Ada-Java Middleware for Legacy Software Modernization

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Aegis Software Modernization Uses Soft Real-Time Java Based on PERC Ultra

USS Bunker Hill (CG 52) was first of 22 Ticonderoga-class guided-missile cruisers to undergo extensive capability upgrade as part of Cruiser Modernization Program

Context and Motivation for "Ada Java Method Invocation"

- Billions of dollars of software IP implemented in Ada: energy, transportation, aerospace, defense
- Many companies are shifting attention to Java for new development
- The transition to Java is easier if the value of existing Ada IP can be preserved
  - AJMI enables Ada and Java to be efficiently and robustly combined in mixed-language applications
  - Majority of existing Ada software based on Ada 83 and Ada 95 standards
  - Minimize certification disruption by building AJMI on Ada 95 run time environment

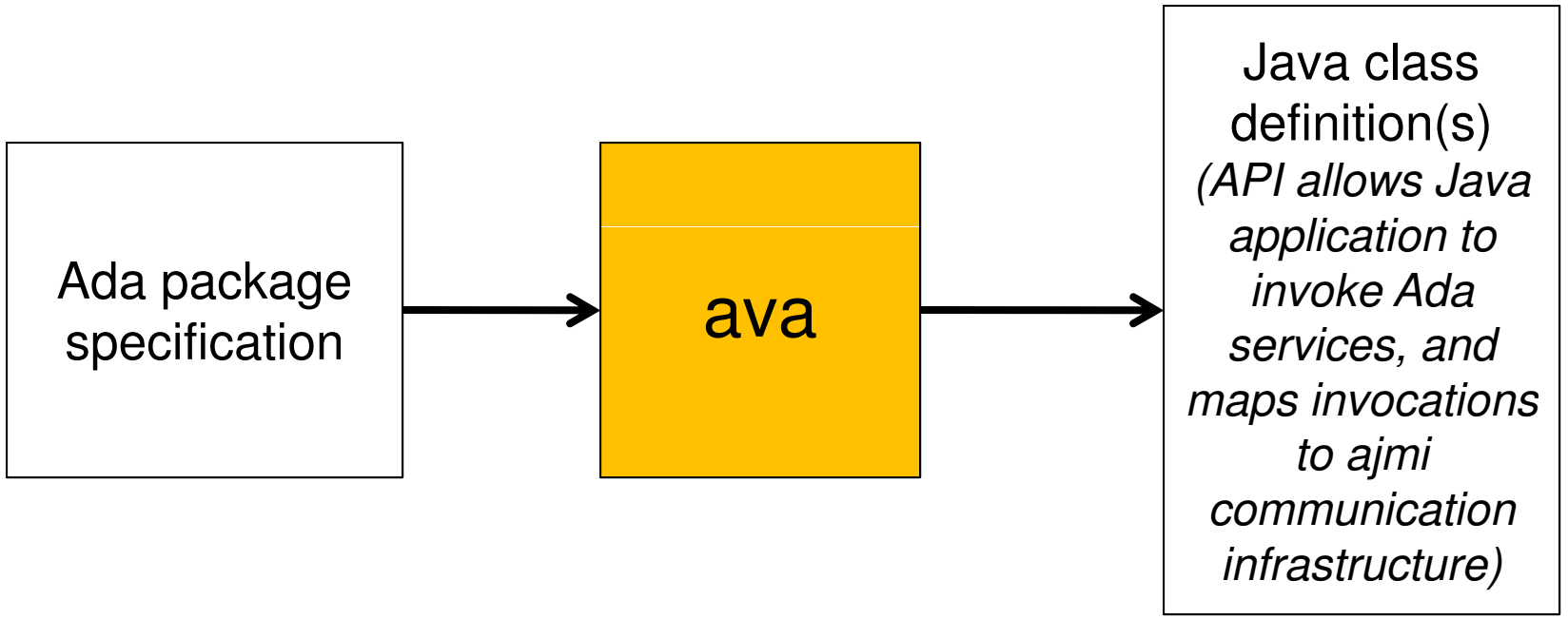
Alternative Approaches (Related Work)

- Roll your own interface with Ada ⇔ C ⇔ JNI ⇔ Java
  - Cumbersome, error prone, expensive to maintain
  - Allows C (Ada) to manipulate Java data but does not directly allow Java to access C (Ada) data.
- GNAT Ada Java Interface Suite (AJIS)
  - Automatically generates Java wrappers for Ada specifications
  - Java programmers can extend the auto-generated Java wrapper and an Ada proxy can represent this extended Java object
  - But GNAT AJIS does not generate Ada wrappers for Java classes
  - GNAT AJIS programs are vulnerable to memory leaks and inter-language dangling pointers
  - Relies on heap memory management and Ada 2005 features

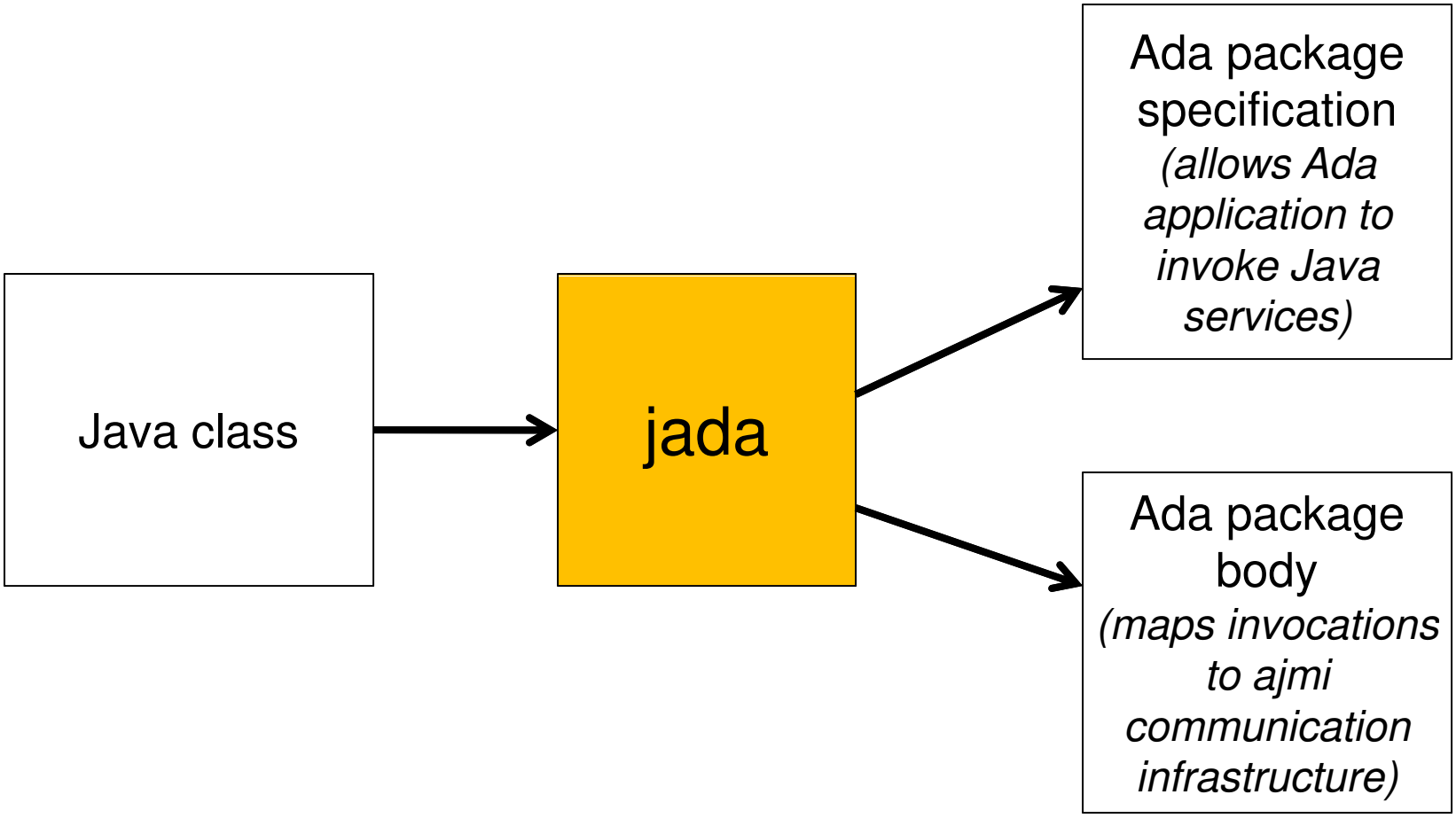
AJMI Capabilities

- Auto-generates Ada wrappers for Java and Java wrappers for Ada
- Enables mixed-language object orientation
  - Ada tagged types may override Java
  - Java may override Ada tagged types
- Compatible with Ada 95 and Ada 2005 run times, Ada 83/95/05 source
- Compatible with standard edition and safety-critical Java
- Different middleware implementations enable Java and Ada to reside in shared memory of same process, in isolated partitions of ARINC 653 or MILS OS or Linux, on different networked processors
- Restrictive AJMI subset enablea reliable integration of JSR-302-style Java with Ravenscar-style Ada in stack memory

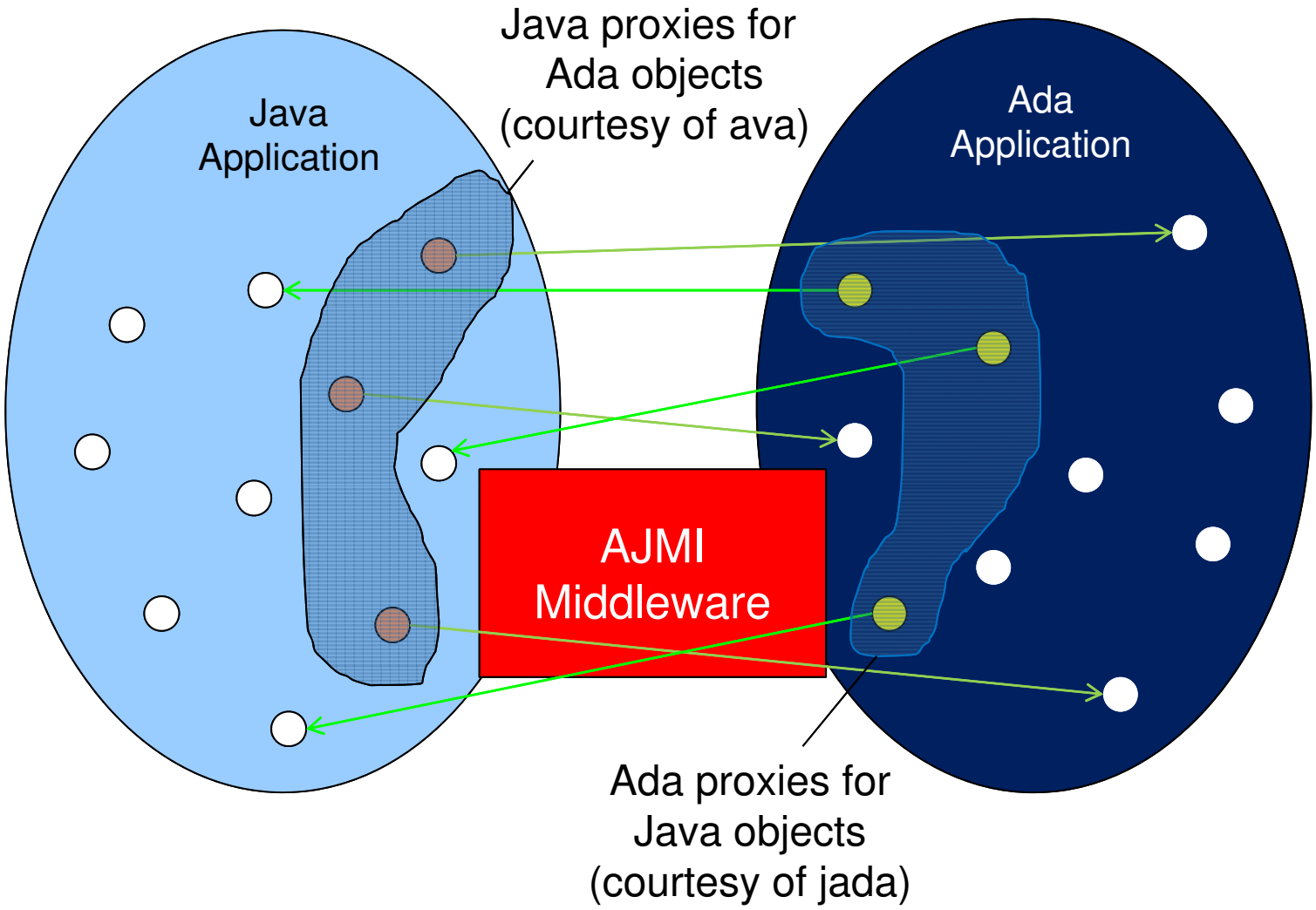
AJMI interface generation tools: ava



AJMI interface generation tools: jada



AJMI Execution model



Sample mixed-language application (Java perspective)

```
public class JavaMain {

    public static void main(String[] args) {
        UARTDriver uart = new UARTDriver(iocallback); // create an Ada object: UARTDriver is Java Proxy
        JavaGUIListener listener = new JavaGUIListener();
        JavaMonitorGUI gui = new JavaMonitorGUI(listener);
        DeviceMonitor monitor = new DeviceMonitor(gui); // create an Ada object : DeviceMonitor is JavaProxy
        JavaApplication app = new JavaApplication(uart);


        // JavaIOCallback is a Java extension of an ava-generated Java proxy
        JavaIOCallback iocallback1 = new JavaIOCallback(app, JavaIOCallback.INPUT_AVAILABLE);
        JavaIOCallback iocallback2 = new JavaIOCallback(app, JavaIOCallback.OUTPUT_READY);
        app.doWork();                                   // spawns a Java background thread

        // ask Ada to call back to my Java code under certain circumstances
        uart.notifyWhenInputAvailable(iocallback1);     // invoke Ada service
        uart.notifyWhenOutqueueEmpty(iocallback2);      // invoke Ada service
        monitor.monitorUART(uart, 1000, gui);           // invoke Ada and do not return
    }

}
```

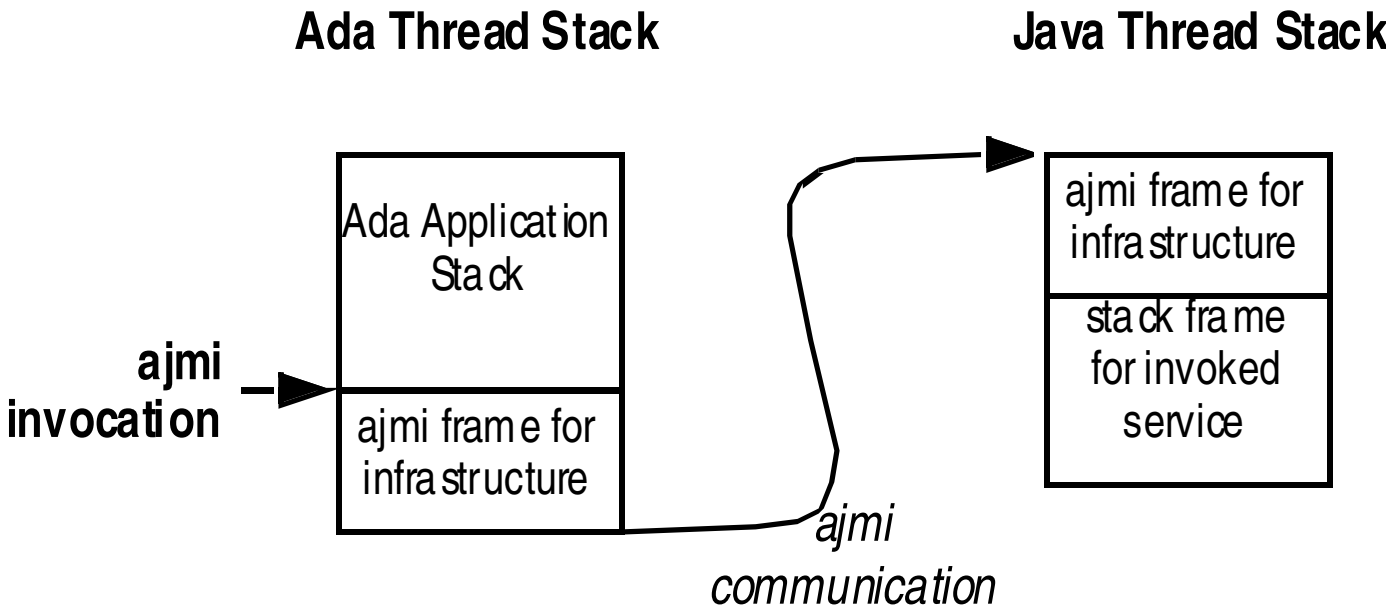
Memory organization overview

- Java and Ada have very different “temporary memory” models
  - Ada allocates on the stack. Strong typing assures absence of dangling pointers.
  - Java allocates on the heap. Garbage collection assures absence of dangling pointers.
- The mixed-language programming model allows each language to allocate in its own style.
- By default, shared objects have a stack-oriented life time:
  - Java objects may live longer than an “interaction”, but proxies are “disabled” at the moment when stack memory would normally be reclaimed
- Optional (lower integrity) protocols are available to deal with objects that live longer than a particular “interaction”.
  - These protocols would be discouraged in safety-critical integrations

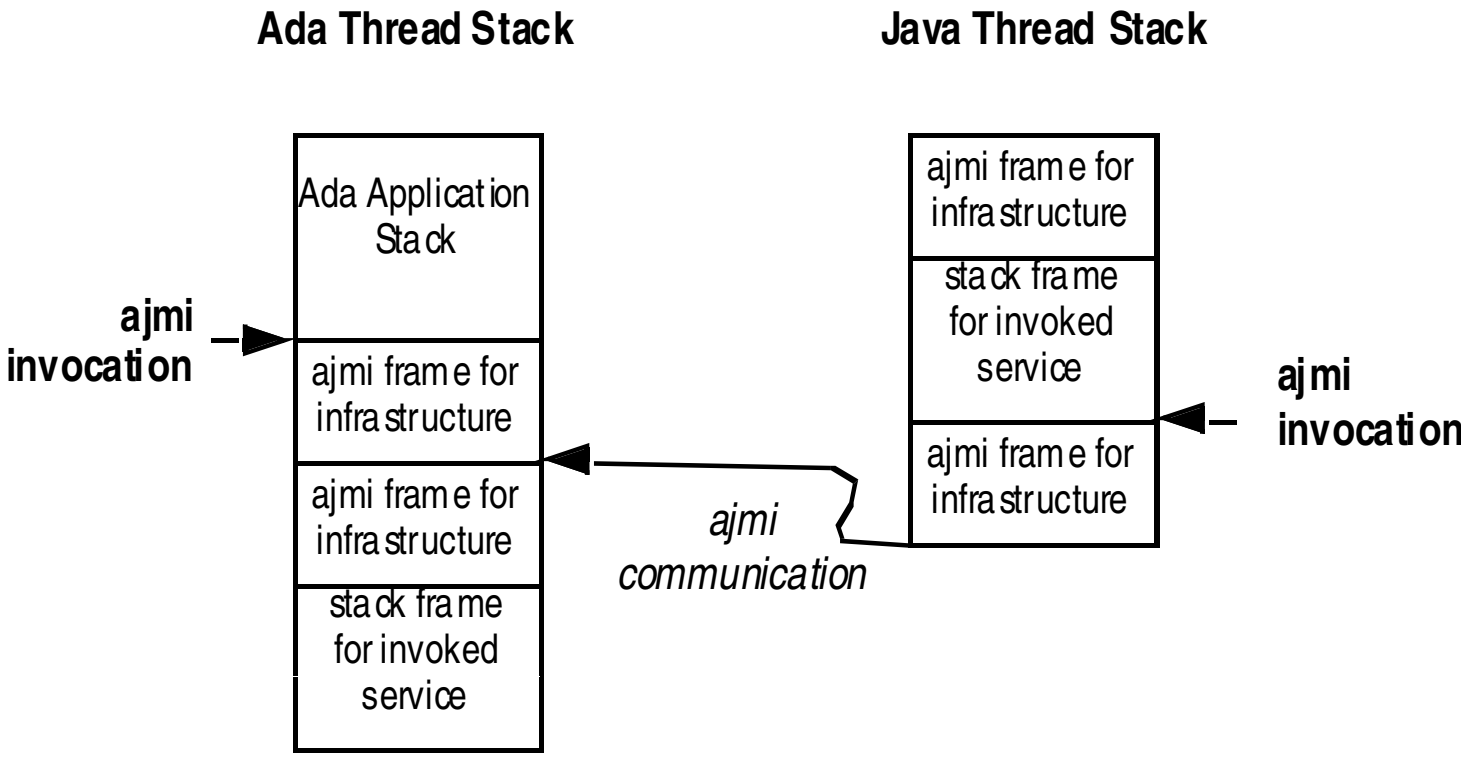
Thread organization overview

- In Java, thread identity is important because a Java thread that “locks” a Java resource is allowed to “relock” the same resource without restriction
- If Java calls Ada and Ada calls back to Java, the call-back into Java needs to be the same Java thread
- Model: an Ada task melds with a Java thread to become a conceptual AJMI thread
  - Implementations may optimize certain scenarios by allowing the Ada task and Java thread to run as a single operating system thread
  - Memory allocations sometimes need to be taken from the stack frame of the companion language’s run-time environment at the point of the most recent AJMI invocation. Examples follow.

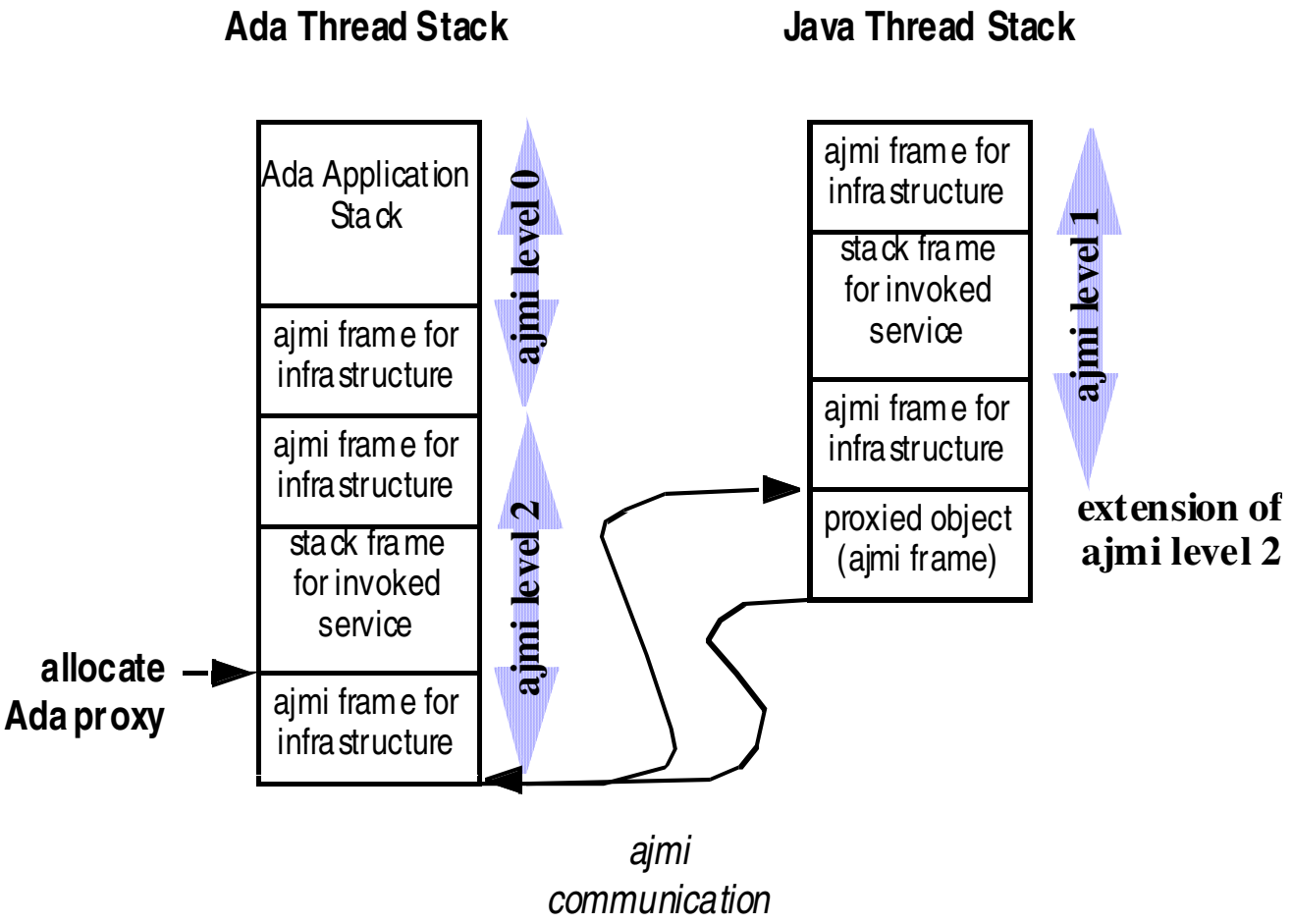
Thread stack usage: Ada invokes Java method



Thread stack usage: Java calls back to Ada



Thread stack usage: invoked Ada stack allocates Java object



Status

- Detailed design has been completed but the technology is not yet fully implemented
  - This design is much more ambitious than existing technologies
  - Represents Java objects in a style that is natural to the Ada 95 environment
  - Represents Ada 83/95/05 objects in a style familiar to Java programmers
  - Supports reliable and efficient inter-language sharing of stack-allocated objects
- An initial implementation integrates Object Ada 95 with PERC Ultra in shared memory as a single Linux x86 process
  - Support for other Ada, Java, processors, operating systems and middleware configurations will be prioritized according to customer demand
- Performance measurements and user experiences with the initial implementation may result in changes to the API design, the AJMI run time, and the AJMI tool chains