CGS 3763: Operating System Concepts Spring 2006

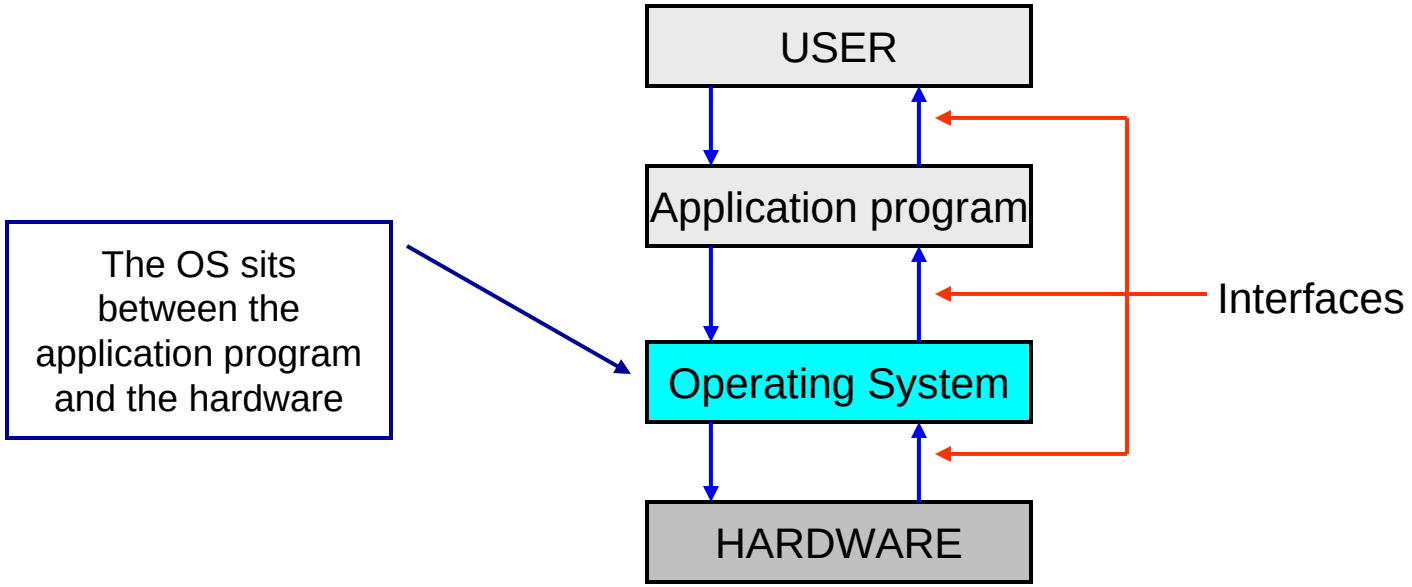
Introduction to Operating Systems

Instructor : Mark Llewellyn
markl@cs.ucf.edu
CSB 242, 823-2790
http://www.cs.ucf.edu/courses/cgs3763/spr2006

School of Electrical Engineering and Computer Science
University of Central Florida

What is an Operating System?

- In the most general sense an operating system is a collection of system software routines that sit between an application program and the computer hardware on which that application is to be executed.



What is an Operating System? (cont.)

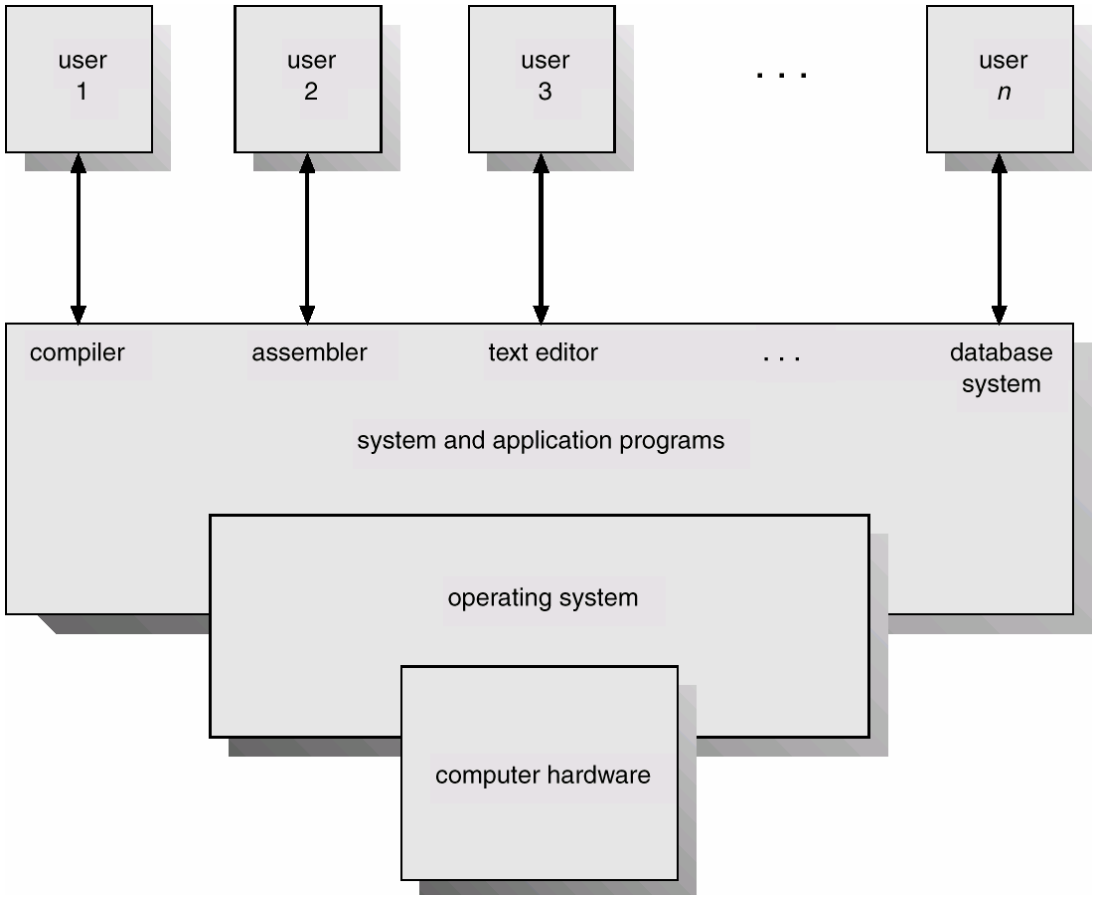
- For now, we can think of an OS as:

  1) is the interface or intermediary between a user/application and the computer hardware
  2) provides an environment in which the user can execute programs conveniently and
     - application and/or system software
  3) manages the computer's resources efficiently
     - memory, disk space, CPU time, I/O, software, etc.

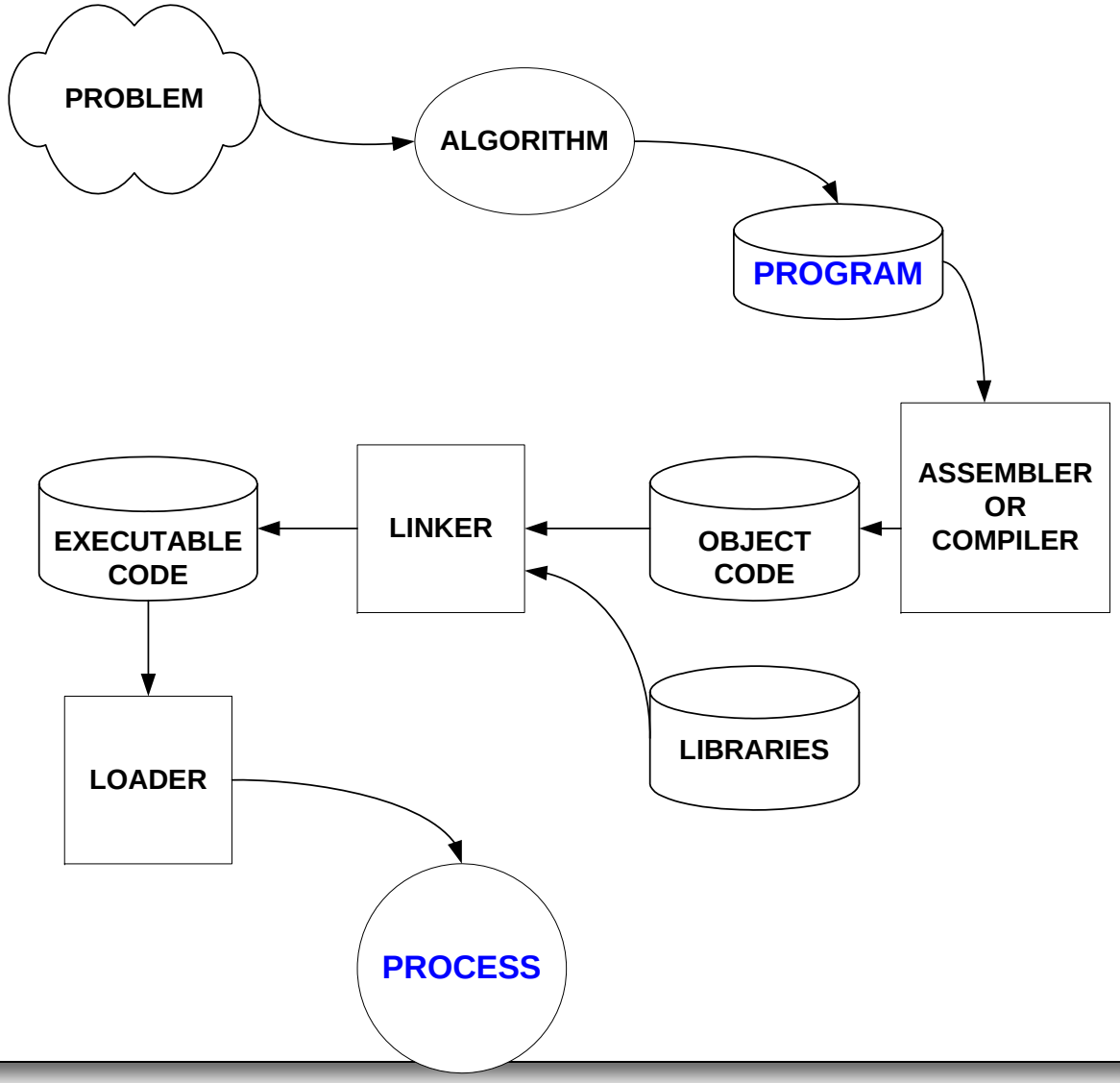
- Often an OS is a tradeoff between convenience and efficiency
  – Windows (GUI) vs. Unix (command interpreter)

The OS As An Intermediary

- We'll discuss hardware later in Chapter 2.
- What's an application?
  - Software to accomplish a task
    - Spread sheet, word processor, browser, email
  - What about system software?
    - Depending on who you ask, can be considered application programs, a computer resource, or part of the OS



What Is A Process?



What Is A Process (cont.)

- A *process*:
  - is a program in execution.
  - has a process control block (PCB)
  - has a program counter (PC)

- A process can have one or more *threads*.
  - A thread is sometimes known as a *lightweight process*

Types of Operating Systems

- Focus on two system resources
  - CPU (processor) Utilization
  - Main Memory Utilization
- Utilization is measure of busy time over total study time (T_{busy}/T_{Total})
- In the old days computers were
  - physically very large
  - but very small in terms of resources and capabilities
  - also very, very expensive
- Important to achieve high utilization of resources

Early Systems

- Instructions and data written in binary
- Loaded using switches on front panel
- Computers also had a few buttons
  - Halt, Run, Load, Set PC (displayed contents), Increment PC
- Everything done by programmer the was no real "user" as we know them today
- Very slow set up time
- Very limited output (set PC and check lights)
- CPU sat idle much of the time.
- Very little wasted memory since RAM was so small.
  - Programmers always "squeezed" program into Main Memory

Early Systems - Hardware Innovations

- Needed way to speed up Input & Output (I/O)
- Paper Tape
  - Data entry difficult, splicing needed or recopy tape
  - Paper tape output faster than looking at lights but hard to read.
- Punch Cards
  - Faster form of input.
  - Offline Card-to-Printer improved readability of output
- Magnetic Tape
  - Input even faster
  - Card-to-tape, tape-to-CPU, CPU-to-tape, tape-to-printer.
- Disk drives as a replacement for tapes

Early Systems - Software Innovations

- Assemblers
  - Symbolic programming rather than 1s and 0s
  - 1:1 relationship between assembler statements and machine instructions
- Linkers & Loaders
  - allowed the use of code libraries
  - didn't have to rewrite common code
- Compilers
  - Programming in High Level Languages (Fortran, COBOL)
  - 1:n relationship between a program statement and machine instructions
  - Eased programming task and improved operational efficiency.

Early Systems - People/Procedural Changes

- Too much work for programmer
- Division of labor became necessary.
  - Divided tasks between a programmer and professional operator
  - Operator could now organize the work more effectively and "batch" jobs
- Batching
  - allows similar jobs to run sequentially
  - efficient use of system software
  - today, refers more to jobs which lack user interaction
    - Example, billing systems used by companies
  - still took long time to set up jobs
  - CPU frequently sat idle

Running Multiple Programs

- Serial/Sequential Execution
  - One job must finish before next job starts
  - Results in very low utilization of resources
- Concurrent Execution
  - Two or more processes executing at the same time but doing different activities
  - Processes take turns using single shared resource
  - Gives the illusion of parallel processing
- Parallel/Simultaneous Execution
  - Two or more processes performing the same activity at the same time
  - Requires two or more of the same resource (e.g., processors, printers, disk drives)

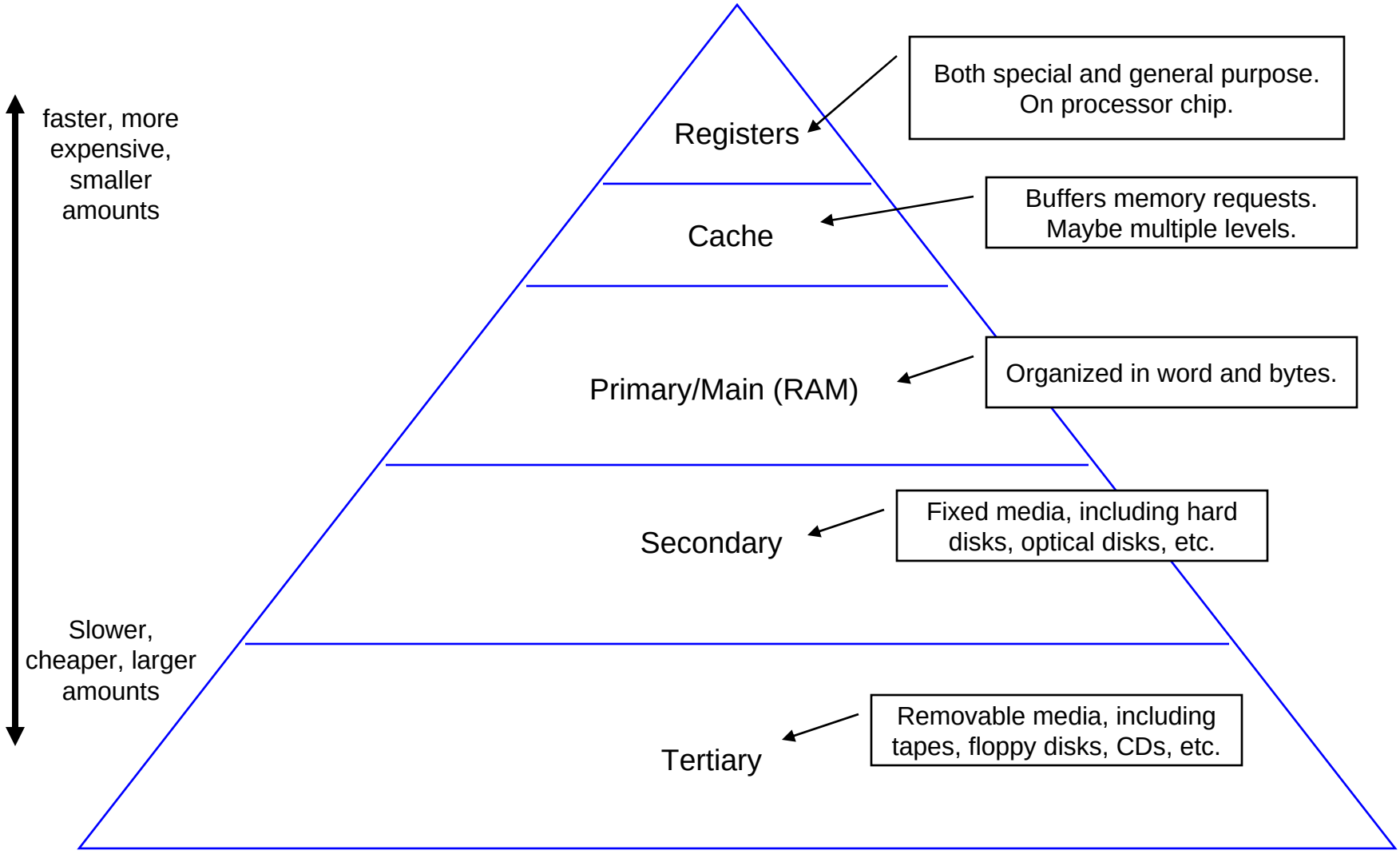
Resident Monitor

- Precursor to the Operating System
  - The beginnings of computer "self-governance"
- Resident in memory all the time, Monitored operations
- Primary task was job sequencing
  - In beginning read jobs sequentially from tape already prepared off-line
  - With disks, could select which jobs to run and when
    - Job Scheduling
- Resident Monitors Improved:
  - CPU Utilization: Faster setup, less idle time.
  - Memory Utilization: Sharing of I/O drivers/code
  - Functionality: Accounting and run time & I/O limits.

The Beginnings of Multiprogramming

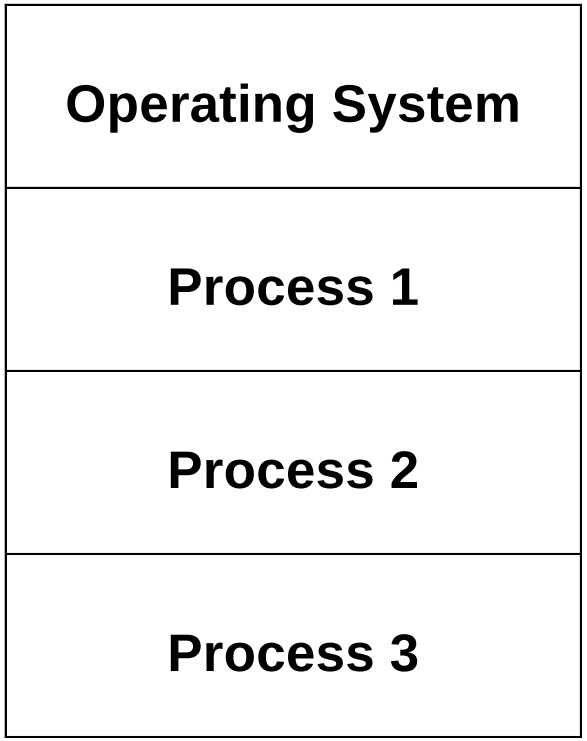
- With RM, had two programs running serially:
  - Application - RM - Application - RM - Application, etc.
  - Application ran to completion before RM took over
- Reduced CPU idle time between jobs but not between I/O operations
  - I/O speed very slow compared to CPU speed
  - Much of I/O deals with accessing data (tape, disk)

An Aside On The Memory Hierarchy



Multiprogramming (cont.)

- Need some way to perform CPU and I/O operations at the same time
- Keep more than one user program in memory
- Switch between programs during I/O operations



Multiprogramming (cont.)

- More efficient use of system, less idle time.
- Made possible because of reduced memory costs.
- Created a whole new set of problems:
  - Memory Management
  - Protection Mechanisms
  - Job Scheduling
  - CPU/Process Scheduling
- Improves resource utilization but not user interaction
  - ***"...manages the computer's resources efficiently..."***
- What about conveniences
  - ***"...the user can execute programs conveniently..."***

Time Sharing

- Introduced to improve the interaction with computer
  - Use of terminals and teleprinters
  - Allows user to input data and interact with program
- Give each process a slice of CPU time
  - Don't wait for next I/O operation
  - Similar to multiplexing
- Possible because user input is so slow
  - 1 char takes 1000 milliseconds to enter while only 2 milliseconds required for an interrupt handler
- Required the development of virtual memory, online file systems and directory structures
- Today's systems generally support a combination of batch and time sharing.

Other Operating System Developments

- Real Time - Response time is critical
  - Hard Real Time
    - Industrial & Robotic controls.
    - Very small bounded delays.
    - Little use of swapping or secondary storage.
  - Soft Real Time
    - Immediate response not as critical.
    - Monitoring devices, etc.
    - Longer delays tolerated
    - Use of secondary storage & priority scheduling.

Other Developments (cont.)

- Personal Computers
  - Many of the OS features we'll study are incorporated in today's PCs.
  - Change in priority since hardware is cheap and only a single user.
  - Greater emphasis on convenience than on efficiency
  - Ultimate in interactive – in a way, we've gone back to the early days
  - Adds new demands also – networking and multimedia.
- Handheld Systems

Other Developments (cont.)

- Parallel vs. Distributed Systems vs. Clustered
  - Needed for various reasons: larger problems, larger data requirements,
  - Parallel/Tightly coupled –share resources (e.g., memory, clock, bus, OS, disks)
    - Asymmetric multiprocessing – master/slave
    - Symmetric multiprocessing – each processor has copy of OS
    - Typically used for scientific applications and simulations.
  - Distributed/Loosely coupled – Separate computers linked via network.
    - Used for client/server applications
    - Peer-to-Peer applications
  - Clustered Systems
    - Computers linked by network but sharing storage

Performance Measurements

- Utilization (maximize)
  - $U = T_{busy} / T_{total}$ where T_{total} is total study time, or
  - $U = T_{used} / T_{available}$

- Throughput (maximize)
  - X = C / T where C is number of completed jobs/processes and T is time frame
  - The rate at which requests are processed

Performance Measurements (cont.)

- Turnaround Time (minimize)
  - Typically used in reference to batch systems
  - The time it takes to complete/execute a job/process

- Response Time (minimize)
  - Typically used in reference to interactive systems
  - The time it takes for the system to respond to a user request from submission to start of a response