Adaptability, Extensibility, and Flexibility in Real-Time Operating Systems: the Georgia Tech DRTOS

Pramote Kuacharoen, Tankut Akgul,

Professor Vincent Mooney and Professor Vijay K. Madisetti

{pramote,tankut,mooney,vkm}@ece.gatech.edu

School of Electrical and Computer Engineering

Georgia Institute of Technology

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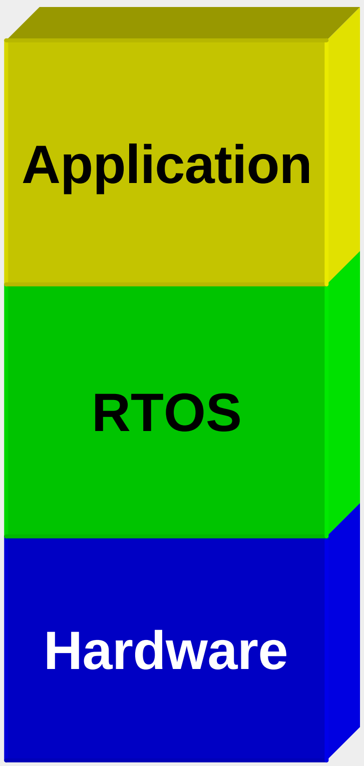
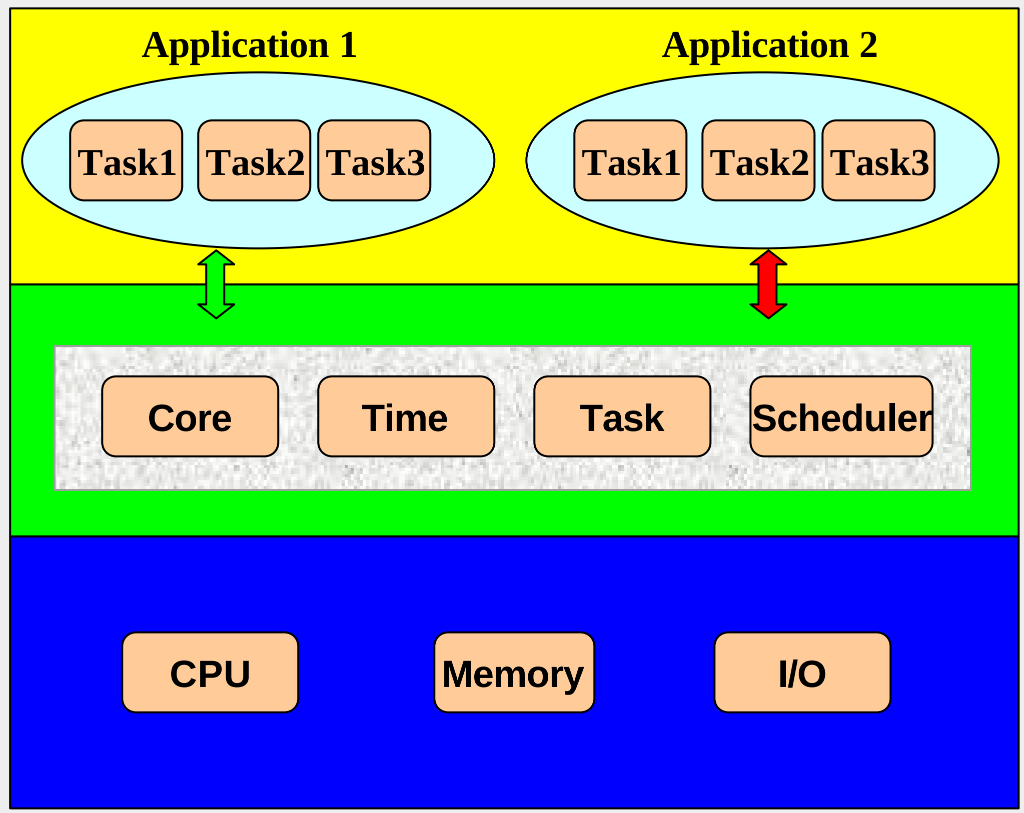
Outline

- Introduction
- Related Work
- Technical Approach
- Experiments and Results
- Conclusion

Introduction (continued)

Embedded Systems





Related Work

- **SPIN (University of Washington) 1996**
  - A general purpose operating system that provides extensibility, safety and good performance.
  - SPIN OS consists of a set of extension services and core system services that execute within the kernel's virtual address space
  - Extensions can be loaded into kernel at any time. Once loaded, they integrate themselves into the existing infrastructure and provide system service specific to the application that require them.
  - User space and kernel space are kept separate.
  - Single processor.
  - The core system services cannot be changed.

Related Work (continued)

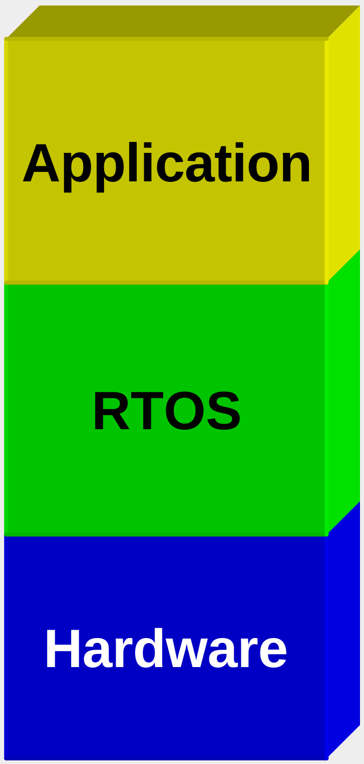
- **Exokernel (MIT) 1997**
  - General purpose operating system.
  - Exokernel's sole function is to allocate, de-allocate, and multiplex physical resources in a secure way (very good protection is provided).
  - The lower level interface allows flexible user-level implementations of traditionally rigidly defined OS services.
  - Single processor.
  - The core kernel code cannot be changed.

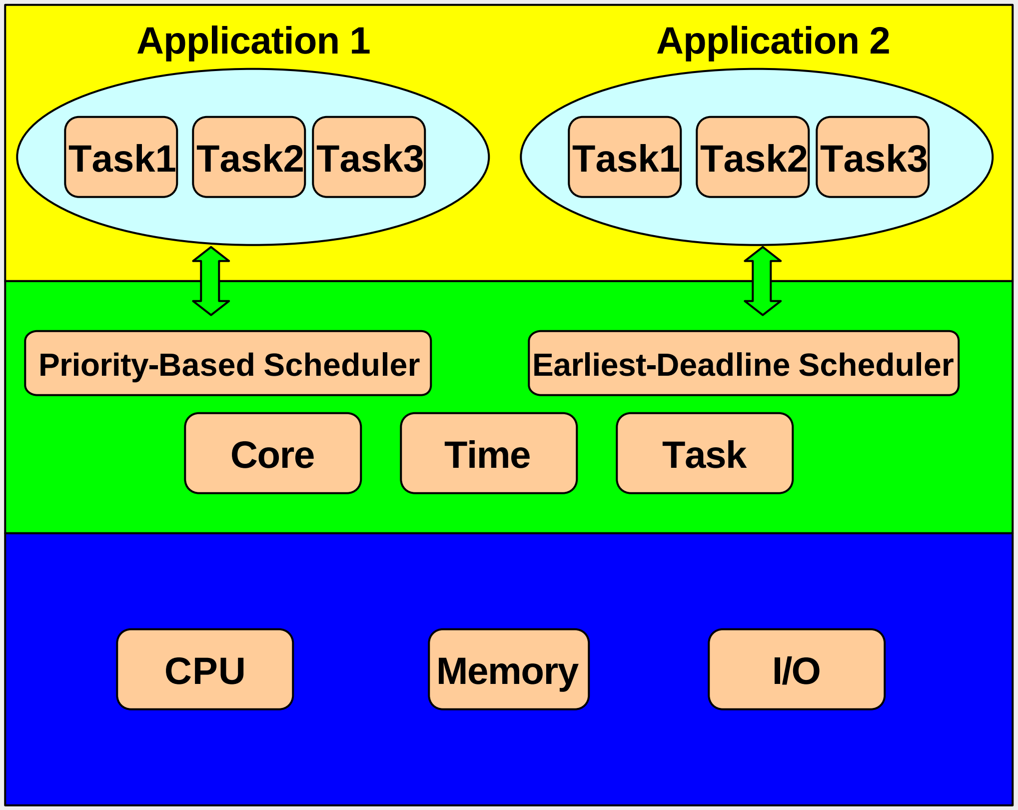
Why is it important to be able to dynamically change the core?

- **Unsafe or not convenient to reboot**
- **Adaptability and Flexibility**
  - Example: interrupt handling
    - Case 1: very fast handling of interrupts (always stop current interrupt)
    - Case 2: non-interruption of a particular interrupt
  - There may be no way to predict all the additional cases which could come up

DRTOS **Technical Approach**

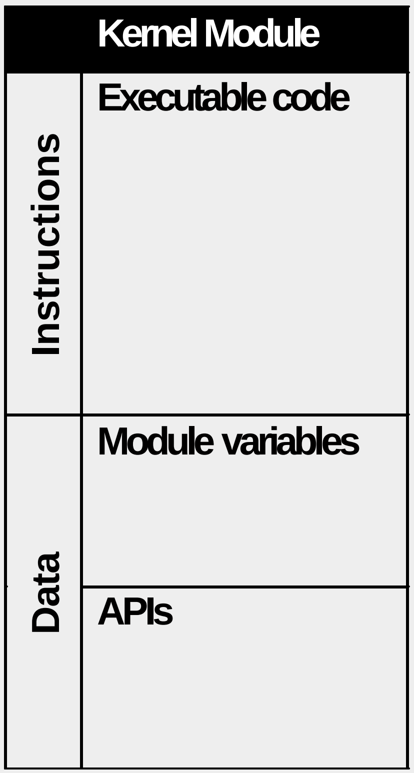
Embedded Systems

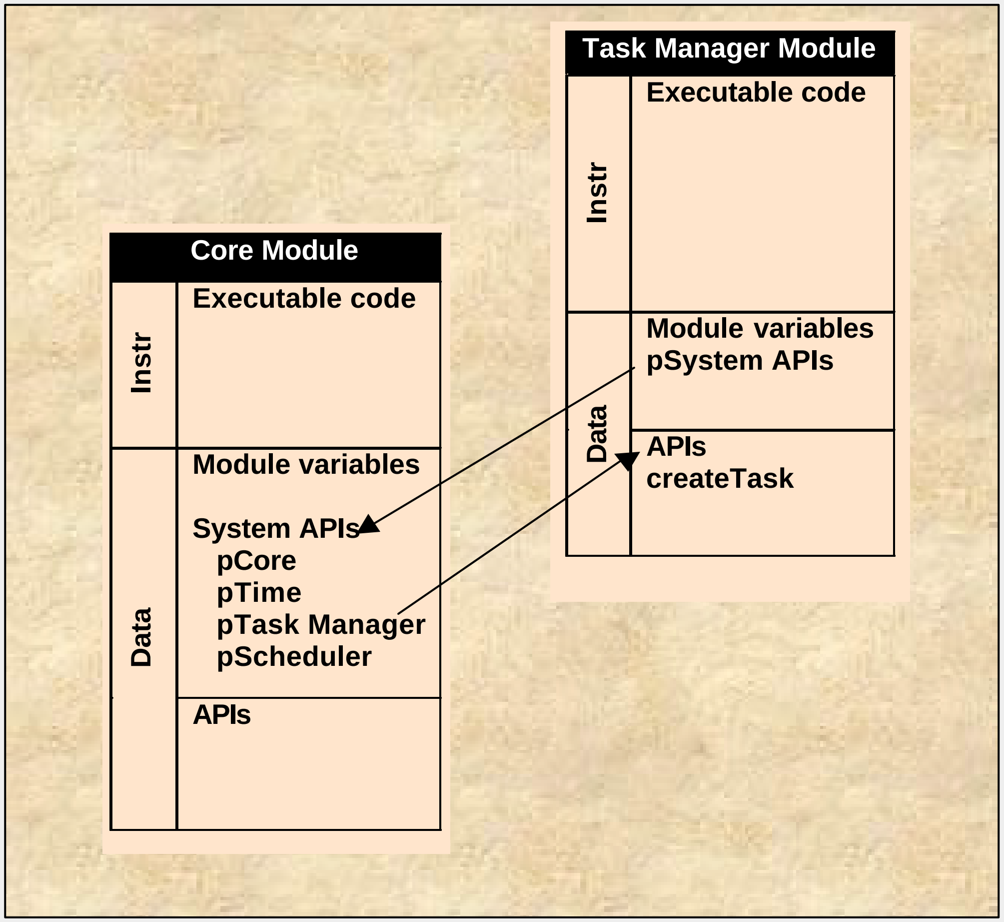




DRTOS **Technical Approach (continued)**

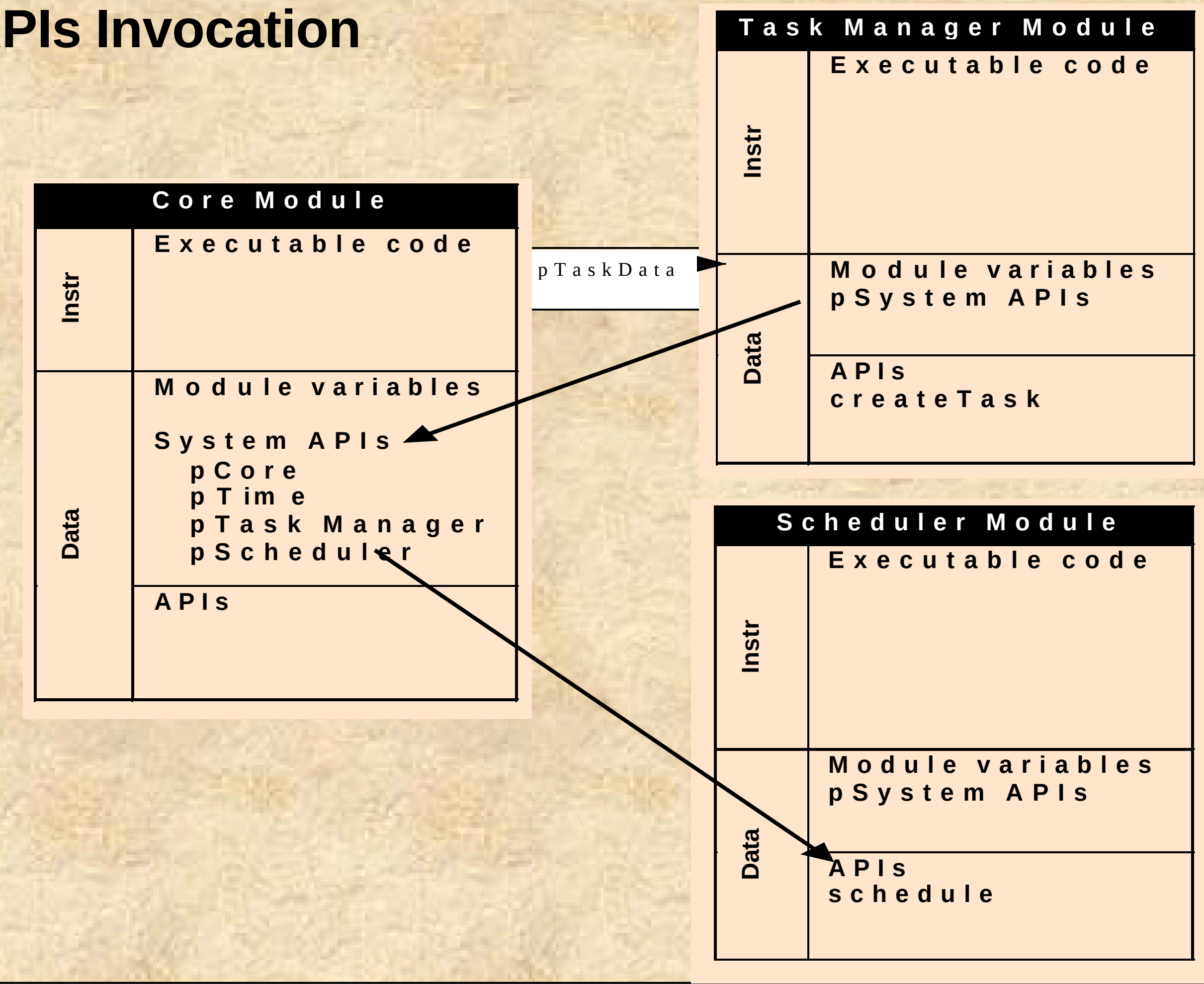
Module Installation





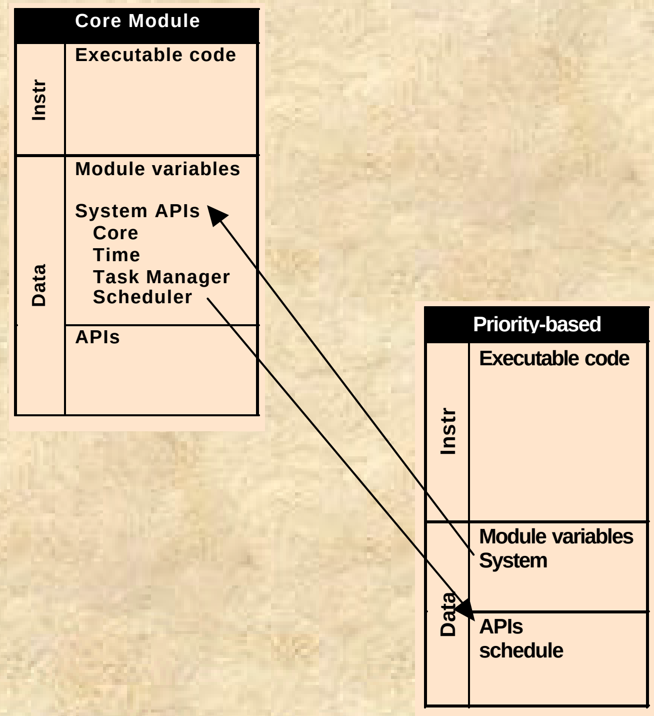
DRTOS **Technical Approach (continued)**

APIs Invocation



DRTOS **Technical Approach (continued)**

Updating Scheduler module



Load a priority-based scheduler

Link the priority-based scheduler to the core module

Unlink the round robin scheduler

The round robin scheduler can be deleted from the memory

DRTOS **Technical Approach (continued)**

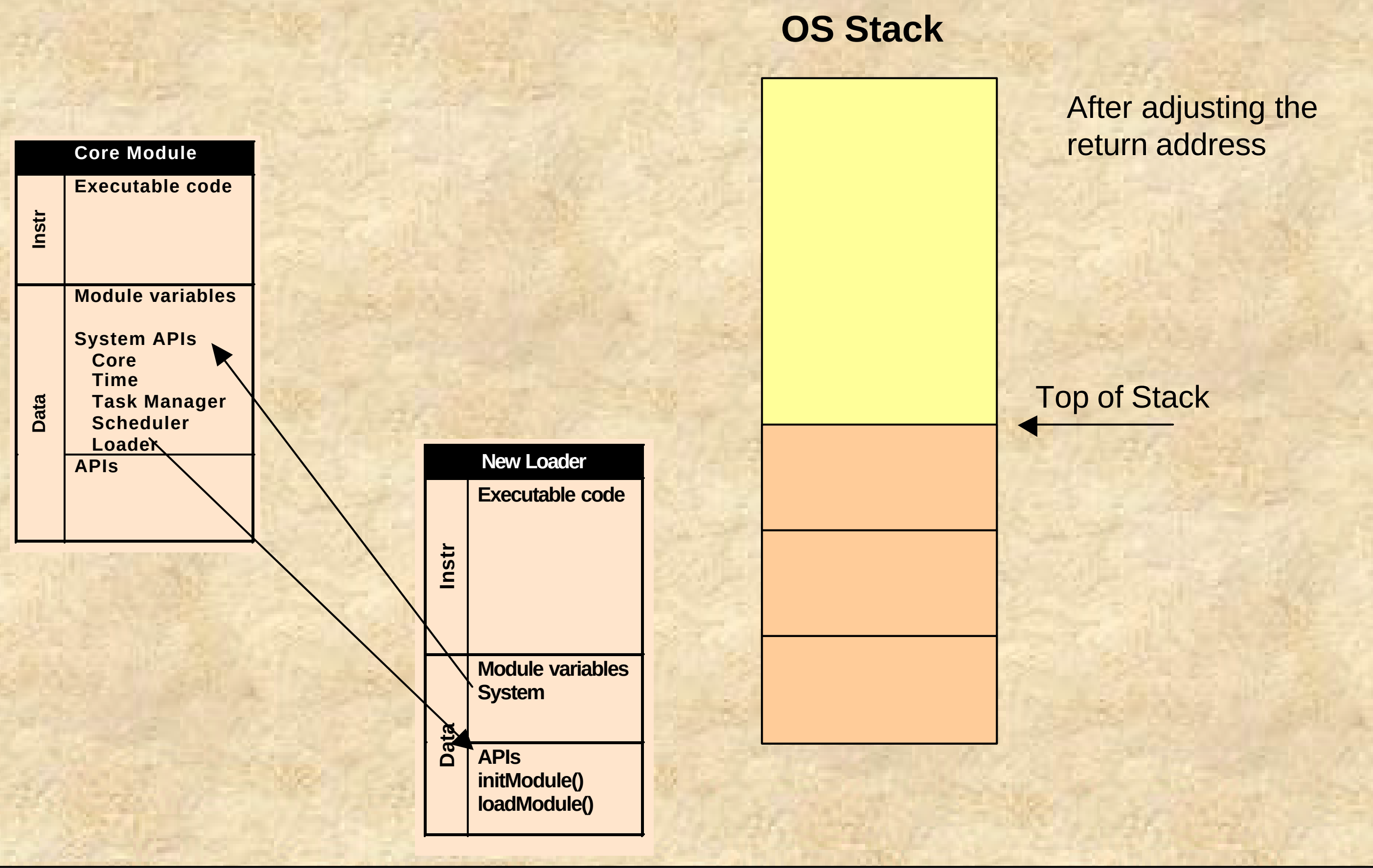
- Function pointers are used for APIs
- Invocation of a scheduler API
  - `System *pSys = (System *) pTaskData->pSystem;`
  - `SchedulerMethod *scheduler = (SchedulerMethod *) pSys->scheduler;`
  - `scheduler->schedule(pNewTask, TASK_READY);`
- Updating Core module
  - Either (1) System variable must either be in the same location as before
  - Or (2) each module must be notified when Core module is updated (all modules’ System variables must point to the new location for the System variable).

DRTOS **Technical Approach (continued)**

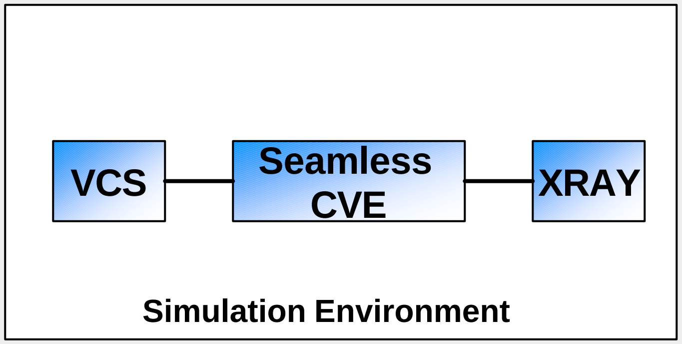
- Updating Loader module
  - The current loader module is called to update to the new loader module.
  - The *initModule()* function of the new loader module is invoked.
  - The return address from the *initModule()* function must be adjusted to the location which calls the update API of the old loader module by clearing the stack to ignore the call from the old loader module.
  - The old loader module can be deleted from the memory.

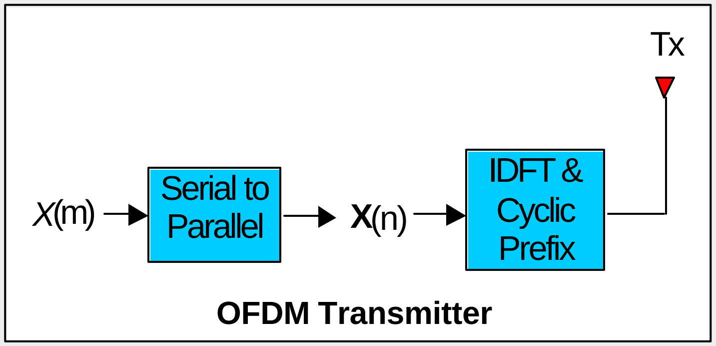
DRTOS **Technical Approach (continued)**

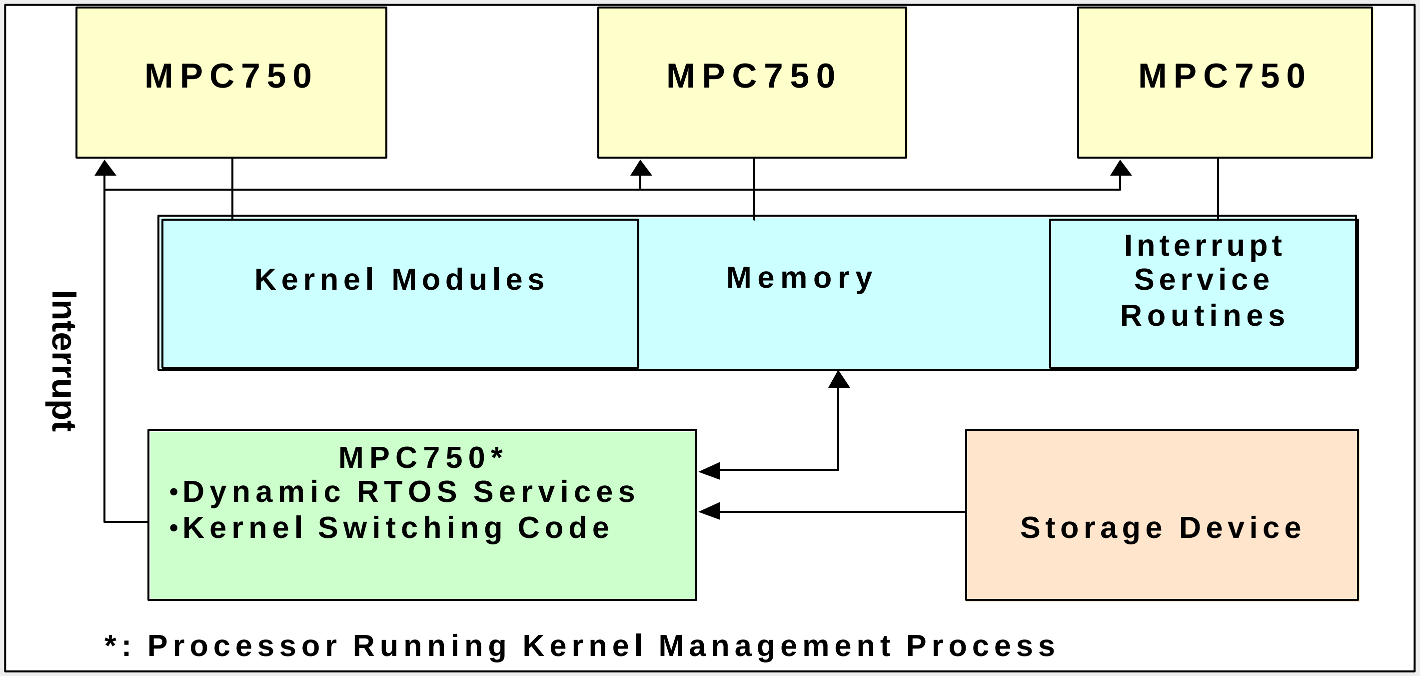
Updating Loader module



Experiment 1



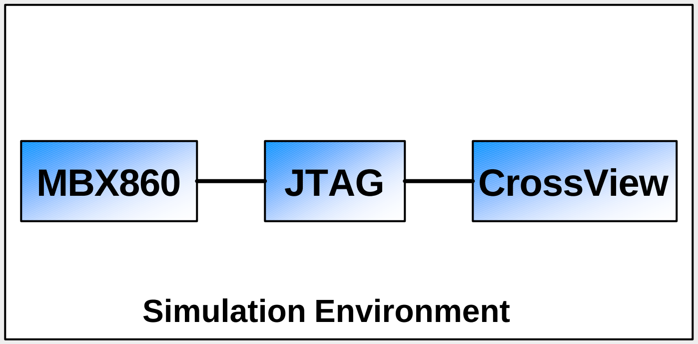


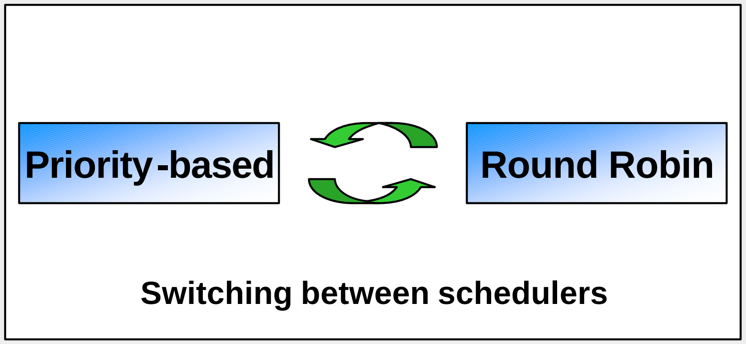


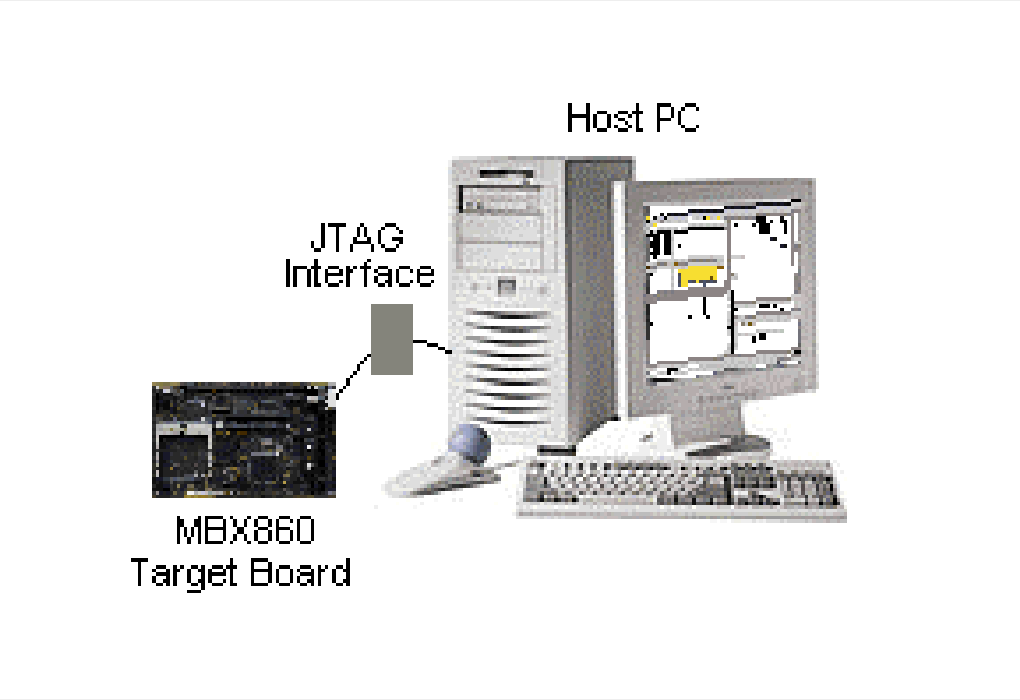
Experiment 1 (continued)

- Initially running VUI code
  - uses round-robin scheduler
- Want to change to OFDM code
  - install new I/O code
  - install new priority scheduler code
- OFDM Code Size: 1600 lines of code
- Time to load (VUI still operational): 4 kbytes x 2 cycles/byte
- Time to switch to new DRTOS code: 60 cycles

Experiment 2



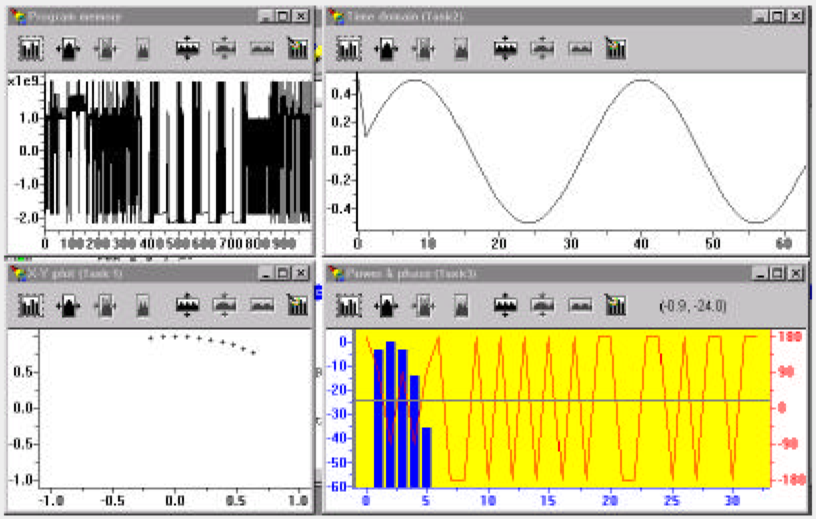




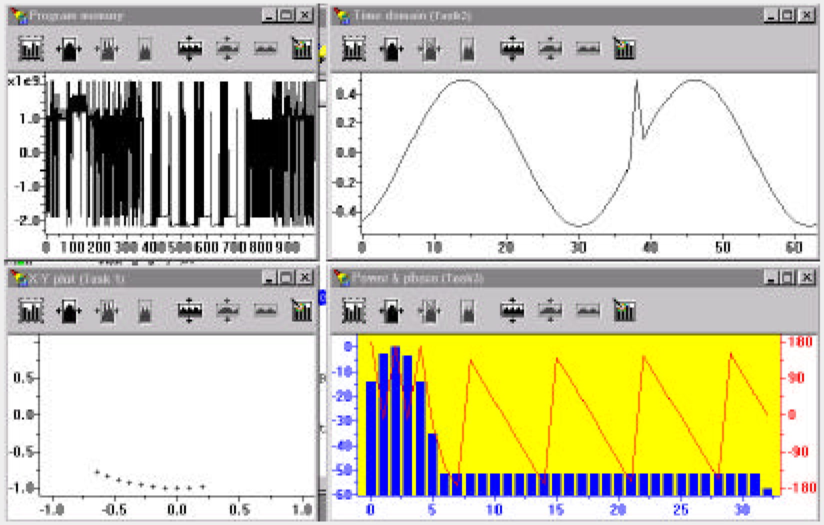
Experiment 2 (continued)

- Three tasks
  - DRTOS uses priority-based scheduler
- Change to round robin scheduler
  - install round robin scheduler code
  - migrate tasks from the previous scheduler
- Round Robin Code Size: 200 lines of code
- Switching Time: 60 + 8n assembly instructions (n = number of tasks currently in the system, the scheduler needs to poll each task to get its handle)

Experiment 2 (continued)



Priority-based scheduler



Round robin scheduler

Conclusion

- Existing real-time operating systems not fully dynamic
- The needs of a new real-time operating system architecture to support emerging applications
- Our approach: the Georgia Tech DRTOS
- Initial experiments and results