CORBA for Power Management

Rockwell Collins Advanced Technology Center
Advanced Computing Systems
Presented By: David Haverkamp, Dr. David Jensen, Steven Koenck
E-Mail: dahaverk@rockwellcollins.com
dwjensen@rockwellcollins.com
sekoenck@rockwellcollins.com

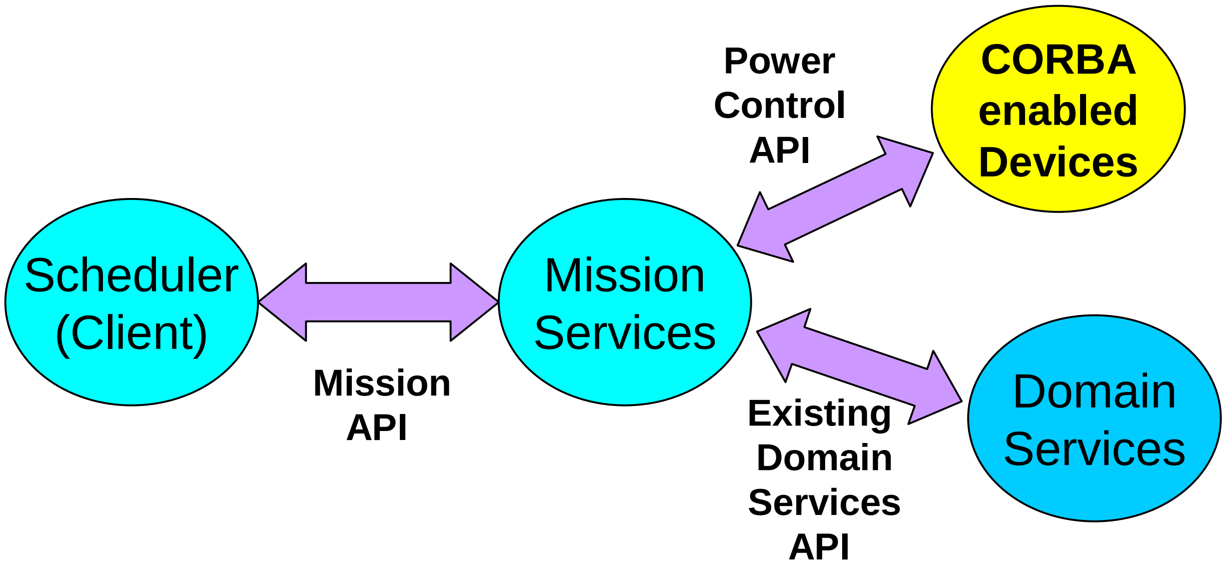
Introduction

- **CORBA is being introduced in embedded systems**
  - Benefits proven in workstation and networked systems
- **Many embedded systems have difficult design constraints**
  - Power limitations because of heat and/or batteries
  - Size and weight because of environment
- **DARPA's Power Aware Computing / Communications (PAC/C) provides an excellent test case**
  - Mission Aware Power Management (MAPM) program will introduce PAC/C technologies into the JTRS platform
  - PAC/C program involvement has provided exposure to many novel technologies
  - MAPM funding has produced some of these results
- **Our involvement in the Joint Tactical Radio System (JTRS) program has allowed us to research the application of CORBA in this challenging environment.**
- **In this talk, we discuss some preliminary approaches used in our investigations**
  - Power management interface using CORBA
  - An approach for CORBA support in low power embedded systems

Power Management Interface Background

- **Like all system engineering decisions, the choice of an appropriate power management policy in the early stages of the design process drives cost, portability, and maintainability**
- **CORBA power management interfaces have the potential to introduce power and energy management to distributed systems**
- **The OMG offers a potential venue for the creation of a standard set of interfaces for power management of Distributed Embedded systems**

A Conceptual view of Power Management for JTRS



- **Power Scheduler acts as a Client sending Control messages through Mission Services.**
- **Mission Service directs command messages to either:**
  - **"CORBA Devices"** invokes device drivers specific to:
    - General Purpose uProcessor, DSP, Modem, etc.
  - **Domain Services**
    - Software Radio Specific components.
      - setup of waveforms channel application stream

CORBA Interfaces to system Devices

- **Embedded systems can be composed of many system processors**
  - **Software Radio**
    - **General purpose uP**
    - **DSP's**
    - **Modem**
    - **Power Supplies.**
  - **Device power saving capabilities not all equal**
- **Power Management Interfaces need generic power saving policies and modes**
  - stand-by, idle, reduced power, lower quality, and complete shutdown/halt.
- **Advanced Configuration and Power Interface Specification (APCI)**
  - uP interfaces can use some APCI concepts for generic device interfaces
  - operating system (OS)-directed configuration for
    - motherboard device configuration and
    - power management of both devices and entire systems.
    - Not currently oriented toward Distributed systems.
- **Power Management via CORBA allows for an Abstract view of the underlying distributed system**

Power Management Policy via CORBA

- **Scheduler control via CORBA interfaces allow a system oriented power management policy**
  - Eager
    - Power implications easy, processor can always be on.
    - Could manipulate the processor clock to provide "just enough" performance
  - Lazy
    - Efficient but more involved
    - "Suspend", "standby" or "shutdown" processors not being used
    - Wake-up policy implications

Current State of Power Aware Computing

- **Power interfaces are conceptually simple**
  - definition and implementation becomes complex because of the number of subsystems and power modes, application and operating system demands, and provisions for future extensions.
- **Underlying Device (uP,DSP,etc) effects System Power Save Capabilities**
  - Some specific uP have Dynamic Voltage and Frequency Scaling
    - Transmeta - Crusoe
    - Intel - StrongARM and XScale
    - IBM - PowerPC 405LP
  - Some power management is more appropriate for automatic compiler insertion in low-level assembly or as part of the BSP.
    - floating point is not used in applications so don't clock FP unit
      - Can be a hardware register setup configuration or uP specific assembly instruction
- **CORBA API being applied to JTRS platform and evaluated under DARPA PAC/C program**

CORBA for Low Power Embedded Devices

Rockwell Collins Advanced Technology Center
Advanced Computing Systems
Presented By: David Haverkamp, Dr. David Jensen, Steven Koenck

E-Mail: dahaverk@rockwellcollins.com
dwjensen@rockwellcollins.com
sekoenck@rockwellcollins.com

Low Power Embedded Devices

- **Target Platforms**
  - **Handheld Devices - Battery operated**
  - **Unmanned Air Vehicles – Mission Constraints**
  - **Ground Sensors – Long Life**
- **Intimidating set of requirements (Environmental Constraints)**
  - **Size & weight, limited battery capacity and available power**
  - **Power limitations affect the microprocessor selection, memory size, and software implementation.**
- **In contrast, embedded designers want the advantages of portability, maintainability, and design cost savings that CORBA designs offer.**
- **However, it is recognized that the current generation of commercial CORBA software and their supporting commercial operating systems assert a significant (often unattainable) power demand on these low power embedded devices.**
- **Future JTRS Clusters will support handheld devices and Unmanned Air Vehicles (UAVs) and introduce even greater power constraints.**
  - Types of clusters – airborn, handheld, UAV, weapon data-link, munitions

Research Approach to Reduce Power Overhead

Rockwell Collins

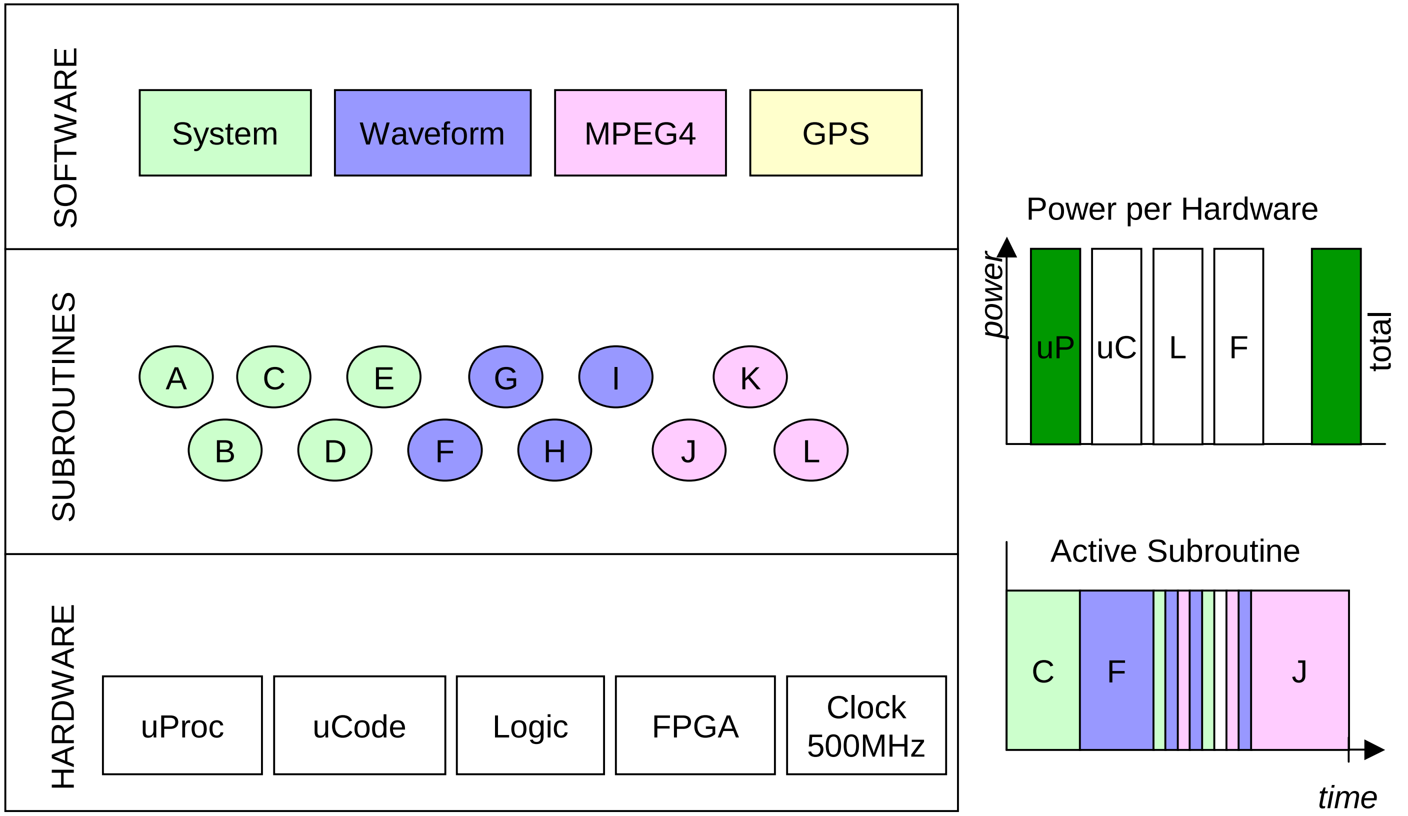
- **We have identified a research path to reduce the power overhead introduced today with CORBA.**
  - Experience in microprocessors, microcode, adaptive computing, and hardware-software co-design.
- **Basic premise is to move computationally intensive algorithms from software to hardware.**
  - Known power savings by eliminating microprocessor overhead through direct implementation in gates.
  - Dramatic acceleration of function ($\geq$ 100x)
  - Embedded systems typically have fixed computation requirements
  - Moving algorithms to hardware allows slowing clock of entire system!
- **We are applying this concept to the Software Communication Architecture**
  - Rockwell Collins IRAD project: "Software Communication Architecture Processing Environment" (SCAPE)
  - Concept genesis under the DARPA PAC/C MAPM project

SCAPE Project

- **Software Communication Architecture Processing Environment (SCAPE) Approach**
  – Gates are cheap and plentiful - move computationally intensive software to hardware
  – Rationale - Accelerate functions to slow down clock.
- **5 Methods for Acceleration**
  – Hardwired Logic - memory mapped - common API for supportability
  – FPGA Logic - memory mapped - common API for supportability
  – Microcode - how do we support? document?
  – Traps to Software
  – Software logic (algorithm improvements)
- **Constructive Plan**
  – Identify SCA computing demands
  – Profile software performance
  – Accelerate computationally intense functions
  – Document results

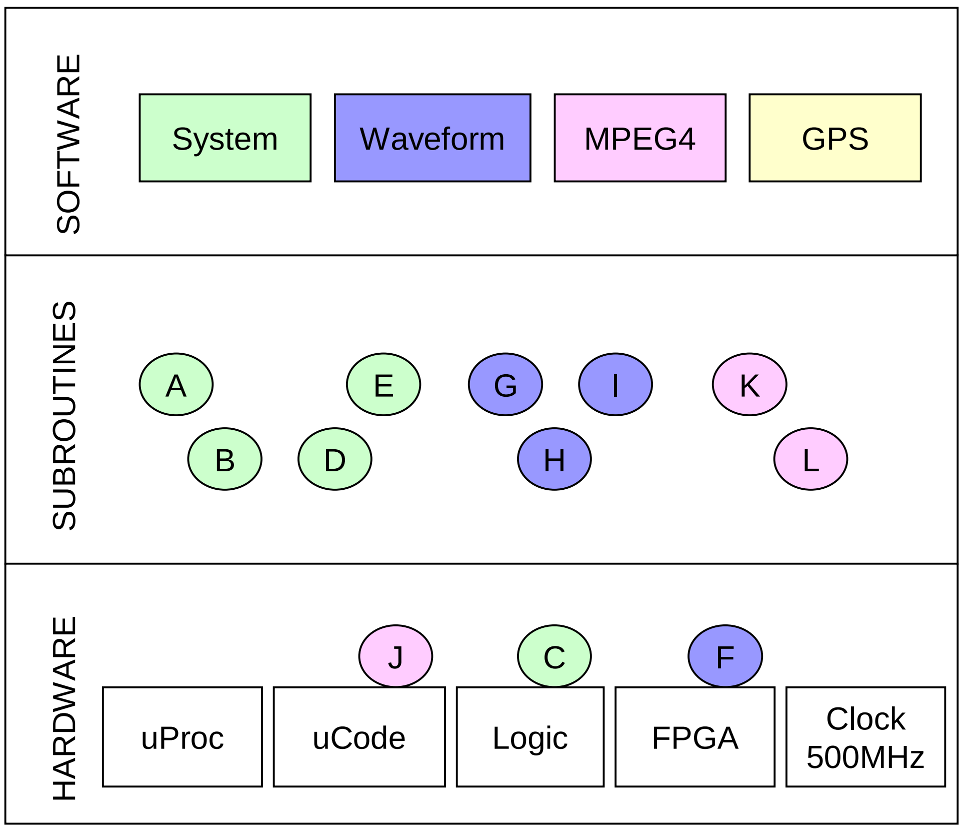
SCAPE Power Savings

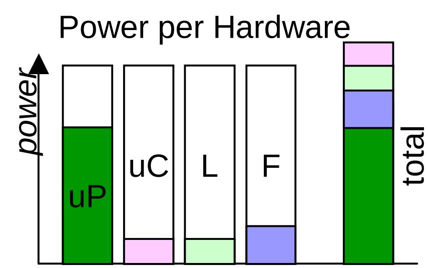
- **Notional Example of Power Savings through SCAPE**
- **Subroutines represent CORBA, POSIX, and Application routines**
- **Power being expended initially by microprocessor**

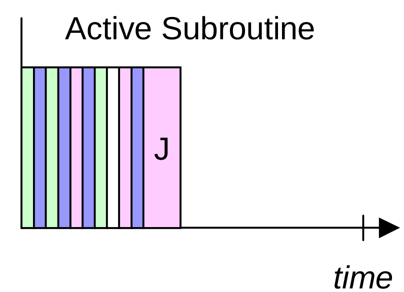


SCAPE Power Savings - Continued

- **Top three computationally intensive tasks migrated to hardware**
- **Custom microcode, logic, and FPGA implementation accelerate functions**
- **Power now being expended by all hardware elements**

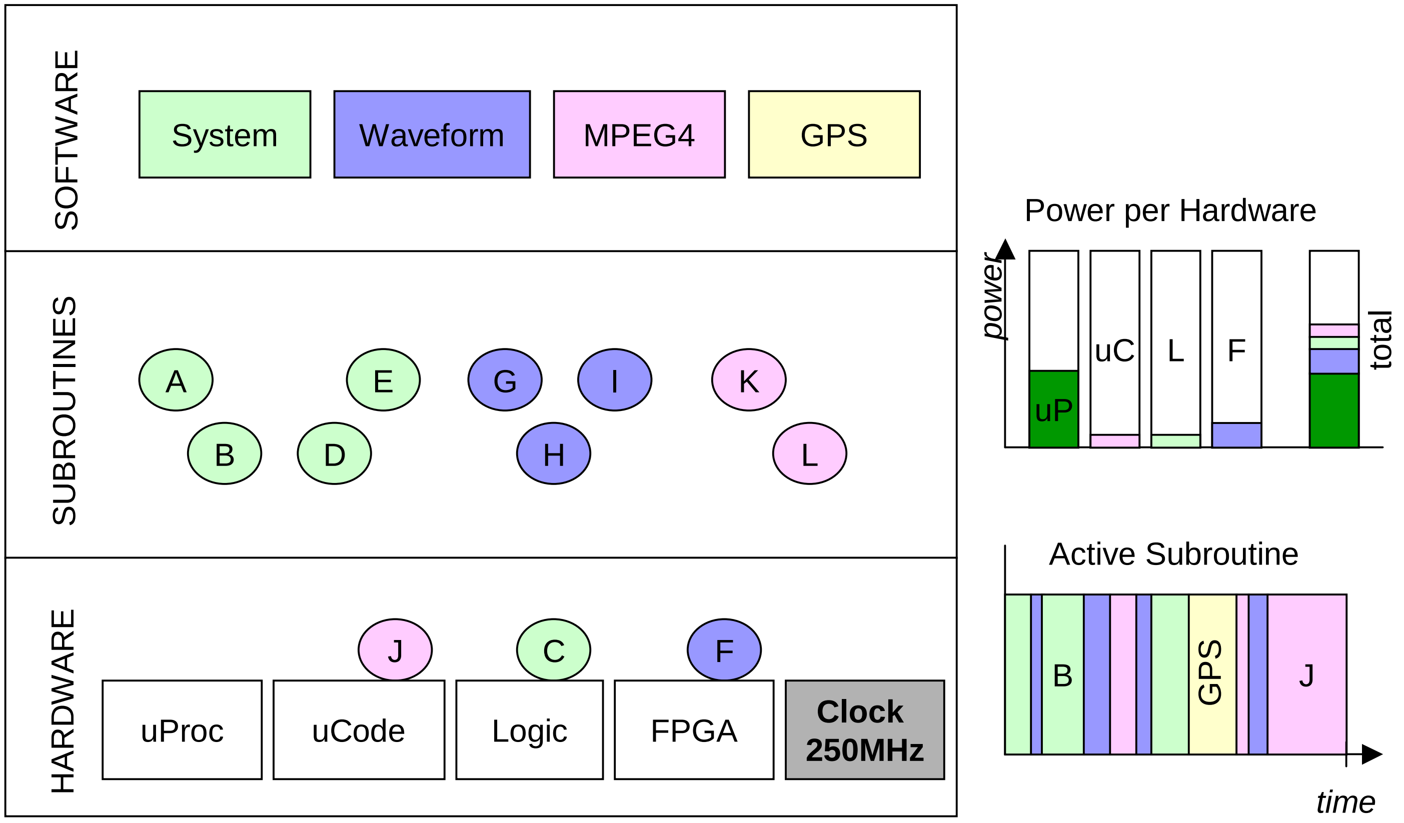






SCAPE Power Savings – First Round

- **Real time requirements haven't changed!**
- **Clock speed can be dramatically reduced – along with power expended!**
- **New set of subroutines can now be identified and repeat process**

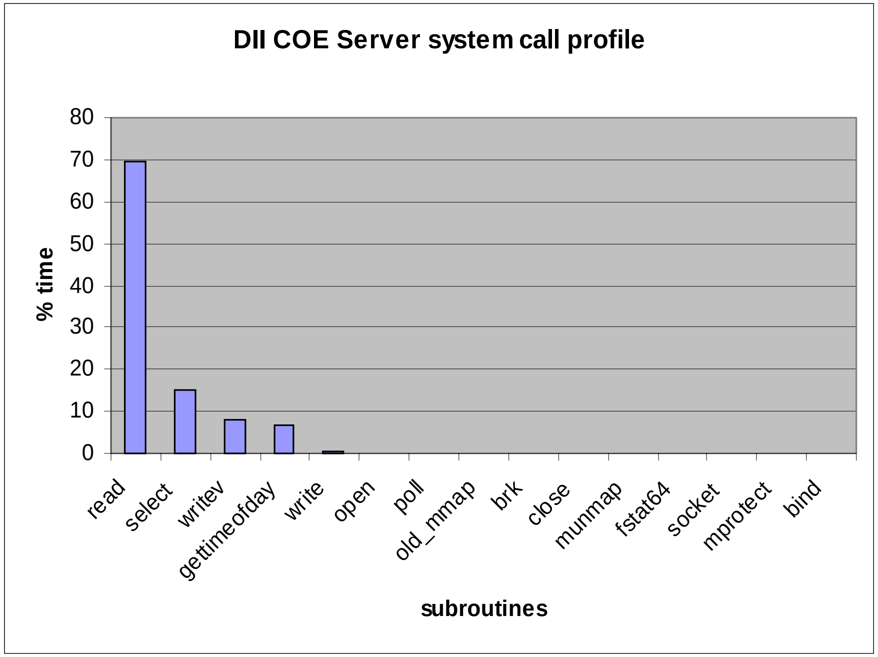


Will this work?

- **Three hardware areas to target computationally intensive software**
  - Custom logic – very fast - expensive ASIC
  - Custom microcode – 10x typical vs software
  - FPGA logic – fast – relatively inexpensive vs ASIC
- **Benefits of CORBA enable this approach**
  - Interfaces are Standardized
  - Software developed on workstations using CORBA will port easily to SCAPE.
  - Optimized SCA Environment
- **Identify key OS and CORBA functions to optimize**
  - High usage
  - Compute intensive

Pareto Principle

- **During previous PAC/C PI meeting MAPM Software Radio Workshop - JTRS Engineering identified POSIX, CORBA, and network protocol processing as more computationally intensive.**
- **Improving POSIX & CORBA will be more beneficial for this environment than focusing on traditional DSP algorithms.**
- **Based on experience, Marshalling & Demarshalling algorithms (CORBA) are being analyzed for implementation in hardware (FPGA)**
- **Beginning to profile SCA (Software Communication Architecture) to identify additional algorithms**
- **Some preliminary profiling results from a DII COE server suggest that the 80:20 rule will apply to the SCAPE effort.**



Pareto Principle - the 80:20 rule - *"A minority of input produces the majority of results."*

Conclusions

- **CORBA offers many proven benefits including cost, portability, and maintainability.**
- **CORBA has challenges in the embedded systems market because of power and complexity overhead.**
- **We have identified approaches to ease the application of CORBA.**
  - Power management APIs
  - Power efficient implementation of CORBA & POSIX.
- **The power and energy saving benefits can be dramatic.**
  - Rockwell Collins Mission Aware Power Management (MAPM) program under the DARPA PAC/C program has a goal to reduce energy use by 50% through the use of power management technologies.