PB173 - Tématický vývoj aplikací v C/C++ (podzim 2013)

Skupina: Aplikovaná kryptografie a bezpečné programování

https://is.muni.cz/auth/el/1433/podzim2013/PB173/index.qwarp?fakulta=1433;obdobi=5983;predmet=734514;prejit=2957738;

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Network communication - sockets

Network communication with sockets

- Many different libraries
  - e.g., René Nyffenegger class wrappers
  - https://github.com/ReneNyffenegger/development_misc/tree/master/c++/socket
  - build atop of Windows Sock library <WinSock2.h>
- Client & Server mode of communication
  1. Server run and is waiting for client(s)
  2. Client connects to server (IP, port)
  3. Server creates new thread for every new client
  4. Client sends data to server (SendLine("data"))
  5. Server receives data and respond to client

Socket client and server

```
class SocketClient : public Socket {
public:
  SocketClient(const std::string& host, int port);
};

class SocketServer : public Socket {
public:
  SocketServer(int port, int connections, TypeSocket type=BlockingSocket);
  Socket* Accept();
};
```

```
enum TypeSocket {BlockingSocket, NonBlockingSocket};

class Socket {
public:

  virtual ~Socket();
  Socket(const Socket&);
  Socket& operator=(Socket&);

  int recvtimeout(SOCKET s, char *buf, int len, int timeout);

  std::string ReceiveLine(int timeout = 0);
  std::string ReceiveBytes();

  std::string ReceiveResponse(std::string endSeq, int timeout);
  int ReceiveLineToFile(std::string filePath, int timeout, int* pWrittenValues = NULL);

  void   Close();

  // The parameter of SendLine is not a const reference
  // because SendLine modifes the std::string passed.
  void   SendLine (std::string);

  // The parameter of SendBytes is a const reference
  // because SendBytes does not modify the std::string passed
  // (in contrast to SendLine).
  void   SendBytes(const std::string&);
};
```

Start new proxy server

```
void startProxy(int proxyPort) {
   // TERMINATE PREVIOUS THREAD
   if (m_pProxyThread != NULL) {
      m_bStopThread = TRUE;
      m_pSocketServer->Close();
      Sleep(1000);
      delete m_pSocketServer;
   }

   m_pSocketServer = new SocketServer(atoi(proxyPort), 1);

   m_bStopThread = FALSE;
   m_pProxyThread = AfxBeginThread(StartProxy, (void*) m_pSocketServer,
                                   THREAD_PRIORITY_NORMAL);
}
```

Waiting for new client

```
UINT StartProxy(void* a) {
   SocketServer* pSocketServer = (SocketServer*) a;
   cout << "Proxy started";

   while (1) {
      try {
         Socket* s=pSocketServer->Accept();
         cout << "\nNew connection detected and waiting for service";
         // TERMINATE IF REQUIRED
         if (m_bStopThread) break;
         m_pProxyThread = AfxBeginThread(Answer, (void*) s,
                                         THREAD_PRIORITY_NORMAL);
      }
      catch(...) {
         // TERMINATE IF REQUIRED (POSSIBLE REASON FOR EXCEPTION)
         if (m_bStopThread) break;
         else cout << "Exception in pSocketServer->Accept";
      }
   }
   return 0;
}
```

Connect client, send message

```
UINT clientCommunicate(void* a) {
    SocketClient*    pCardSocket = NULL;
    // Connect to socket
    try {
        pCardSocket = new SocketClient("127.0.0.1", 4001);
    }
    catch (...) {
        cout << "Fail to connect to socket";
        pCardSocket = NULL;
    }
    if (pCardSocket != NULL) {
        // Send command to server
        pCardSocket->SendLine(cmd);
        // Wait for response
        string = pCardSocket->ReceiveLine();
        // TODO: Parse response
    }
    if (pCardSocket) delete pCardSocket;
    return 0;
}
```

Obtain message from socket, respond

```
UINT Answer(void* a) {
    Socket* pSocket = (Socket*) a;
    while (1) {
        Sleep(100);
        if (pSocket != NULL) {
            std::string r = pSocket->ReceiveLine();
            if (value != "") {
                // TODO: Parse socket input

                // TODO: Create response
                 std::string  cmd("some response");
                 pSocket->SendLine(cmd);
            }
        }
        else return -1;
    }
     // Delete served socket
    delete pSocket;
    return 0;
}
```

Optimization

Optimization steps

1. Do not optimize prematurely - write clean and correct code first!

2. When code works, find performance bottleneck and remove it

3. Document optimization and test it thoroughly

Performance measurement - manual

- Manual speed measure
  1. Measure time before target operation
  2. Execute operation
  3. Measure time after target operation
  4. Compute and print difference

```
clock_t elapsed = -clock();
aes256_encrypt_ecb(&ctx, buf);
elapsed += clock();
```

Manual measurement – possible problems

- It is time consuming
  - additional code, manually inserted
  - less readable, error prone (use DEBUG macro)
- Precision
  - some function returns time in seconds (e.g., time())
    - short operations will take 0
  - prefer functions returning result in ms or CPU ticks
    - e.g., clock()
    - check documentation for real precision
  - run operation multiple times (e.g., 1000x)
    - and divide the resulting time by that factor

Manual measurement – possible problems

- Additional unintended overhead may screw the results
  - one-time initialization of objects
  - cache usage, disk swap
  - garbage collection (not in C/C++)
- Need to know the probable bottleneck in advance
  - timing code is inserted manually
  - you are selecting what you like to measure
  - time consuming to localize bottleneck

Automatic measurement - profiling

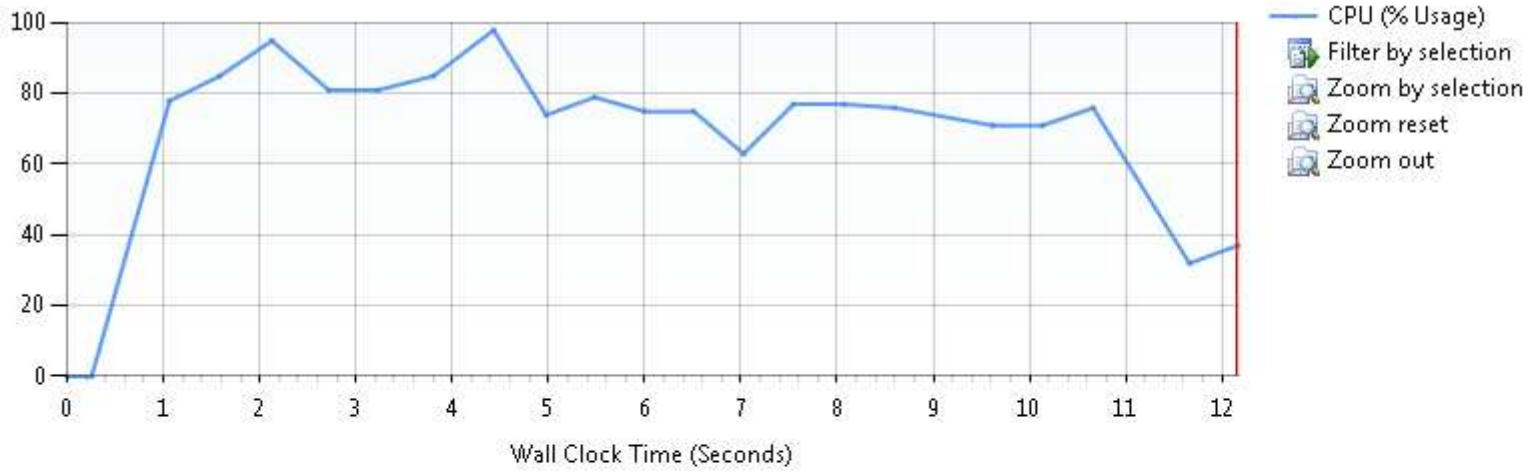
- Automatic tool to measure time and memory used
- “Time” spend in specific function
- How often a function is called
- Call tree
  - what function called actual one
  - based on real code execution (condition jumps)
- Many other statistics, depend on the tools

MS Visual Studio Profiler

- Analyze->Launch Performance Wizard
- Profiling method: CPU Sampling
  - check periodically what is executed on CPU
  - accurate, low overhead
- Profiling method: Instrumentation
  - automatically inserts special accounting code
  - will return exact function call counter
  - (may affect performance timings a bit)
    - additional code present
- May require admin privileges (will ask)

MS VS Profiler – results (Summary)

- Where to start the optimization work?



Hot Path

The most expensive call path based on sample counts

Name	Inclusive %	Exclusive %
aes_subBytes(unsigned char *)	79.20	0.23
rj_sbox(unsigned char)	78.97	1.26
gf_mulinv(unsigned char)	77.59	0.75
gf_log(unsigned char)	**39.43**	**39.43**
gf_alog(unsigned char)	**37.30**	**37.30**

MS VS Profiler – results (Functions)

- Result given in number of sampling hits
  - meaningful result is % of total time spend in function
- Inclusive sampling
  - samples hit in function or its children
  - aggregate over call stack for given function
- Exclusive sampling
  - samples hit in exclusively in given function
  - usually what you want
    - fraction of time spend in function code (not in subfunctions)

MS VS Profiler – results (Functions)

pb173_aes101115.vsp | time.h | aes32.h | pb173_aes.cpp

Current View: Functions

Function Name	Inclusive Samples	Exclusive Samples	Inclusive Samples %	Exclusive Samples %
[pb173_aes.exe]	5	5	0.29	0.29
__RTC_CheckEsp	1	1	0.06	0.06
__tmainCRTStartup	1,740	0	100.00	0.00
_main	1,740	0	100.00	0.00
_mainCRTStartup	1,740	0	100.00	0.00
aes_addRoundKey(unsigned	10	10	0.57	0.57
aes_expandEncKey(unsigned	322	1	18.51	0.06
aes_mixColumns(unsigned	26	10	1.49	0.57
aes_shiftRows(unsigned cha	3	3	0.17	0.17
aes_subBytes(unsigned char	1,378	4	79.20	0.23
aes256_encrypt_ecb(struct a	1,740	1	100.00	0.06
gf_alog(unsigned char)	806	806	46.32	46.32
gf_log(unsigned char)	846	846	48.62	48.62
gf_mulinv(unsigned char)	1,668	14	95.86	0.80
rj_sbox(unsigned char)	1,694	24	97.36	1.38
rj_xtime(unsigned char)	15	15	0.86	0.86
testProfile(void)	1,740	0	100.00	0.00

Doubleclick to move into Function Details view

46 % of time spend in gf_alog function

Function Code View

d:\documents\develop\pb173\pb173_aes\pb173_aes\aes32.cpp

```
                /* ------------------------------------------------------------------------ */
                uint8_t gf_alog(uint8_t x) // calculate anti-logarithm gen 3
  1.4 %         {
< 0.1 %             uint8_t atb = 1, z;

 42.0 %             while (x--) {z = atb; atb <<= 1; if (z & 0x80) atb^= 0x1b; atb ^= z;}

< 0.1 %             return atb;
  0.3 %         } /* gf_alog */
```

- How to speed up `gf_alog` function?

aestab.c

```
AES_RETURN aes_init(void)
{   uint_32t  i, w;

#if defined(FF_TABLES)

    uint_8t  pow[512], log[256];

    if(init)
        return EXIT_SUCCESS;
    /*  log and power tables for GF(2^8) finite field with
        WPOLY as modular polynomial - the simplest primitive
        root is 0x03, used here to generate the tables
    */

    i = 0; w = 1;
    do
    {
        pow[i] = (uint_8t)w;
        pow[i + 255] = (uint_8t)w;
        log[w] = (uint_8t)i++;
        w ^=  (w << 1) ^ (w & 0x80 ? WPOLY : 0);
    }
    while (w != 1);
// ...
```

MS VS Profiler – save results

- You can save results and compare later
- To check the real impact of your optimization
- Don’t forget to eventually stop the optimization ☺

Memory consumption profiling

- MSVS Profiler does not provide for native apps
  - unfortunately, available only for managed code
- Visual Studio is detecting memory leaks!
  - _CrtDumpMemoryLeaks()
  - run program in debug mode (possibly without any breakpoint)
  - let it finish and watch Output pane
- Valgrind *-v --leak-check=full*
- Write your own new and delete
  - and log the allocated/freed memory

Practical assignment - implementation

- Implement API functions relevant for connection and data exchange between two online clients
  - try to connect to online client from list
  - perform authentication between client
    - (no secure channel necessary at the moment)
  - exchange larger block of data (at least 1MB)
  - disconnect from client

Practical assignment - analysis

- Produce detailed speed estimation for:
  - connection to the server
  - authentication of the client to server
  - obtaining of user list
  - data exchange between two online clients
- Which function(s) is consuming most of the CPU?
  - provide a list with %