Java and Real Time Storage Applications

Gary Mueller

Janet Borzuchowski

Flavors of Java for Embedded Systems

- Software Java Virtual Machine(JVM)
- Compiled Java
- Hardware Java Virtual Machine
- Java Virtual Machine as the RTOS

Software JVMs and RTOS

- Software JVM runs as a non-critical, non-real time, low priority task
  - Hardware configuration
  - Maintenance and diagnostics
  - Code upgrades and loads
- Java threads including garbage collection can be executed at a low priority

WindRiver® Personal Jworks™

- Software JVM runs as a set of tasks on VxWorks®
- Does not provide real-time response
- Garbage collection and other Java tasks can be executed at a lower priority than other time critical tasks.
  - Retains determinism of VxWorks®

Compiled Java

- Java is compiled into native machine code
- Garbage collection is implemented through runtime libraries
- Provides the benefit of an object oriented language without the performance penalty of an interpreted language

WindRiver® Diab™ FastJ®

- Compiles C, C++ and Java to native machine code
- Configure core libraries to reduce code size
- Memory management options
  - Explicit memory management
    - Similar to C/C++, eliminates garbage collection
  - Standard, non-incremental garbage collection
    - When memory is low or explicitly called
  - Preemptive, incremental garbage collection
    - Runs as preemptable, low priority background task

Hardware JVM

- JVM is implemented in silicon.
- Ultimate in speed and performance
- Implemented as either a co-processor or separate processor on a custom chip

ARM® Jazelle™

- Hardware JVM for ARM® family of processors
- Executes both Java byte codes and ARM® machine codes
- Special instruction to enter Java state and execute Java byte codes

JVM is the RTOS

- JVM is the RTOS
- Combines the JVM and an operating system into a single entity

Esmertec JBed™

- Entire application including device drivers can be written in Java
- Bytecode is translated to machine code prior to downloading or upon class loading

Why Java for Embedded Systems?

- Java is an object oriented language
  - All the advantages of object technology
  - Enforces object concepts
- Space, performance and deterministic problems are being solved
- New software engineers are trained in Java
- Faster time to market

Java and Embedded Systems

- Space
  - Will the JVM and class libraries fit?
- Performance
  - Can the JVM run fast enough to meet hard real time deadlines?
- Deterministic
  - Is the JVM deterministic?
  - Can garbage collection be scheduled?

Contact Information

Gary Mueller

garymueller@qwest.net

303-465-4279

Janet Borzuchowski

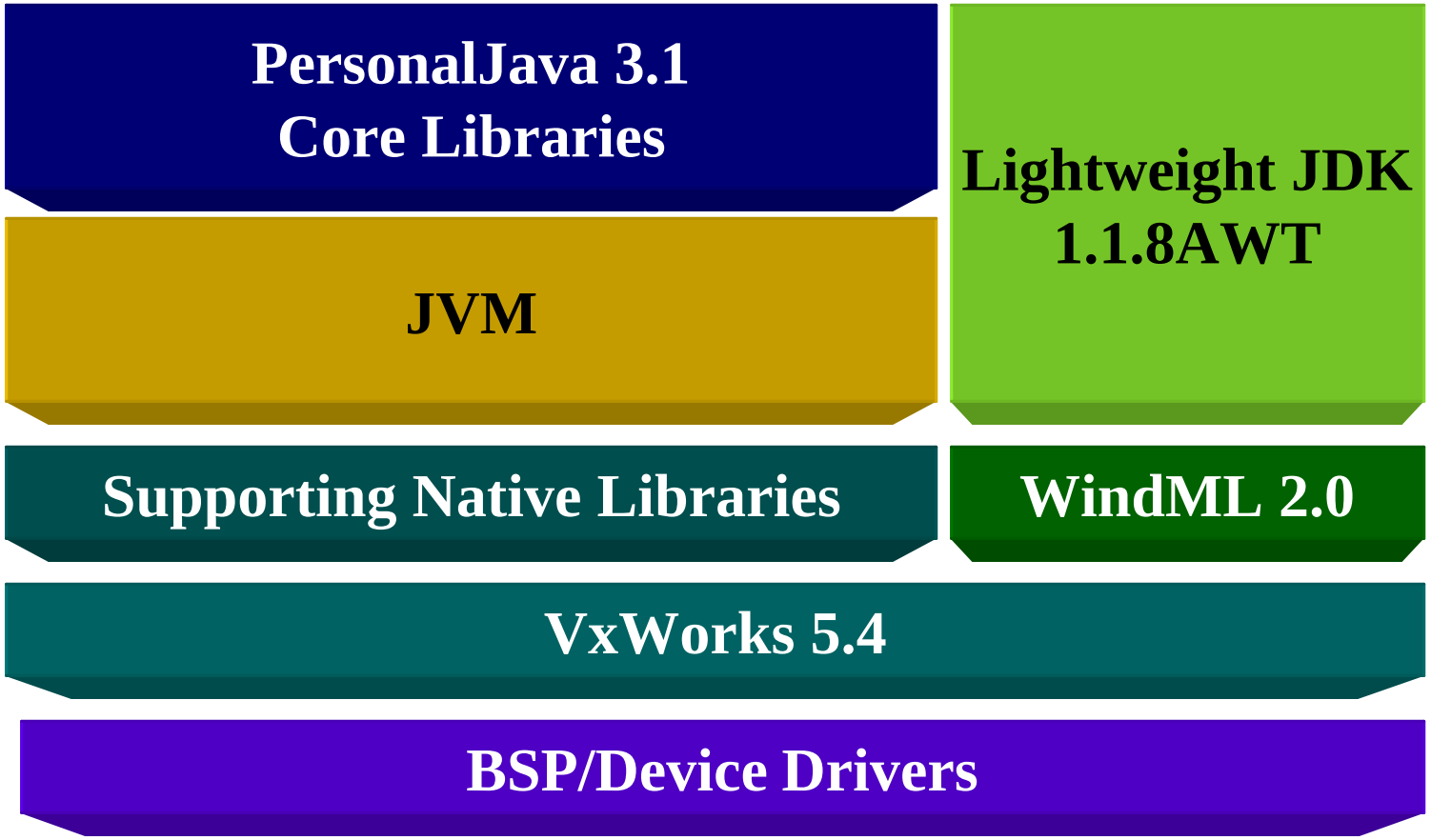
janet_borzuchowski@stortek.com

303-673-8297

Software Java Virtual Machine

- *Classic* use of Java
- Most desktop applications execute Java using a JVM running as a process or task on the desktop
- Browsers execute Java within the browser with a JVM

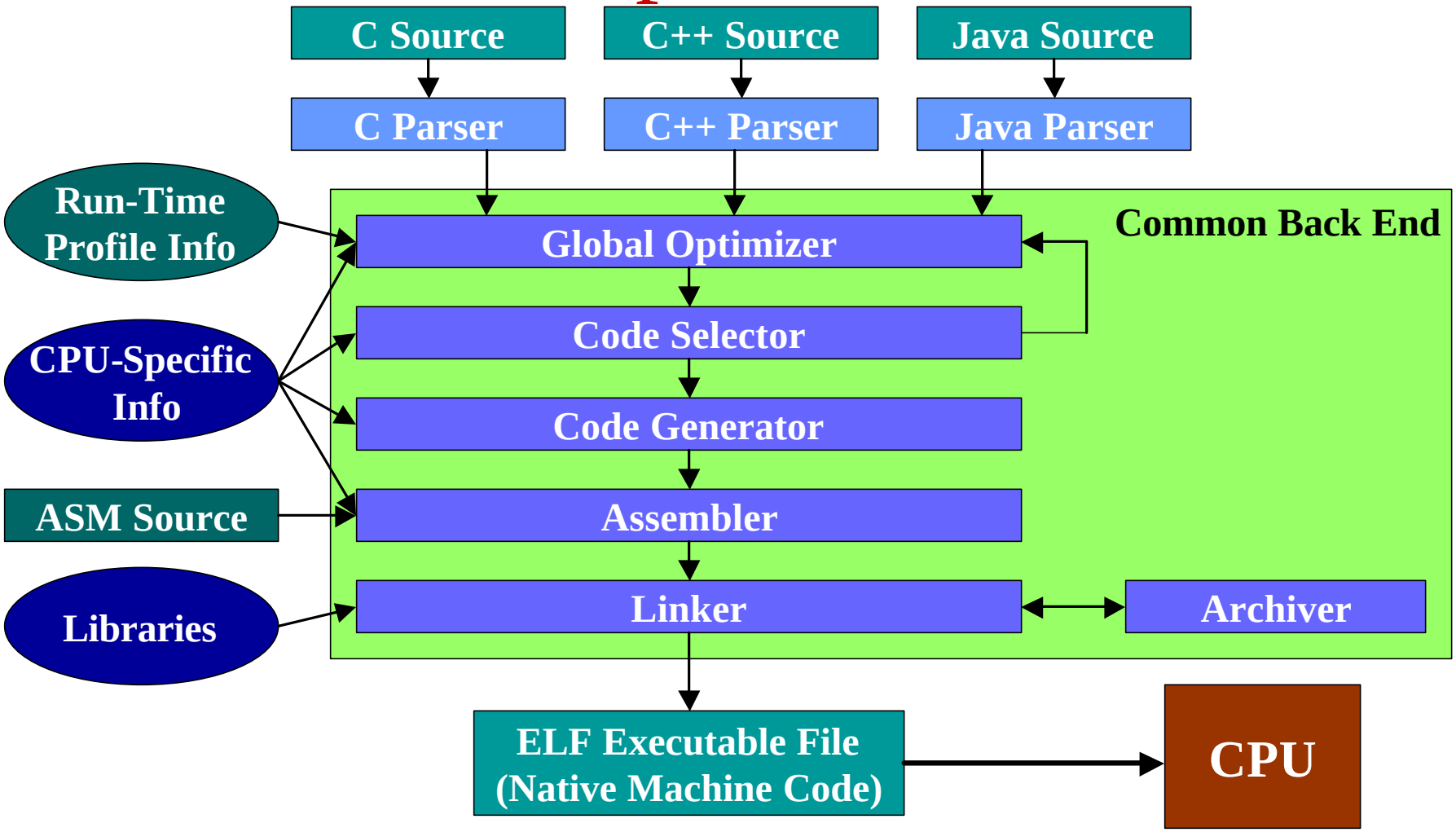
Personal Jworks™ Architecture



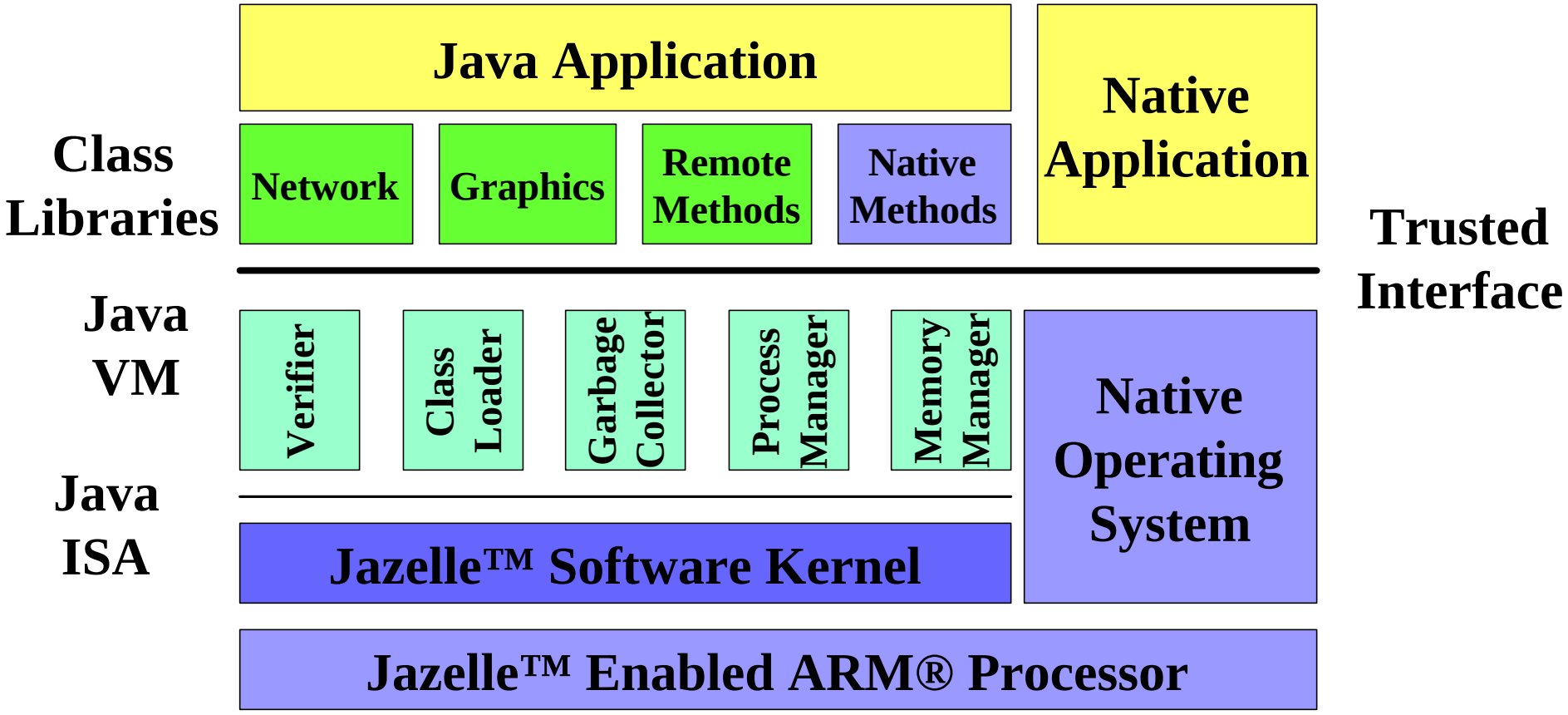
Gnu Compiler for Java™ (*gcj*)

- Compiled applications are linked with the *gcj* runtime library, *libgcj*
  - Java source code to native machine code
  - Java source code to Java bytecode
  - Java bytecode to native machine code
- Requires port of *libgcj* library
  - Core classes
  - Garbage collector
  - Bytecode interpreter

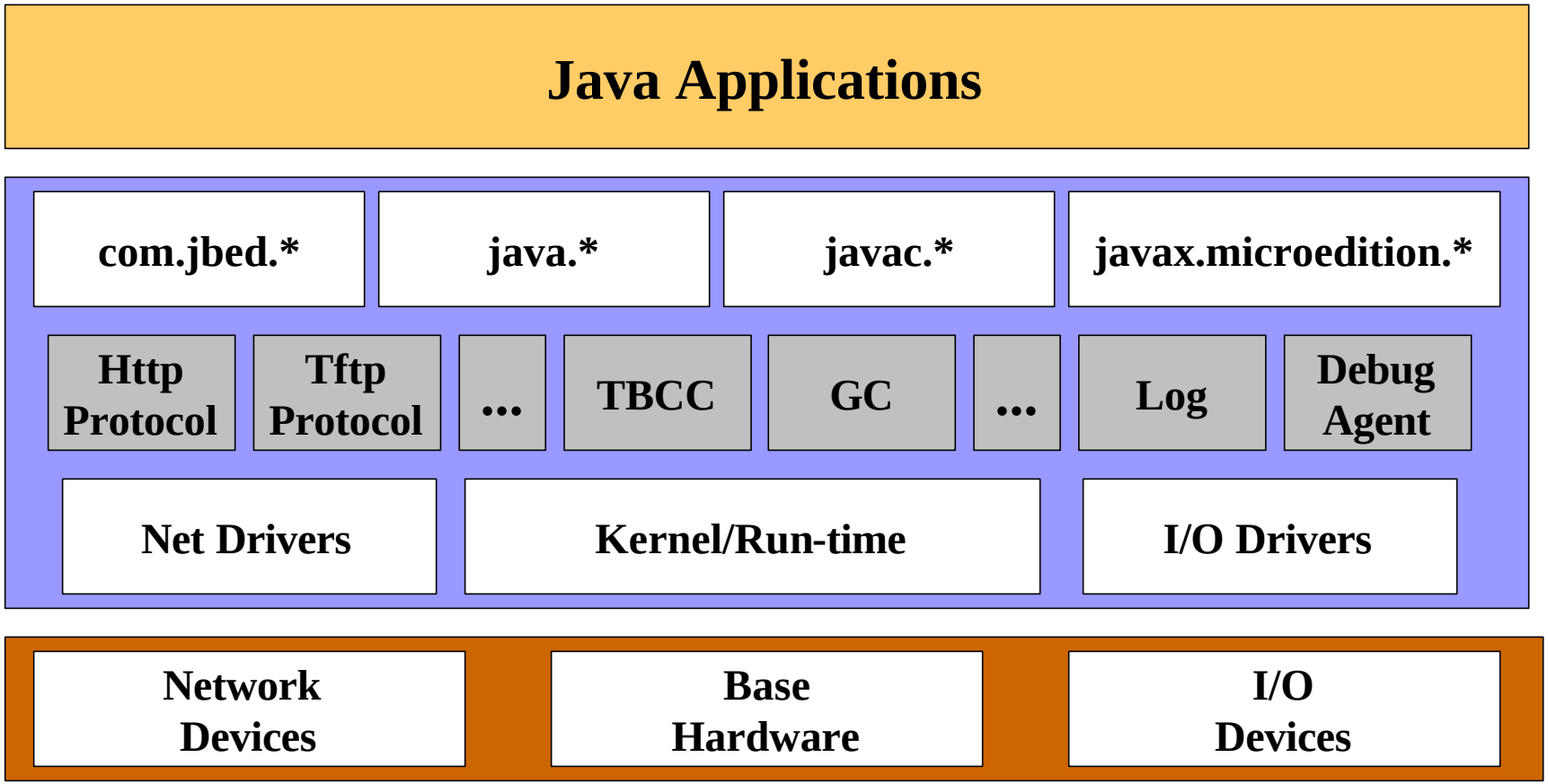
FastJ® Compiler Architecture



Jazelle™ Run-Time Architecture



Jbed™ Run-Time Architecture



On the Java Road

- Introducing C++ and Object design and analysis to time critical code
- Evaluating FastJ™
- Exploring Jbed™ option
- Discussing Jazelle™ with ARM®
  - Negotiating a non-disclosure agreement

Steps to Java

- First Step --- FastJ™
  - Similar to current development environment
  - Least disruptive
  - Does not require hardware changes
- Next step --- Jbed™
  - Combination of hardware/software
- Final Step --- Jazelle™
  - Requires hardware changes

Our Environment

- 9840 and 9940 family of tape drives
- ARM7® 32 bit processor
- 2-4MB of RAM
  - Code image
- 32MB - 64MB data buffer
- SCSI, ESCON, and Fibre Channel Interface
- Specialized ASICs

State of Java and Embedded Systems

- Resurgence in Java chips
  - ARM - England
  - Ajile - United States
  - Vulcan Machines Ltd - England
  - NTT Docomo - Japan
- Personal Digital Assistants
- Next generation mobile phones

Java Runtime Environment

- Java is an interpreted language
- Java is *compiled* to an intermediate language
  - Java Byte Codes
  - Assembly language for the Java Virtual Machine
- Java Virtual Machine executes Java Byte code
- JVM are usually written in C or C++