Project 2

Zen and the art of sending signals
Background – Context
Switching
Background – Context Switching

- One processor and multiple threads running concurrently – How?
Background – Context
Switching

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Background – Context Switching

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- When this quantum expires, or the thread blocks, context-switch to a different thread.

1. Where should I save the thread context during a context-switch?
2. What should this context consist of?
Background – Kernel Stack
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• User process is a kernel thread with USERCONTEXT structure.
Background – Kernel Stack

- **User process is a kernel thread with USER_CONTEXT structure.**
- **Store the current context (state) before context switching.**
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```c
struct Kernel_Thread {
    unsigned long esp; // Stack pointer (absolute)
    void* stackPage;   // The beginning of the stack
..............................
};
```
Background – Kernel Stack

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• Store the current context (state) before context switching.

• **Where is the kernel stack?**

```c
struct Kernel_Thread {
    unsigned long esp; // Stack pointer (absolute)
    void* stackPage;   // The beginning of the stack
........................
};
```

• **esp** points at the end of the stack (stack grows down from higher to lower address)
Background – User Processes
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• Two stacks: kernel stack and user stack.
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- User Stack (stores state in user mode)
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- Start_User_Thread:
Background – User Processes

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- User Stack (stores state in user mode)
- Start_User_Thread:
  set up the *kernel* stack to look as if the thread had previously been running and then context-switched to the ready queue.
Background – Context Information

The items at the top are pushed first.

Program Counter → EIP

User stack pointer points to the end of the DS.

Stack grows down from higher address to lower address.

### User Stack Location

- Stack Data Selector (data selector)
- Stack Pointer (end of data memory)

### Interrupt State

- Eflags
- Text Selector (code selector)
- Program Counter (entry addr)
  - Error Code (0)
  - Interrupt Number (0)
- EAX (0)
- EBX (0)
- ECX (0)
- EDX (0)
- ESI (Argument Block address)
- EDI (0)
- EBP (0)
- DS (data selector)
- ES (data selector)
- FS (data selector)
- GS (data selector)
Project 2: Signals
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- Inter-process communication
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- Signals are to user processes what interrupts are to the kernel.

- Process temporarily stops what it is doing, and is instead redirected to the signal handler.

- When the handler completes, the process goes back to what it was doing (unless another signal is pending!)
1. Process A is executing then either finishes quantum OR blocked

\[ \text{Kill}(A, \text{SIGUSR1}) \]

\[ X = x + 1; \]

\[ \text{OR Get-Key()} \]
1. Process A is executing then either finishes quantum OR blocked

... Kill(A, SIGUSR1) ...

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SIGUSR1 Handler

Memory

Process A CS

Process B CS
1. Process A is executing then either finishes quantum OR blocked

   ....
   Kill(A, SIGUSR1)
   ......
   ....
   X = x + 1;
   OR Get_Key()
   ......
   SIGUSR1 Handler

   Memory
1. Process A is executing then either finishes quantum OR blocked
2. Process B is now executing and sends a signal to A.

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Kill(A, SIGUSR1)
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... Kill(A, SIGUSR1) ...
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SIGUSR1 Handler
1. Process A is executing then either finishes quantum OR blocked
2. Process B is now executing and sends a signal to A.
3. Process A is executing again. However, control is transferred to SIGUSR1 handler.
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2. Process B is now executing and sends a signal to A.
3. Process A is executing again. However, control is transferred to SIGUSR1 handler.

```c
... Kill(A, SIGUSR1)
...
...
...
X = x + 1;
OR Get_Key()
...
...
SIGUSR1 Handler
```

Memory

Process B
CS

Process A
CS
1. Process A is executing then either finishes quantum OR blocked
2. Process B is now executing and sends a signal to A.
3. Process A is executing again. However, control is transferred to SIGUSR1 handler.
4. SIGUSR1 handler finishes. Then control transfers to Process A again (if no other signal pending).
Project Requirements
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1. Add the code to handle signals.
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2. System calls.
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3. Background processes are NOT detached. (Now they are children)
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Look for TODO macro
Supported Signals
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Supported Signals

- **SIGKILL**: treated as `Sys_Kill` of project1.
- **SIGUSR1 & SIGUSR2**
- **SIGCHLD**
- Background processes are NOT detached any more (refCount will start as 2).
- Sent to a parent when the background child dies.
- Default handler - reap the child
System Calls
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- `Sys_Signal`: register a signal handler
System Calls

• Sys_Signal: register a signal handler
• Sys_RegDeliver: initialize signal handling for a process
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System Calls

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- **Sys_Kill**: send a signal
- **Sys_ReturnSignal**: indicate completion of signal handler
System Calls

- Sys_Signal: register a signal handler
- Sys_RegDeliver: initialize signal handling for a process
- Sys_Kill: send a signal
- Sys_ReturnSignal: indicate completion of signal handler
- Sys_WaitNoPID: wait for any child process to die
Sys__ Signal
Sys__ Signal

- Register a signal handler for a process
Sys__ Signal

- Register a signal handler for a process
- `state->ebx` - pointer to handler function
Sys__ Signal

- Register a signal handler for a process
- state->ebx - pointer to handler function
- state->ecx - signal number
Sys__ Signal

- Register a signal handler for a process
- state->ebx - pointer to handler function
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- Returns: 0 on success or error code (< 0) on error
Sys_ Signal

- Register a signal handler for a process
  - state->ebx - pointer to handler function
  - state->ecx - signal number
- Returns: 0 on success or error code (< 0) on error
- Calling Sys_Signal with a handler to SIGKILL should result in an error.
Sys_Signal
Sys_Signal

• Initial handler for SIGCHLD (reaps all zombie) is
Sys_Signal

- Initial handler for SIGCHLD (reaps all zombie) is
- Def_Child_Handler
Sys_Signal

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- Two predefined handlers:
- Initial handler for SIGCHLD (reaps all zombie) is Def.Child_Handler
- Two predefined handlers:
  - SIG_IGN, SIG_DFL (check include/libc/signal.h)
Sys_Signal

- Initial handler for SIGCHLD (reaps all zombie) is `Def_Child_Handler`
- Two predefined handlers:
  - `SIG_IGN`, `SIG_DFL` (check `include/libc/signal.h`)
- Example: `Signal(SIGUSR1,SIG_IGN);`
Register three functions:

1. Ignore
2. Default
3. Return_Signal trampoline (calls Sys_ReturnSignal)

Signals cannot be delivered until this is registered.

- state->ebx - pointer to Return_Signal function
- state->ecx - pointer to the default handler
- state->edx - pointer to the ignore handler

Returns: 0 on success or error code (< 0) on error

These routines are registered automatically. (check src/libc/entry.c)
Sys_Kill
Sys_Kill

• Send a signal to a process
Sys_Kill

- Send a signal to a process
- state->ebx - pid of process
Sys_Kill

- Send a signal to a process
  - state->ebx - pid of process
  - state->ecx - signal number
Sys_Kill

• Send a signal to a process
• state->ebx - pid of process
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• Returns: 0 on success or error code (< 0) on error
Sys_ReturnSignal
Sys_ReturnSignal

• Complete signal handling for this process.
Sys_ReturnSignal

- Complete signal handling for this process.
- No Parameters
Sys_ReturnSignal

- Complete signal handling for this process.
- No Parameters
- Returns: 0 on success or error code (< 0) on error
Sys_ReturnSignal

- Complete signal handling for this process.
- No Parameters
- Returns: 0 on success or error code (< 0) on error
- Called by a process immediately after it has handled a signal.
Sys_WaitNoPID
Sys_WaitNoPID

- Reap a child process that has died
**Sys_WaitNoPID**

- Reap a child process that has died
- state->ebx - pointer to status of process reaped
Sys_WaitNoPID

- Reap a child process that has died
- `state->ebx` - pointer to status of process reaped
- Returns: pid of reaped process on success, -1 on error.
Signals Golden Rules
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• If there no handler registered, the default handler will be executed.

• Signal handling is non-reentrant.
Signals Delivery in Kernel
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- src/geekos/signal.c
Signals Delivery in Kernel

- src/geekos/signal.c
- Send_Signal
Signals Delivery in Kernel

- src/geekos/signal.c
- Send_Signal
- Check_Pending_Signal
Signals Delivery in Kernel

- `src/geekos/signal.c`
- `Send_Signal`
- `Check_Pending_Signal`
- `Set_Handler`
Signals Delivery in Kernel

- src/geekos/signal.c
- Send_Signal
- Check_Pending_Signal
- Set_Handler
- Setup_Frame
Signals Delivery in Kernel

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- Send_Signal
- Check_Pending_Signal
- Set_Handler
- Setup_Frame
- Complete_Handler
Check_Pending_Signal
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- A signal is pending for that user process.
Check_Pending_Signal

- A signal is pending for that user process.
- The process is about to start executing in user space.
Check_Pending_Signal

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• CS register != KERNEL_CS
Check_Pending_Signal

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- (see include/geekos/defs.h)
Check_Pending_Signal

- A signal is pending for that user process.
- The process is about to start executing in user space.
- CS register != KERNEL_CS
- (see include/geekos/defs.h)
- The process is not currently handling another signal.
Setup_Frame

User Stack Location (SP)

Interrupt_State (Context Information)

Kernel Stack

Memory

Higher Address

Lower Address
1. Push a copy of the context from kernel stack to user stack.
Setup_Frame

1. Push a copy of the context from kernel stack to user stack.
2. Push the address of the “signal trampoline”.

User Stack Location (SP)

Interrupt_State (Context Information)

Interrupt_State (Context Information)

Signal Trampoline

Memory

Higher Address

Lower Address
1. Push a copy of the context from kernel stack to user stack.
2. Push the address of the “signal trampoline”.
3. Advance user stack pointer in kernel stack.
1. Push a copy of the context from kernel stack to user stack.
2. Push the address of the “signal trampoline”.
3. Advance user stack pointer in kernel stack.
4. Change program counter in kernel stack to point to signal handler.
Complete_Handler

User Stack Location (SP)

Interrupt_State (Context Information)

Kernel Stack

Interrupt_State (Context Information)

Signal Trampoline

Memory

Higher Address

Lower Address
Complete_Handler

1. Copy of the context from user stack to kernel stack.
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2. Update user stack pointer in kernel stack.