Name:_____ **SID:** _____

CSCE 351: Operating System Kernels

Lab 4 – Remote Viewer Tools and Kernel Debugging

Basic Setup:

- Windows 2000/XP workstation with Windows CE .Net 4.2 installed.

Objectives:

The objectives of this lab are as follows:

- Discover how to insert debugging statements in the kernel source
- Explore the process and thread structures
- Utilizing the Platform Builder remote viewing tool to monitor threads and processes

Estimated Lab Time: 75 minutes

Introduction

This is an excerpt from http://www.microsoft.com/technet/prodtechnol/wce/plan/chapt1.mspx.

"As a multitasking operating system, Windows CE can support up to 32 simultaneous processes, each process being a single instance of an application. In addition, multithreading support allows each process to create multiple threads of execution. A thread is a part of a process that runs concurrently with other parts. Threads operate independently, but each one belongs to a particular process and shares the same memory space. The total number of threads is limited only by available physical memory."

In this exercise, we will briefly look at the process structure and thread structure. For every process created in the system, a process structure is created to represent that particular process in the kernel. The process structure contains all the necessary information to facilitate management of that process. The more information about the process structure is provided below.

Process Structure

The following is the process structure defined in kernel.h (C:\WINCE420\PRIVATE\WINCEOS\COREOS\NK\INC):

```
struct Process {
    BYTE        procnum;        /* 00: ID of this process [ie: it's slot number] */
    BYTE        DbgActive;      /* 01: ID of process currently DebugActiveProcess'ing
this process */
    BYTE        bChainDebug;    /* 02: Did the creator want to debug child processes? */
    BYTE        bTrustLevel;    /* 03: level of trust of this exe */
#define OFFSET_TRUSTLVL     3   // offset of the bTrustLevel member in Process structure
    LPPROXY     pProxList;      /* 04: list of proxies to threads blocked on this process
*/
    HANDLE      hProc;          /* 08: handle for this process, needed only for
SC_GetProcFromPtr */
    DWORD       dwVMBase;       /* 0C: base of process's memory section, or 0 if not in
use */
```

```
    PTHREAD     pTh;            /* 10: first thread in this process */
    ACCESSKEY   aky;            /* 14: default address space key for process's threads */
    LPVOID      BasePtr;        /* 18: Base pointer of exe load */
    HANDLE      hDbgrThrd;      /* 1C: handle of thread debugging this process, if any */
    LPWSTR      lpszProcName;   /* 20: name of process */
    DWORD       tlsLowUsed;     /* 24: TLS in use bitmask (first 32 slots) */
    DWORD       tlsHighUsed;    /* 28: TLS in use bitmask (second 32 slots) */
    PEXCEPTION_ROUTINE pfnEH;   /* 2C: process exception handler */
    LPDBGPARAM  ZonePtr;        /* 30: Debug zone pointer */
    PTHREAD     pMainTh;        /* 34  primary thread in this process*/
    PMODULE     pmodResource;   /* 38: module that contains the resources */
    LPName      pStdNames[3];   /* 3C: Pointer to names for stdio */
    LPCWSTR     pcmdline;       /* 48: Pointer to command line */
    DWORD       dwDyingThreads; /* 4C: number of pending dying threads */
    openexe_t   oe;             /* 50: Pointer to executable file handle */
    e32_lite    e32;            /* ??: structure containing exe header */
    o32_lite    *o32_ptr;       /* ??: o32 array pointer for exe */
    LPVOID      pExtPdata;      /* ??: extend pdata */
    BYTE        bPrio;          /* ??: highest priority of all threads of the process */
    BYTE        fNoDebug;       /* ??: this process cannot be debugged */
    WORD        wPad;           /* padding */
    PGPOOL_Q    pgqueue;        /* ??: list of the page owned by the process */
#if HARDWARE_PT_PER_PROC
    ulong       pPTBL[HARDWARE_PT_PER_PROC];   /* hardware page tables */
#endif

};  /* Process */
```

As stated in the excerpt, Windows CE only allows the maximum of 32 processes. This is very small compare to other operating systems that allows hundreds of process. For illustration, please log in to your CSE account and find out the number of processes currently **existing** on the system. Write your answer in the space below:

What was the command you used? _____

Number of processes on CSE: _____

Also find the number of processes **existing** on your PC right now.

What was the program that you used? _____

Number of processes on your PC: _____

Since each process can have multiple threads, you can have more than just 32 paths of execution. For each thread created, a structure is used to contain information related to that particular thread. More information about the thread structure is given below.

Thread Structure

Scheduler operates on threads based on their priorities. The following is the thread structure defined in kernel.h (C:\WINCE420\PRIVATE\WINCEOS\COREOS\NK\INC):

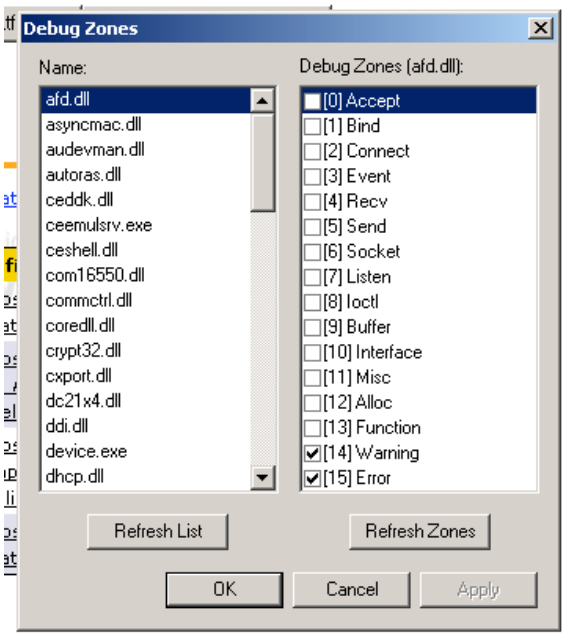
```
struct Thread {
    WORD        wInfo;      /* 00: various info about thread, see above */
    BYTE        bSuspendCnt;/* 02: thread suspend count */
    BYTE        bWaitState; /* 03: state of waiting loop */
    LPPROXY     pProxList;  /* 04: list of proxies to threads blocked on this thread */
    PTHREAD     pNextInProc;/* 08: next thread in this process */
```

```
    PPROCESS    pProc;      /* 0C: pointer to current process */
    PPROCESS    pOwnerProc; /* 10: pointer to owner process */
    ACCESSKEY   aky;        /* 14: keys used by thread to access memory & handles */
    PCALLSTACK  pcstkTop;   /* 18: current api call info */
    DWORD       dwOrigBase; /* 1C: Original stack base */
    DWORD       dwOrigStkSize;  /* 20: Size of the original thread stack */
    LPDWORD     tlsPtr;     /* 24: tls pointer */
    DWORD       dwWakeupTime; /* 28: sleep count, also pending sleepcnt on waitmult */
    LPDWORD     tlsSecure;      /* 2c: TLS for secure stack */
    LPDWORD     tlsNonSecure;   /* 30: TLS for non-secure stack */
    LPPROXY     lpProxy;    /* 34: first proxy this thread is blocked on */
    DWORD       dwLastError;/* 38: last error */
    HANDLE      hTh;        /* 3C: Handle to this thread, needed by NextThread */
    BYTE        bBPrio;     /* 40: base priority */
    BYTE        bCPrio;     /* 41: curr priority */
    WORD        wCount;     /* 42: nonce for blocking lists */
    PTHREAD     pPrevInProc;/* 44: previous thread in this process */
    LPTHRDDBG   pThrdDbg;   /* 48: pointer to thread debug structure, if any */
    LPBYTE      pSwapStack; /* 4c */
    FILETIME    ftCreate;   /* 50: time thread is created */
    CLEANEVENT *lpce;       /* 58: cleanevent for unqueueing blocking lists */
    DWORD       dwStartAddr; /* 5c: thread PC at creation, used to get thread name */
    CPUCONTEXT  ctx;        /* 60: thread's cpu context information */
    PTHREAD     pNextSleepRun; /* ??: next sleeping thread, if sleeping, else next on
runq if runnable */
    PTHREAD     pPrevSleepRun; /* ??: back pointer if sleeping or runnable */
    PTHREAD     pUpRun;     /* ??: up run pointer (circulaar) */
    PTHREAD     pDownRun;   /* ??: down run pointer (circular) */
    PTHREAD     pUpSleep;   /* ??: up sleep pointer (null terminated) */
    PTHREAD     pDownSleep; /* ??: down sleep pointer (null terminated) */
    LPCRIT      pOwnedList; /* ??: list of crits and mutexes for priority inversion */
    LPCRIT      pOwnedHash[PRIORITY_LEVELS_HASHSIZE];
    DWORD       dwQuantum;  /* ??: thread quantum */
    DWORD       dwQuantLeft;/* ??: quantum left */
    LPPROXY     lpCritProxy;/* ??: proxy from last critical section block, in case stolen
back */
    LPPROXY     lpPendProxy;/* ??: pending proxies for queueing */
    DWORD       dwPendReturn;/* ??: return value from pended wait */
    DWORD       dwPendTime; /* ??: timeout value of wait operation */
    PTHREAD     pCrabPth;
    WORD        wCrabCount;
    WORD        wCrabDir;
    DWORD       dwPendWakeup;/* ??: pending timeout */
    WORD        wCount2;    /* ??: nonce for SleepList */
    BYTE        bPendSusp;  /* ??: pending suspend count */
    BYTE        bDbgCnt;    /* ??: recurse level in debug message */
    HANDLE      hLastCrit;  /* ??: Last crit taken, cleared by nextthread */
    //DWORD     dwCrabTime;
    CALLSTACK   IntrStk;
    DWORD       dwKernTime; /* ??: elapsed kernel time */
    DWORD       dwUserTime; /* ??: elapsed user time */
};  /* Thread */
```

Activity 1: Using remote viewing tools

1. Create a new platform with the following specification:
   - Platform name: *lastname_kernel* (e.g. shen_kernel)
   - Use *c:\csce351_lab* for the path of your project.
   - In step 3 of the "New Platform Wizard" choose "Internet Appliance".
   - In step 4 choose only **Internet Explorer**.
   - In step 5 choose the **default** setting.

2. Change from *Emulator:X86 Win32 (WCE Emulator) Release* to *Emulator:X86 Win32 (WCE Emulator) Debug*.
3. Build the platform.
4. Download the image to the emulator (make sure you set system memory in download setting to 64 MB and screen size to 320x240 with 8 bit).
5. Once the emulator is initialized, go to **platform builder -> target** and choose **CE Debug Zone**.
6. Once the Debug Zone is initialized, click refresh to get the latest data from module list (see figure below).



7. Click OK to exit.
8. Go to **target->CE Modules and Symbols Viewer** and look for *nk.exe*. This is where you can see the status of all your modules.

How many modules have been loaded? _____

9. Close **Modules and Symbols viewer** and launch the **Process Viewer (target->CE processes)**.

How many processes do you see? _____

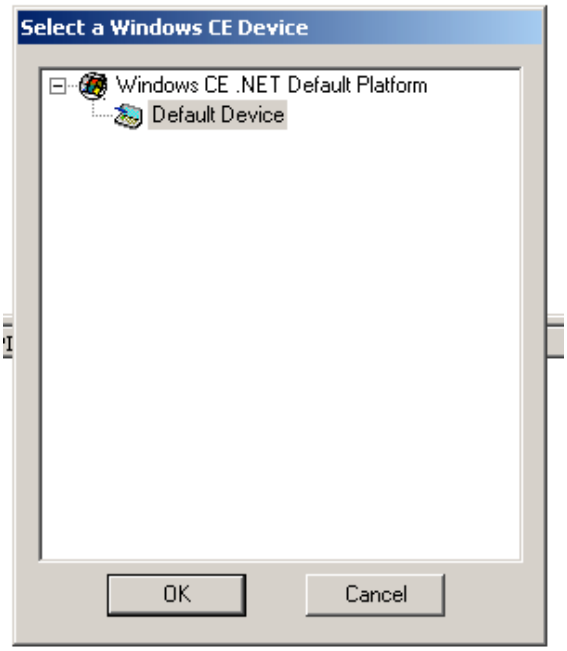
10. Close the **Process Viewer** and launch the **Thread Viewer (target->CE threads)**.

From the Process drop down menu choose *device.exe*.

How many threads do you see? _____

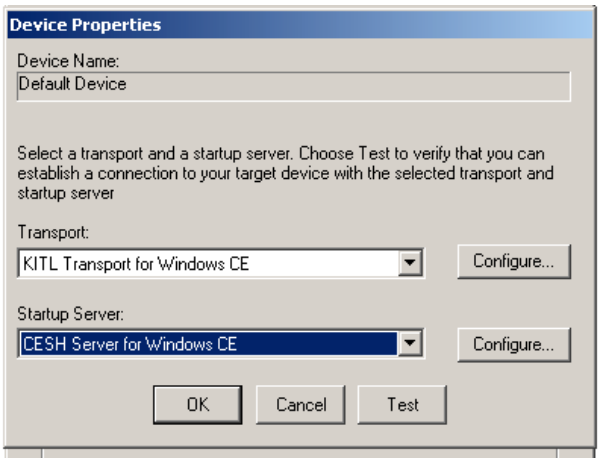
11. Close **Thread Viewer**.

12. From Platform Builder **Tools** menu, choose **Remote Kernel Tracker**. You should see a small window similar to the figure below.



13. Click **Cancel** to close the window.
14. From the **connection menu** (see figure below), choose **Configure Windows CE Platform Manager**.

15. Choose **properties** button and you should see a small configuration window (see figure below). Make sure your configuration is the same as the figure.



16. Click **test** to verify the connectivity. If successful, close the Testing Device window by clicking "OK" then Device Properties window ("OK") then Platform Manager Configuration window ("OK").
17. From tools menu, click **Remote Process Viewer**. It should connect successfully.

18. From target menu, select **CE Processes**. **What do you think are some of the differences between monitoring process, threads, modules using tools from Target menu and remote tools from Tools menu?**

Activity 2: Source Code Revision and fast rebuild

Please use the same workspace from Activity 1. Make sure that you disconnect the simulator and shut down all remote monitoring tasks you experiment with in Activity 1.

Step 1. Download the script file from the following link:
- cse.unl.edu/~lshen/build_kernel.bat

Step 2. Save the script file to
- C:\Program Files\Windows CE Platform Builder\4.20\cepb\bin

Step 3. Using My Computer go to C:\WINCE420\PRIVATE\WINCEOS\COREOS\NK\KERNEL and copy schedule.c to *C:\csce351_lab* directory. **IMPORTANT: Do not skip.**

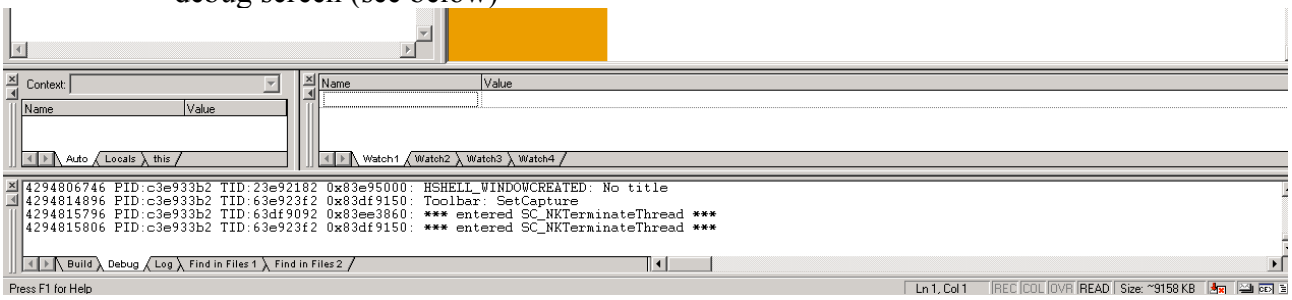
Step 4. In the platform builder, click file | open and choose file c:\WINCE420\PRIVATE\WINCEOS\COREOS\NK\KERNEL\schedule.c

Step 5. Insert one line in function SC_NKTerminateThread(DWORD dwExitCode) to print out debug message:
DEBUGMSG(1,(L"*** entered SC_NKTerminateThread ***\r\n"));

Step 6. Once launched, you need to create a new platform workspace. To do so, you select:
- Build | Open Build Release Directory.
- go to C:\Program Files\Windows CE Platform Builder\4.20\cepb\bin.
- Type build_kernel at the command line prompt. Notice this is very fast. We are only building the core image here.

Step 7. Wait until the build process is complete then download the image to emulator.

Step 8. In emulator, open "Recycle Bin" and close it to see your print out message in the debug screen (see below)



Step 9. Disconnect from the emulator.

Step 10. Repeat the process but this time to print out the process's name of the thread that has just been terminated in SC_NKTerminateThread.

- Hints:
  - pCurThread is the pointer pointed to the thread to be terminated
  - pProc is the pointer in the thread structure. It is a pointer to the process of the thread
  - lpszProcName is the pointer to the process name in the process structure

Step 11. Reconnect the emulator and launch and terminate Recycle Bin again to check your correctness.

Step 12. You can save the modified *schedule.c* for future reference. Once you are done, show your work with answers to all the questions to the TA. Be sure to replace the modified schedule.c with the original version. Do not delete the original version from *C:\csce351_lab\schedule.c*.

If you cannot finish during the lab period, finish this lab on your own time and show the result to the TA at the beginning of next week.

End of Lab 2