclusions
The Embedded Java Stack

- Java byte code
- Java Class Library
- Java Virtual Machine
- Operating System
- Hardware platform

- Java Native Interface

- Size
- Complexity
- Number of components
- Single point of failure
- No RT Support
Enabling RT Support

- Java byte code
- RT- profile
- JVM
- RTOS
- Hardware platform

- Java Native Interface

- Size
- Complexity
- Number of components
- Single point of failure

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Towards JAVA FPGA

- Components migrated to HW
- Likely an ASIC design
- The stack is still fat
- No RTOS => Bare Metal
- No need for JNI
What does this bring us?

Note: Image from JOP handbook
It depends!

What are your requirements for delivery?
What are your requirements for maturity?
What are your requirements for support?
What are your requirements for features?
What are your requirements for speed?
What are your requirements for memory?
What are your requirements for ....?
Who are the Suppliers?

Academia → Several FPGA solutions
- JOP
- JOPCMP
- Jamuth
- SHAP

Industry → No FPGA solutions
- aJile
- EJC JAVA
- PERC solutions
- Jamaica-VM platform
- DDC-I Scorpion
A Closer Look at the Offerings

PERC Pico & Raven

Pico HW:
• X86

RTOS:
• Linux, Windows

- “QinetiQ Selects Aonix® PERC® for Taranis UAV” - December 2008 Aonix announced the selection of the PERC Ultra virtual machine for Taranis, a $166.6M UK technology demonstrator program for the next-generation of unmanned aerial vehicle (UAV) for the UK Ministry of Defence (MoD).
- “Signalbau Huber selects PERC” - September 2007 Signalbau Huber Germany selected the Aonix PERC JVM for the next generation traffic control system.
- “Boeing Selects Aonix Software for Unmanned Combat System” - 2006 the PERC ultra JVM was selected for the Joint Unmanned Combat Air System (J-UCAS) under DARPA, US Navy and Air Force.
A Closer Look at the Offerings

aJile

Supports:
• Hard real time
• Multiple JVM’s
• Secure networking
• Multimedia functions

<table>
<thead>
<tr>
<th>Name</th>
<th>Maturity</th>
<th>Memory</th>
<th>Speed</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>aj-100</td>
<td>Deployment</td>
<td>32Kb internal ram</td>
<td>100MHz</td>
<td>[aSla]</td>
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<tr>
<td>aj-102</td>
<td>Deployment</td>
<td>32Kb internal ram and data cache</td>
<td>160MHz</td>
<td>Q1 2009 [aS109]</td>
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<td>aj-200</td>
<td>Deployment</td>
<td>32Kb internal ram</td>
<td>180MHz</td>
<td>Q2 2009, 2 independent JVM’s in hardware [aSlb]</td>
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</table>
A Closer Look at the Offerings

Jamaica VM

<table>
<thead>
<tr>
<th>Name</th>
<th>Maturity</th>
<th>Architectures</th>
<th>RTOS</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Jamaica- VM</td>
<td>Deployment</td>
<td>13 architectures supported</td>
<td>8 RTOSs supported</td>
<td>[Aic]</td>
</tr>
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</table>

Mission/Safety Critical Applications:

- Used on the Airbus A380
That’s Fine, Where are the FPGAs?

Why do you wish a FPGA solution?
• It’s hot?
• To differentiate your product?
• It is the only solution to my problems?
• Any or all of the above.

Our wish for Java FPGA
• Different from other offerings in the segment
• Easier to attract attention from the correct parties
FPGA and SOPC

FPGA is programmable/reconfigurable hardware

System on Programmable Chip
IP Core

• 5 step pipeline
Features, maturity, size and speed

**Research**

**Development**

**Deployment**

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<thead>
<tr>
<th>Name</th>
<th>Maturity</th>
<th>Memory</th>
<th>Speed</th>
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</thead>
<tbody>
<tr>
<td>JOPCM</td>
<td>Research</td>
<td>8Kb Scratch RAM and 4KB instruction cache</td>
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</tr>
<tr>
<td>Jamuth</td>
<td>Research</td>
<td>8Kb Scratch RAM and 4KB instruction cache</td>
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<tr>
<td>SHAP</td>
<td>Prototype</td>
<td>8Kb stack, 2 Kb method cache</td>
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<tr>
<td>JOP</td>
<td>Development</td>
<td>4Kb internal RAM</td>
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**Predictable RT GC**

Dynamic Class loading

Real Time threads

Floating point support

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**Table I**

Properties and Features of Selected Java Processors

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<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Pipeline stages</td>
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<tr>
<td>Instruction folding</td>
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<td>Microcode</td>
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<td>Software Traps</td>
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<td>Stack Realization</td>
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<td>r</td>
<td>-</td>
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<tr>
<td>Objects</td>
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<tr>
<td>Multiple Threads</td>
<td>-</td>
<td>-</td>
<td>(+)b</td>
<td>+</td>
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<td>Thread HW-Support</td>
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<td>Scheduler</td>
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<td>Synchronization</td>
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<td>Real-time Threads</td>
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<tr>
<td>Garbage Collector</td>
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<td>S</td>
<td>S</td>
<td>S</td>
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<tr>
<td>GC for Real-time Threads</td>
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<td>-</td>
<td>+</td>
<td>-</td>
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<tr>
<td>Dynamic Class Loading</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

H Hardware<br> M Microcode<br> i Internal Mem. <br>r Register <br> + supported <br>- not supported <br> ? unknown <br><sup>a</sup> statically allocated threads <br><sup>b</sup> single global monitor

From: The SHAP Microarchitecture and Java Virtual Machine
Java Optimized Processor

Porting to new FPGA:
Often leads to new memory module
Porting to new application:
Often leads to new IO interface

From: JOP Handbook

• Most mature
• Actual deployment
• Open
• Supported via wiki
• Supports many FPGA platforms

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Build your own JOP as a Test

Jopdesign.com
- Complete design and Construction guide
- Good example of Lego mindstorms controller
- Requires: FPGA prototype board, electronics

teknologisk.dk/23755
- Simple HelloWorld
- Adds hardware
- Seven segment display
- Requires: Xilinx board
Chip Multicore Processors

- Multicore has been hot in the past years
  - Intel, AMD
- CMP is a growing field
  - Multiple IP cores used
- Meet JOPCMP
- Jeopard project
- Many services are multithreaded

![Graph showing speedup with number of cores](image)

- Lift
- MMul
- HTable

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Where does this put us?

FPGA Java for:

• Hard realtime systems
• Predictable embedded systems
• Safety/Misson critical systems
Is viable but work on redundancy is needed etc is needed.

FPGA platform

Java byte code

Java processor
Conclusion

• Decide if Java FPGA is the right way for your project
• What is the real time requirements for your project
• It is relative easy to get started with Java FPGA
• A full product requires a good work effort