

Solid C++ code by example

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Sometimes you see code that is perfectly OK according to the definition of the language, but which is flawed because it breaks too many established idioms and conventions. On the other hand, a solid piece of code is something that looks like it is written by an experienced person who cares about professionalism in programming.

This will be an interactive discussion about good vs bad C++ code. We will discuss simple C++ idioms and coding conventions, but we will also touch upon best practices when working with C++ in large codebases with lots of developers with mixed skills.

A 90 minute presentation at the ACCU conference
Oxford, April 13-16 2011

Disclaimer I: this is basically a rerun of the talk I did at ACCU 2010, 80-90% of the material is the same. However, the audience is not the same, so discussions might provide 80-90% new insight...

Disclaimer II: there are some issues that we do not address properly here (at least 3). They are left as an exercise for the reader. Email me if you find them, or if you want to know more!

~/myprog/foo.hpp

```
namespace bar {  
    class Foo {  
        int _value;  
        int my_magic(int a, int b);  
public:  
    Foo(int seed);  
    int calc(int number = 7);  
    int getValue() {  
        return _value;  
    }  
    void print(char* prefix);  
};  
}
```

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namespace bar {  
    class Foo {  
        int _value;  
        int my_magic(int a, int b);  
public:  
    Foo(int seed);  
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    int getValue() {  
        return _value;  
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    void print(char* prefix);  
};  
}
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namespace bar {  
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    Foo(int seed);  
    int calc(int number = 7);  
    int getValue() {  
      return _value;  
    }  
    void print(char* prefix);  
  };  
}
```



Solid code?

~/myprog/foo.hpp

```
namespace bar {  
    class Foo {  
        int _value;  
        int my_magic(int a, int b);  
public:  
        Foo(int seed);  
        int calc(int number = 7);  
        int getValue() {  
            return _value;  
        }  
        void print(char* prefix);  
};  
}
```

~/myprog/foo.hpp

```
namespace bar {  
  class Foo {  
    int _value;  
    int my_magic(int a, int b);  
  public:  
    Foo(int seed);  
    int calc(int number = 7);  
    int getValue() {  
      return _value;  
    }  
    void print(char* prefix);  
  };  
}
```



Bad code?



~/myprog/foo.hpp

```
namespace bar {
  class Foo {
    int _value;
    int my_magic(int a, int b);
public:
  Foo(int seed);
  int calc(int number = 7);
  int getValue() {
    return _value;
  }
  void print(char* prefix);
};
}
```


~/myprog/foo.hpp

```
namespace bar {  
  class Foo {  
    int _value;  
    int my_magic(int a, int b);  
  public:  
    Foo(int seed);  
    int calc(int number = 7);  
    int getValue() {  
      return _value;  
    }  
    void print(char* prefix);  
  };  
}
```

The image shows a C++ code snippet with several red arrows pointing to specific parts of the code. The code is as follows:

```
namespace bar {  
  class Foo {  
    int _value;  
    int my_magic(int a, int b);  
  public:  
    Foo(int seed);  
    int calc(int number = 7);  
    int getValue() {  
      return _value;  
    }  
    void print(char* prefix);  
  };  
}
```


The red arrows point to the following elements:
1. The opening curly brace of the namespace 'bar'.
2. The namespace name 'bar'.
3. The class name 'Foo'.
4. The member variable '_value'.
5. The member function 'my_magic'.
6. The 'public:' access specifier.
7. The constructor 'Foo(int seed)'.
8. The member function 'calc'.
9. The member function 'getValue'.
10. The return statement 'return _value;'.
11. The member function 'print'.
12. The closing curly brace of the class 'Foo'.
13. The closing curly brace of the namespace 'bar'.

PAL - a Primitive Authentication Library in C++ for educational purposes

<http://github.com/olvemaudal/pal>

(from the README file)

Here is the main "use story":

As a client, when prompted for ntlm authentication by the server, I want a tool/library that can help me to create the initial ntlm **request** (type 1 message) that I can send to the server to receive a **challenge** (type 2 message) that needs to be solved by applying my username and password to create an ntlm **response** that I can send to the server. (pew...)

Here are some (imaginary) additional requirements:

- target typically an embedded system
- it should be possible and convenient to create a <100kb client using the PAL library
- must use C++ (due to PHB decision)
- due to compiler support, tr1 and boost can not be used
- initially the library will only be used to communicate HTTP with a Windows 2003 Server SP2, currently no need to support other servers

The NTLM Protocol (simplified)

Client

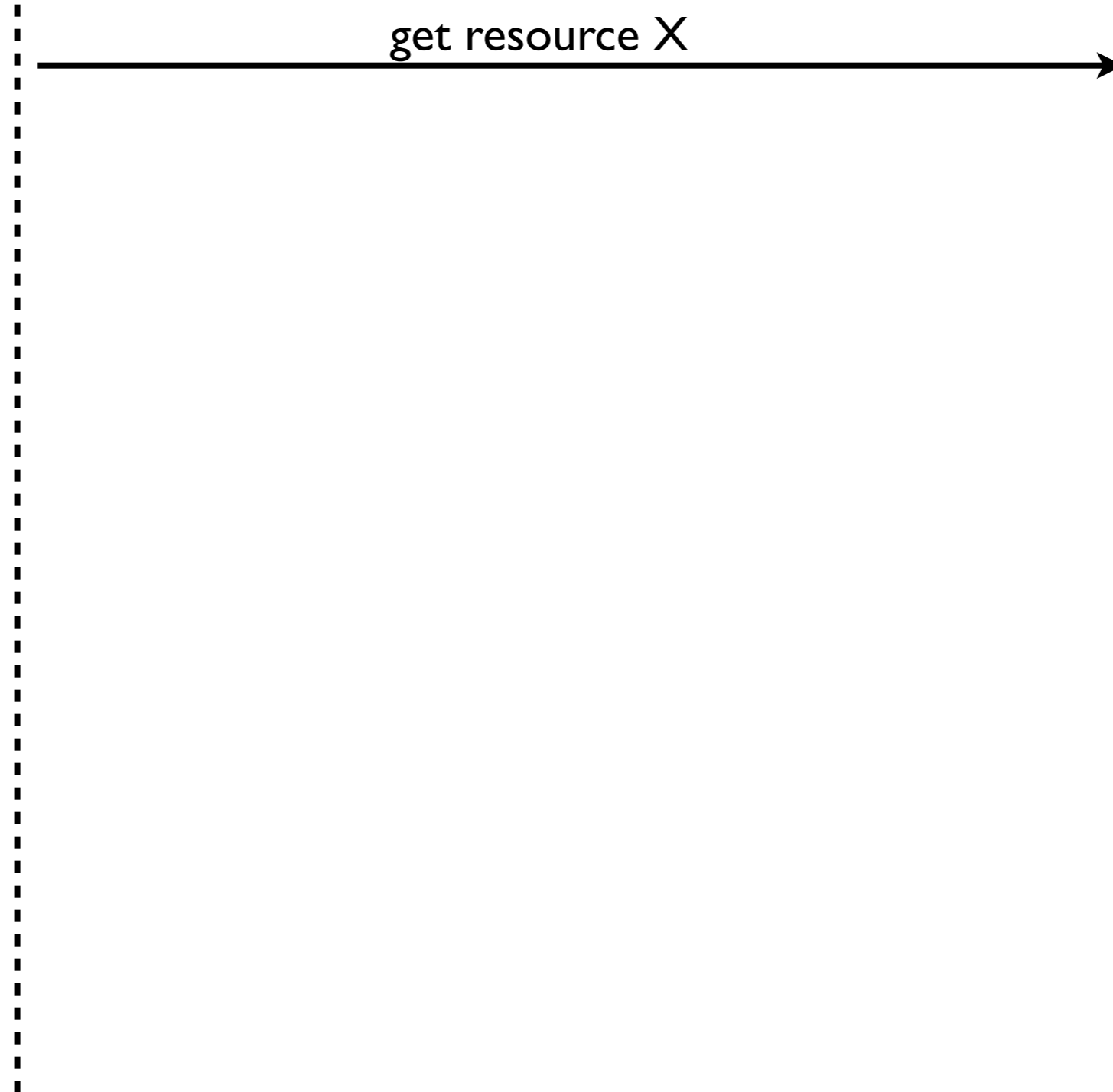
Server



The NTLM Protocol (simplified)

Client

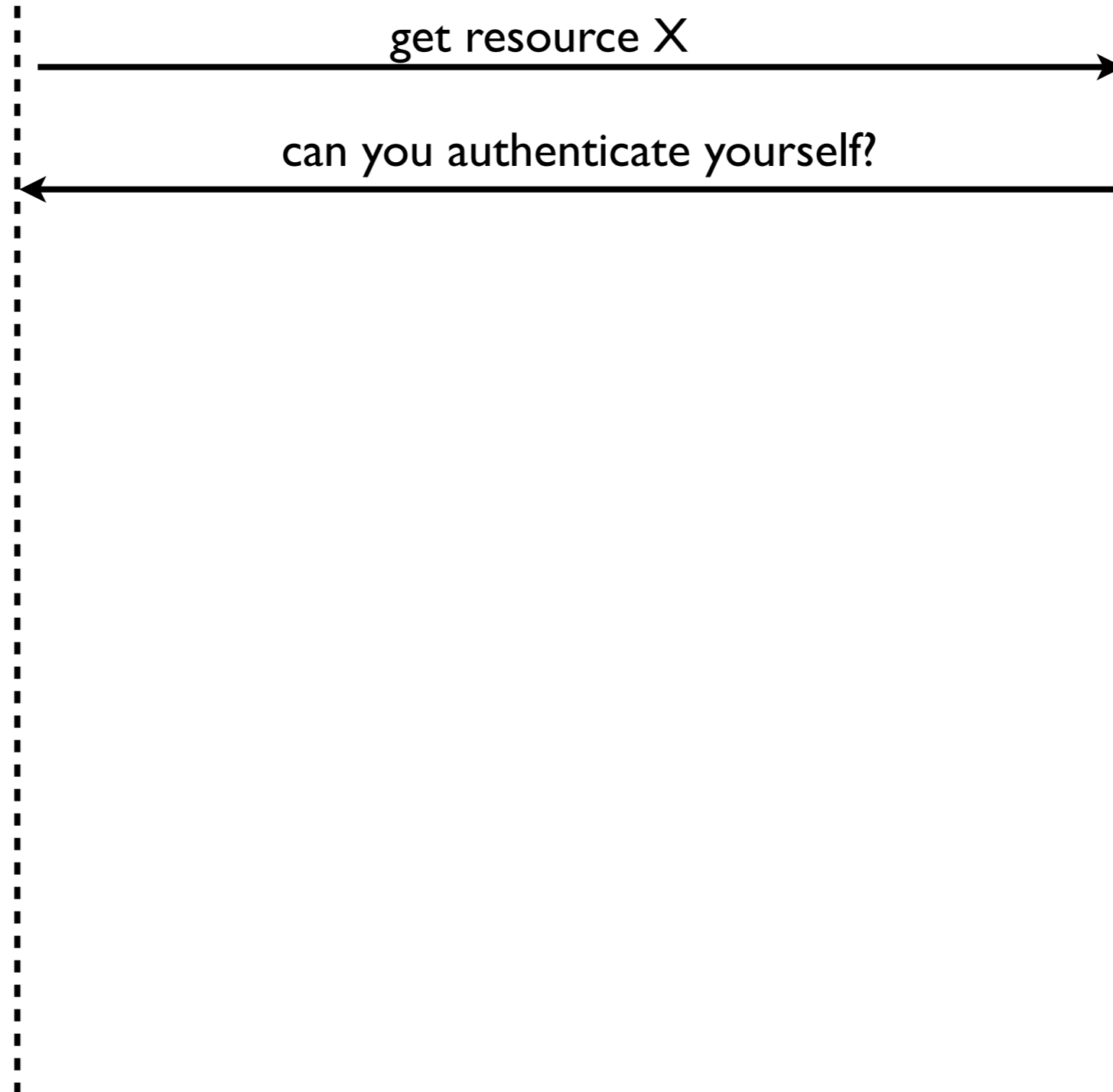
Server



The NTLM Protocol (simplified)

Client

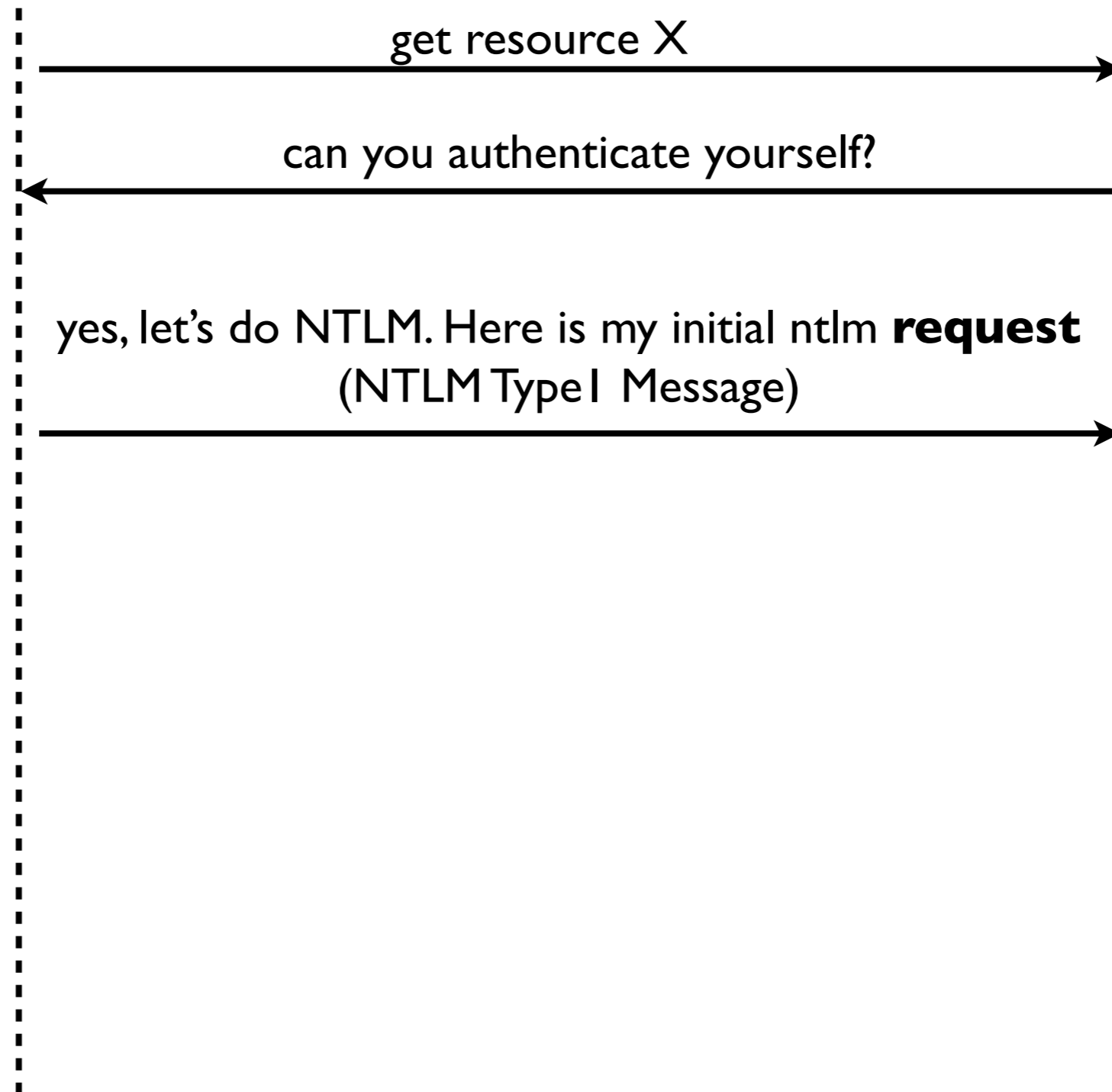
Server



The NTLM Protocol (simplified)

Client

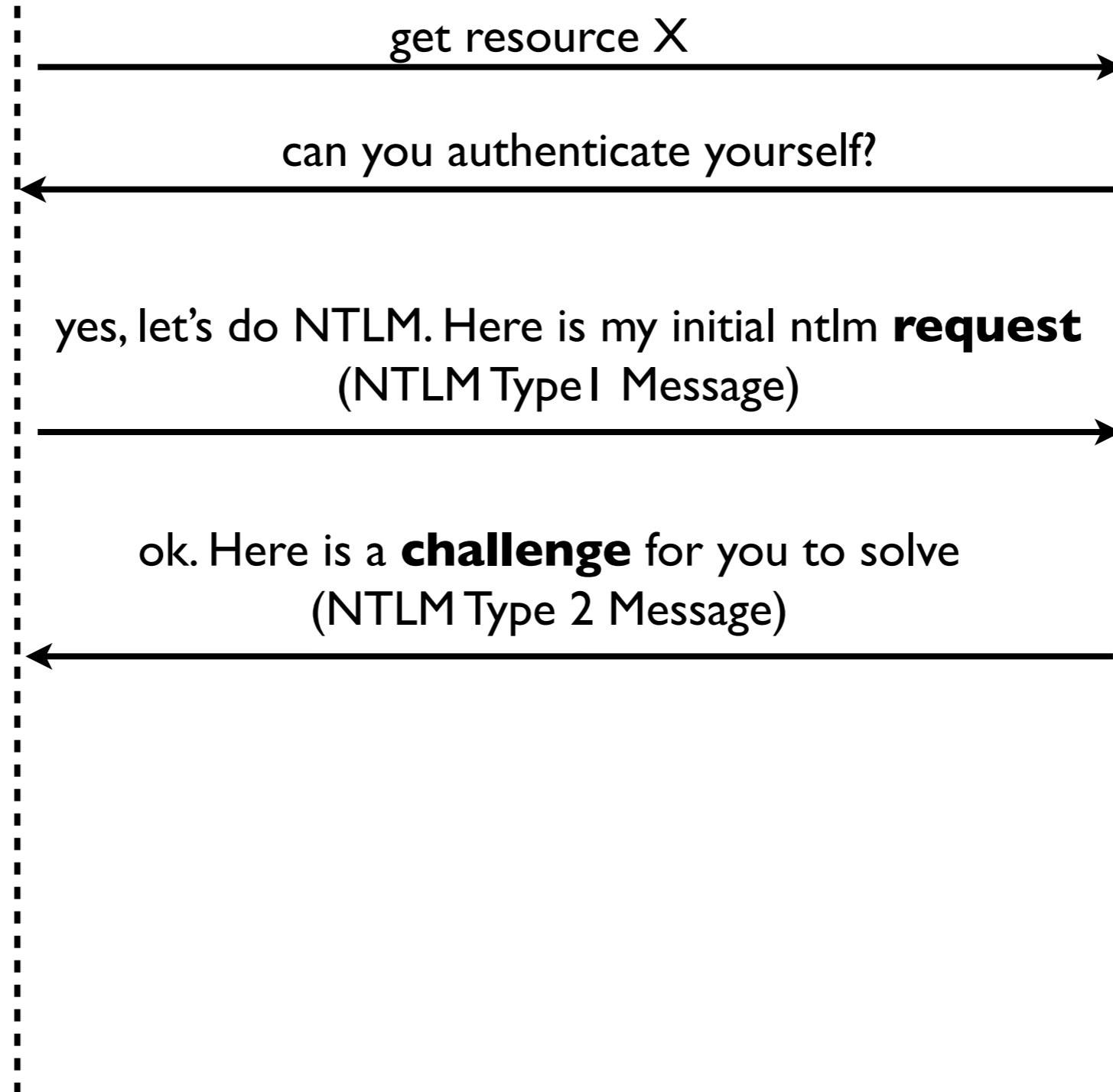
Server



The NTLM Protocol (simplified)

Client

Server



The NTLM Protocol (simplified)

Client

Server

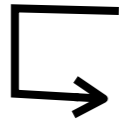
get resource X

can you authenticate yourself?

yes, let's do NTLM. Here is my initial ntlm **request**
(NTLM Type 1 Message)

ok. Here is a **challenge** for you to solve
(NTLM Type 2 Message)

use password to
"solve" the **challenge**
and create an lm/nt
response hash



The NTLM Protocol (simplified)

Client

Server

get resource X

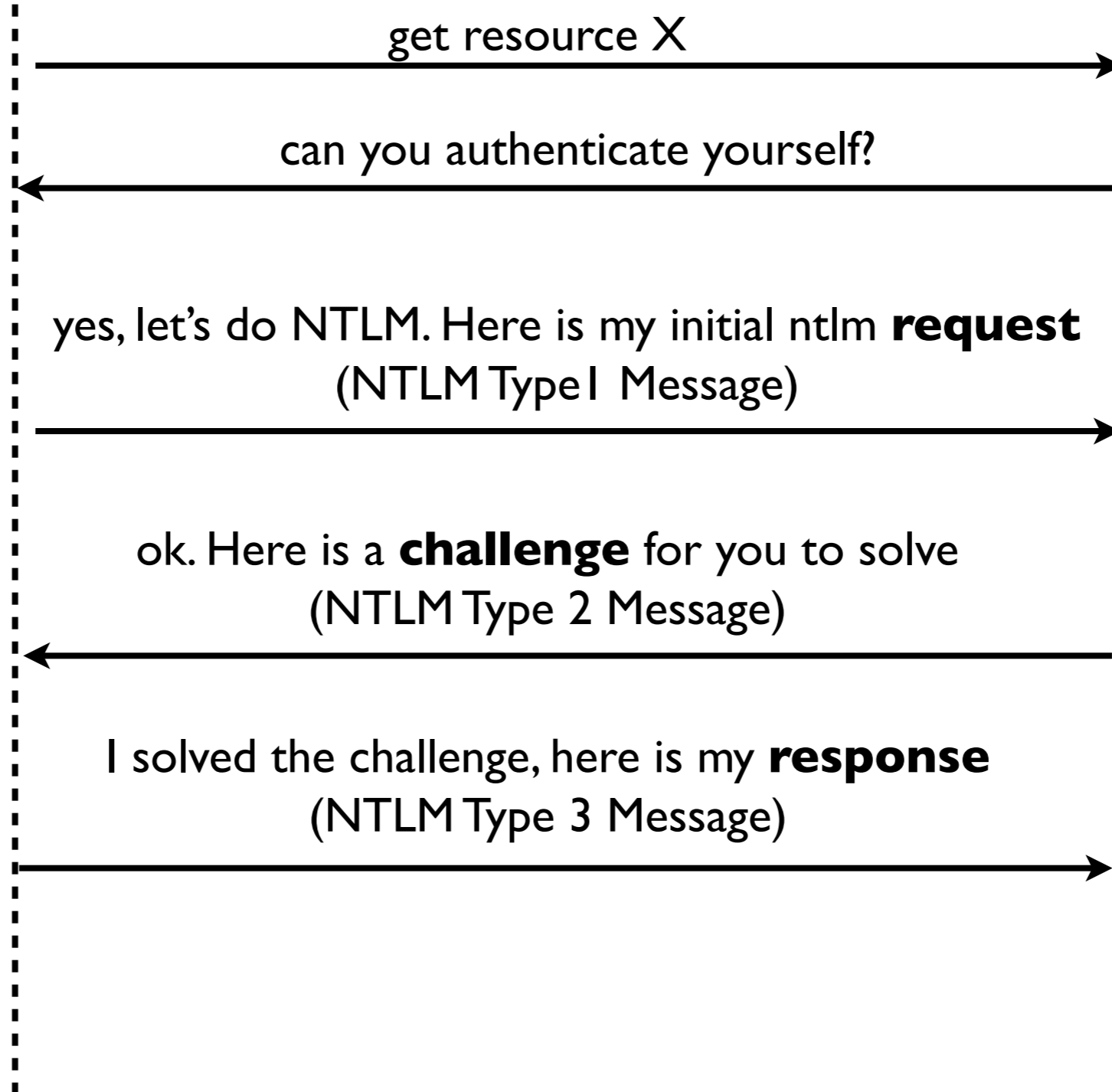
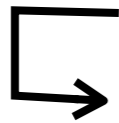
can you authenticate yourself?

yes, let's do NTLM. Here is my initial ntlm **request**
(NTLM Type 1 Message)

ok. Here is a **challenge** for you to solve
(NTLM Type 2 Message)

I solved the challenge, here is my **response**
(NTLM Type 3 Message)

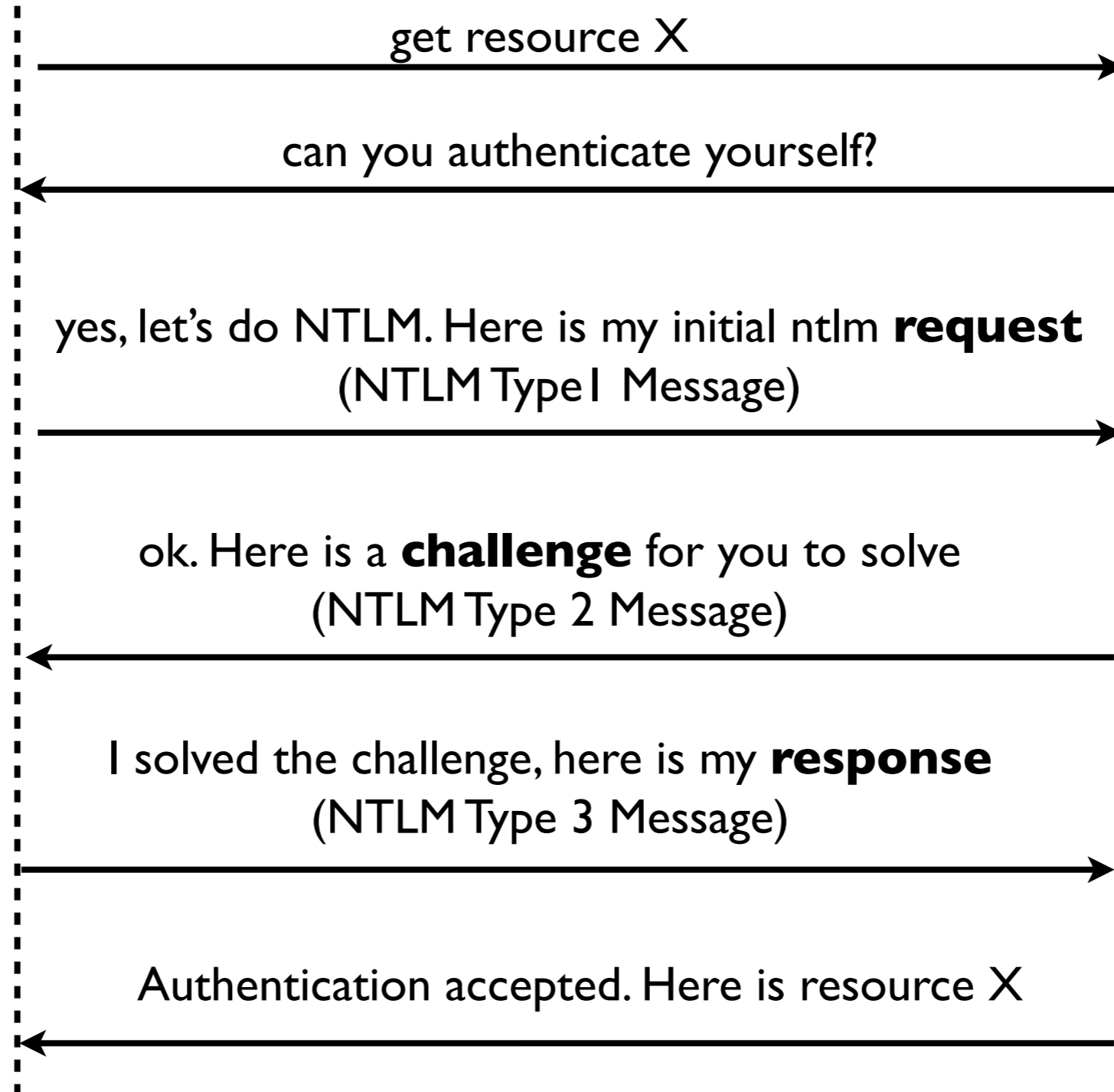
use password to
"solve" the **challenge**
and create an lm/nt
response hash




The NTLM Protocol (simplified)

Client

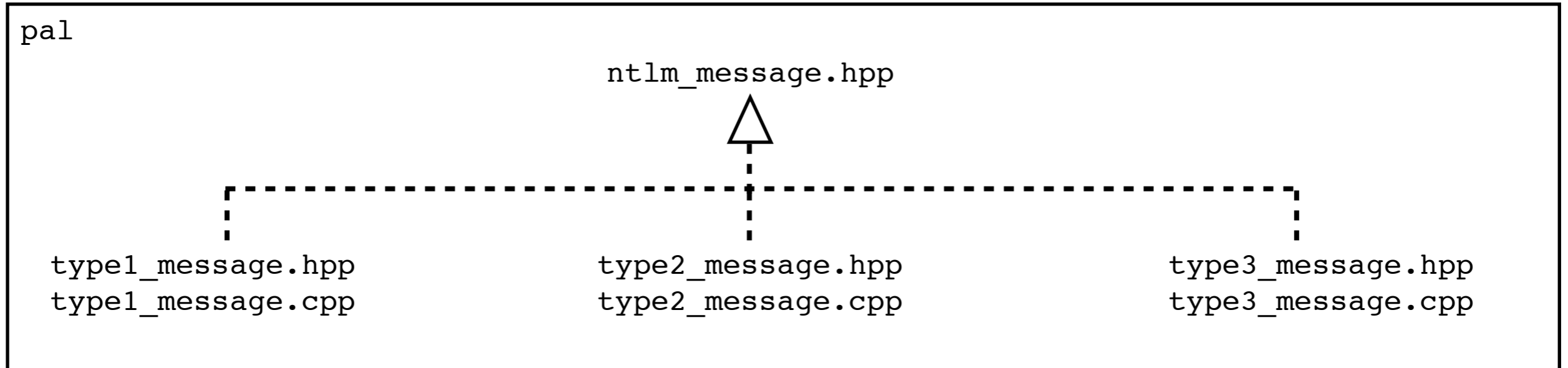
Server



use password to
“solve” the **challenge**
and create an lm/nt
response hash



Code under discussion



Note: *the code under discussion compiles just fine and does exactly what it is supposed to do... but can you suggest improvements?*

Study code....

ntlm_message.hpp

```
#include <vector>
```

```
namespace pal {
```

```
    class ntlm_message {
```

```
    public:
```

```
        virtual std::vector<uint8_t> as_bytes() const = 0;
```

```
};
```

```
}
```



Find 3 issues

```
#include <vector>
```

```
namespace pal {
```

```
    class ntlm_message {
```

```
    public:
```

```
        virtual std::vector<uint8_t> as_bytes() const = 0;
```

```
};
```

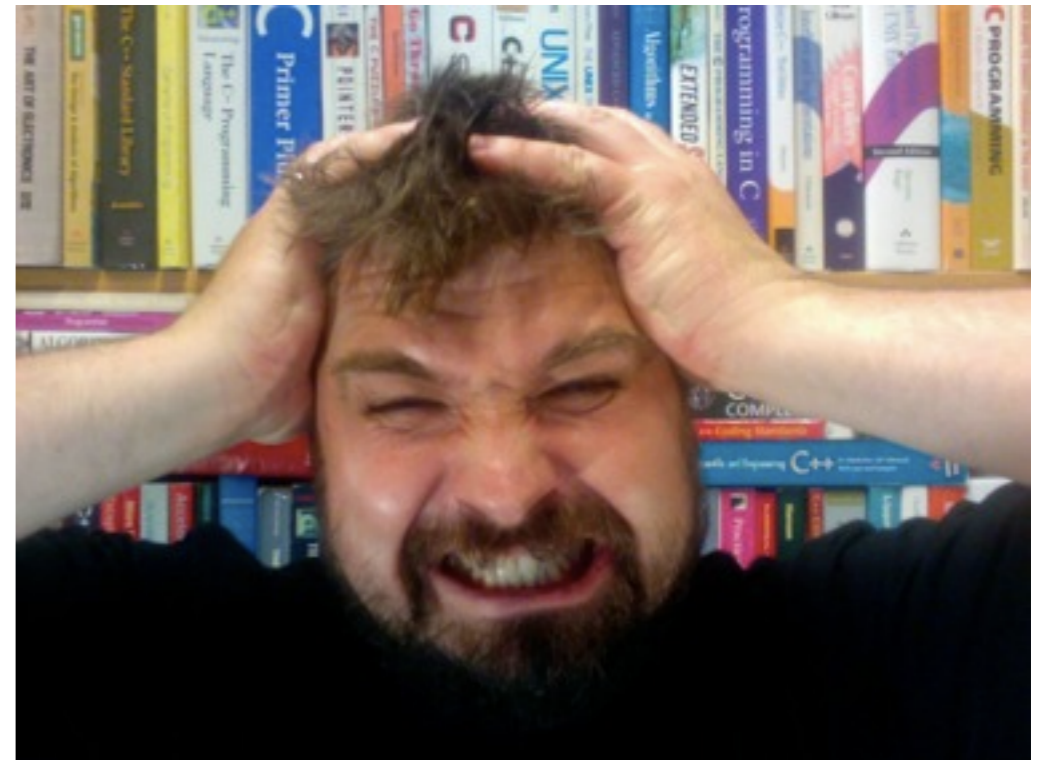
```
}
```

```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```



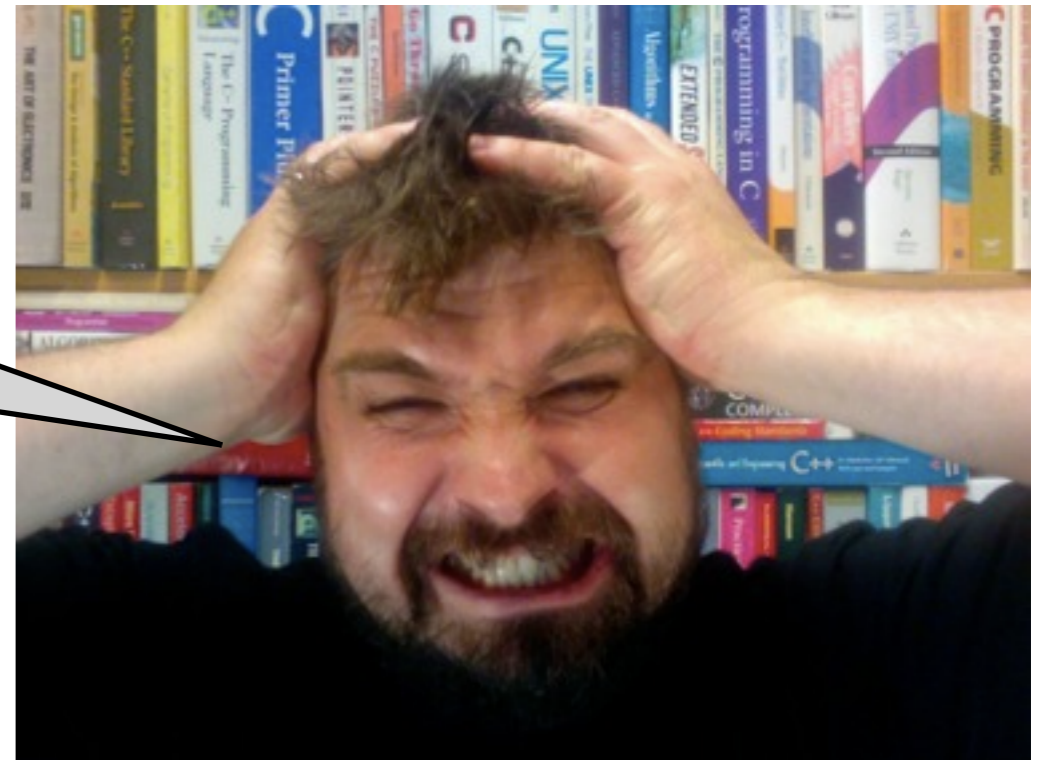

```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```

**WTF? This class must have a
virtual destructor!**



```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```



```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```

missing header guard



```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```



```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```



should include `<stdint.h>`



```
#include <vector>
```

```
namespace pal {
```

```
    class ntlm_message {
```

```
    public:
```

```
        virtual std::vector<uint8_t> as_bytes() const = 0;
```

```
};
```

```
}
```

```
#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
#define PAL_NTLM_MESSAGE_HPP_INCLUDED

#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}

#endif
```

```
#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
#define PAL_NTLM_MESSAGE_HPP_INCLUDED

#include <vector>

namespace pal {

    class ntlm_message {
    public:

        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}

#endif
```



```
#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
#define PAL_NTLM_MESSAGE_HPP_INCLUDED

#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual ~ntlm_message() {}
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}

#endif
```

```
#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
#define PAL_NTLM_MESSAGE_HPP_INCLUDED

#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual ~ntlm_message() {}
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}

#endif
```

```
#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
#define PAL_NTLM_MESSAGE_HPP_INCLUDED

#include <stdint.h>
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual ~ntlm_message() {}
        virtual std::vector<uint8_t> as_bytes() const = 0;
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}

#endif
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#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
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namespace pal {

    class ntlm_message {
    public:
        virtual ~ntlm_message() {}
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}

#endif
```



```
#ifndef PAL_NTLM_MESSAGE_HPP_INCLUDED
#define PAL_NTLM_MESSAGE_HPP_INCLUDED

#include <stdint.h>
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual ~ntlm_message() {}
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}

#endif
```

This is Solid C++!



type1_message.hpp

```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector>

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector>

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```



Find 3 issues


```

#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector> ←

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif

```



```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector>

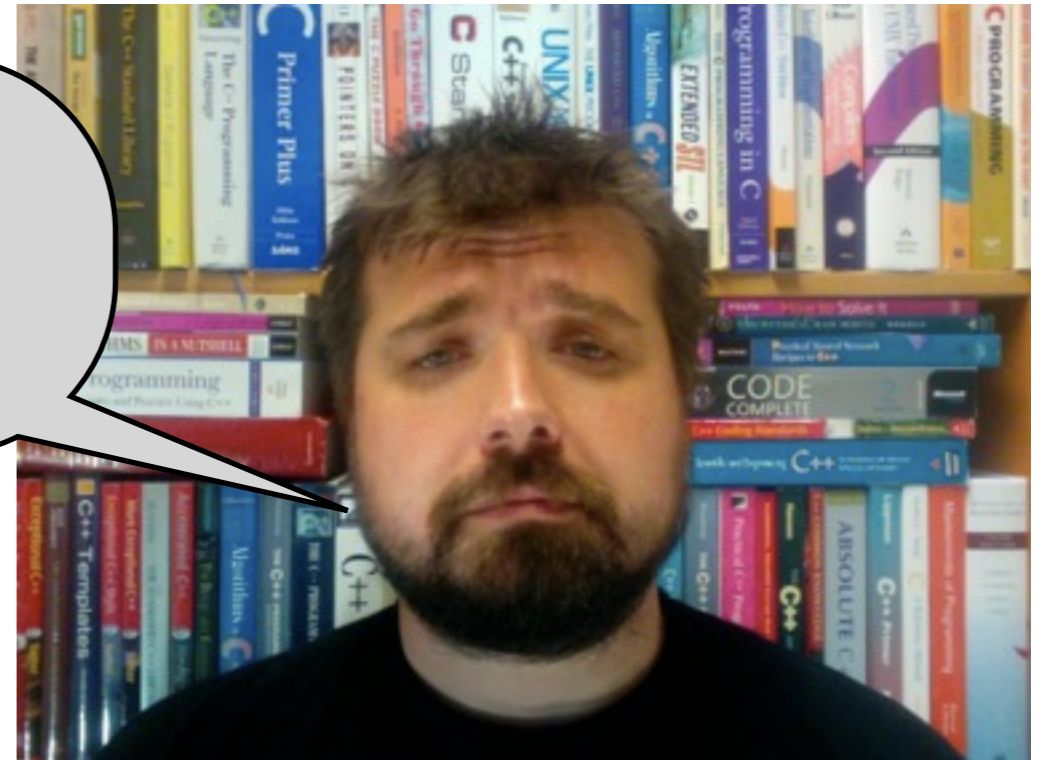
namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

**no need to include
<vector> again**



```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector>

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
public:
        type1_message(uint32_t ssp_flags);
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}

#endif
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namespace pal {

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    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

**focus on usage;
public stuff first, then
private stuff**



```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
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#include "ntlm_message.hpp"

#include <vector>

namespace pal {

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        uint32_t ssp_flags_;
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#endif
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#include <vector>

namespace pal {

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        uint32_t ssp_flags_;
    public:
        → type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

**single argument
constructors should
nearly always have the
explicit specifier**



```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector>

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
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}

#endif
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#include "ntlm_message.hpp"

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
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}

#endif
```



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#include "ntlm_message.hpp"

namespace pal {

    class type1_message : public ntlm_message {

        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type1_message : public ntlm_message {
    private:
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

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#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
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namespace pal {

    class type1_message : public ntlm_message {
    private:
        uint32_t ssp_flags_;
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        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
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}

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    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
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    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
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    };

}

#endif
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#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type1_message : public ntlm_message {
    public:
        explicit type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    private:
        uint32_t ssp_flags_;
    };

}

#endif
```

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        uint32_t ssp_flags_;
    };

}

#endif
```



```
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#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type1_message : public ntlm_message {
    public:
        explicit type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    private:
        uint32_t ssp_flags_;
    };

}

#endif
```

Looks good!



`type1_message.cpp`

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

Find at least 3
issues here

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP"  
 * 8 NTLM Message Type {0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F, 0x10, 0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17, 0x18, 0x19, 0x1A, 0x1B, 0x1C, 0x1D, 0x1E, 0x1F, 0x20, 0x21, 0x22, 0x23, 0x24, 0x25, 0x26, 0x27, 0x28, 0x29, 0x2A, 0x2B, 0x2C, 0x2D, 0x2E, 0x2F, 0x30, 0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39, 0x3A, 0x3B, 0x3C, 0x3D, 0x3E, 0x3F, 0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C, 0x4D, 0x4E, 0x4F, 0x50, 0x51, 0x52, 0x53, 0x54, 0x55, 0x56, 0x57, 0x58, 0x59, 0x5A, 0x5B, 0x5C, 0x5D, 0x5E, 0x5F, 0x60, 0x61, 0x62, 0x63, 0x64, 0x65, 0x66, 0x67, 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F, 0x70, 0x71, 0x72, 0x73, 0x74, 0x75, 0x76, 0x77, 0x78, 0x79, 0x7A, 0x7B, 0x7C, 0x7D, 0x7E, 0x7F, 0x80, 0x81, 0x82, 0x83, 0x84, 0x85, 0x86, 0x87, 0x88, 0x89, 0x8A, 0x8B, 0x8C, 0x8D, 0x8E, 0x8F, 0x90, 0x91, 0x92, 0x93, 0x94, 0x95, 0x96, 0x97, 0x98, 0x99, 0x9A, 0x9B, 0x9C, 0x9D, 0x9E, 0x9F, 0xA0, 0xA1, 0xA2, 0xA3, 0xA4, 0xA5, 0xA6, 0xA7, 0xA8, 0xA9, 0xAA, 0xAB, 0xAC, 0xAD, 0xAE, 0xAF, 0xB0, 0xB1, 0xB2, 0xB3, 0xB4, 0xB5, 0xB6, 0xB7, 0xB8, 0xB9, 0xBA, 0xBB, 0xBC, 0xBD, 0xBE, 0xBF, 0xC0, 0xC1, 0xC2, 0xC3, 0xC4, 0xC5, 0xC6, 0xC7, 0xC8, 0xC9, 0xCA, 0xCB, 0xCC, 0xCD, 0xCE, 0xCF, 0xD0, 0xD1, 0xD2, 0xD3, 0xD4, 0xD5, 0xD6, 0xD7, 0xD8, 0xD9, 0xDA, 0xDB, 0xDC, 0xDD, 0xDE, 0xDF, 0xE0, 0xE1, 0xE2, 0xE3, 0xE4, 0xE5, 0xE6, 0xE7, 0xE8, 0xE9, 0xEA, 0xEB, 0xEC, 0xED, 0xEE, 0xEF, 0xF0, 0xF1, 0xF2, 0xF3, 0xF4, 0xF5, 0xF6, 0xF7, 0xF8, 0xF9, 0xFA, 0xFB, 0xFC, 0xFD, 0xFE, 0xFF}  
 * 12 Flags uint32 as  
 * (16) Supplied Domain (optional) (security barrier)  
 * (24) Supplied Workstation (optional) (security barrier)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```



```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

**focus on readability;
importing a namespace might
save some keystrokes, but often
it does not increase readability**

```
* (24) Supplied Workstation (optional)  
* (32) (start of datablock) if required  
*/
```

```
using namespace std; ←
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

m.html

```
NTLMSSP  
0x01, 0x00  
uint32 as  
(security  
(security barrier)
```



```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP"  
 * 8 NTLM Message Type {0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F, 0x10, 0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17, 0x18, 0x19, 0x1A, 0x1B, 0x1C, 0x1D, 0x1E, 0x1F, 0x20, 0x21, 0x22, 0x23, 0x24, 0x25, 0x26, 0x27, 0x28, 0x29, 0x2A, 0x2B, 0x2C, 0x2D, 0x2E, 0x2F, 0x30, 0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39, 0x3A, 0x3B, 0x3C, 0x3D, 0x3E, 0x3F, 0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C, 0x4D, 0x4E, 0x4F, 0x50, 0x51, 0x52, 0x53, 0x54, 0x55, 0x56, 0x57, 0x58, 0x59, 0x5A, 0x5B, 0x5C, 0x5D, 0x5E, 0x5F, 0x60, 0x61, 0x62, 0x63, 0x64, 0x65, 0x66, 0x67, 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F, 0x70, 0x71, 0x72, 0x73, 0x74, 0x75, 0x76, 0x77, 0x78, 0x79, 0x7A, 0x7B, 0x7C, 0x7D, 0x7E, 0x7F, 0x80, 0x81, 0x82, 0x83, 0x84, 0x85, 0x86, 0x87, 0x88, 0x89, 0x8A, 0x8B, 0x8C, 0x8D, 0x8E, 0x8F, 0x90, 0x91, 0x92, 0x93, 0x94, 0x95, 0x96, 0x97, 0x98, 0x99, 0x9A, 0x9B, 0x9C, 0x9D, 0x9E, 0x9F, 0xA0, 0xA1, 0xA2, 0xA3, 0xA4, 0xA5, 0xA6, 0xA7, 0xA8, 0xA9, 0xAA, 0xAB, 0xAC, 0xAD, 0xAE, 0xAF, 0xB0, 0xB1, 0xB2, 0xB3, 0xB4, 0xB5, 0xB6, 0xB7, 0xB8, 0xB9, 0xBA, 0xBB, 0xBC, 0xBD, 0xBE, 0xBF, 0xC0, 0xC1, 0xC2, 0xC3, 0xC4, 0xC5, 0xC6, 0xC7, 0xC8, 0xC9, 0xCA, 0xCB, 0xCC, 0xCD, 0xCE, 0xCF, 0xD0, 0xD1, 0xD2, 0xD3, 0xD4, 0xD5, 0xD6, 0xD7, 0xD8, 0xD9, 0xDA, 0xDB, 0xDC, 0xDD, 0xDE, 0xDF, 0xE0, 0xE1, 0xE2, 0xE3, 0xE4, 0xE5, 0xE6, 0xE7, 0xE8, 0xE9, 0xEA, 0xEB, 0xEC, 0xED, 0xEE, 0xEF, 0xF0, 0xF1, 0xF2, 0xF3, 0xF4, 0xF5, 0xF6, 0xF7, 0xF8, 0xF9, 0xFA, 0xFB, 0xFC, 0xFD, 0xFE, 0xFF}  
 * 12 Flags uint32 as security barrier  
 * (16) Supplied Domain (optional) (security barrier)  
 * (24) Supplied Workstation (optional) (security barrier)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```



```
#include "type1_message.hpp"
```

```
#include "type1_message.hpp"
```

use the initializer list

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html#type1message  
 *  
 * Type 1 Message  
 *  
 * 0  NTLMSSP Signature           "NTLMSSP"  
 * 8  NTLM Message Type          {0x01,0x00}  
 * 12 Flags                       uint32 as  
 * (16) Supplied Domain (optional) (security barrier)  
 * (24) Supplied Workstation (optional) (security barrier)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```



```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP"  
 * 8 NTLM Message Type {0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F, 0x10, 0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17, 0x18, 0x19, 0x1A, 0x1B, 0x1C, 0x1D, 0x1E, 0x1F, 0x20, 0x21, 0x22, 0x23, 0x24, 0x25, 0x26, 0x27, 0x28, 0x29, 0x2A, 0x2B, 0x2C, 0x2D, 0x2E, 0x2F, 0x30, 0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39, 0x3A, 0x3B, 0x3C, 0x3D, 0x3E, 0x3F, 0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C, 0x4D, 0x4E, 0x4F, 0x50, 0x51, 0x52, 0x53, 0x54, 0x55, 0x56, 0x57, 0x58, 0x59, 0x5A, 0x5B, 0x5C, 0x5D, 0x5E, 0x5F, 0x60, 0x61, 0x62, 0x63, 0x64, 0x65, 0x66, 0x67, 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F, 0x70, 0x71, 0x72, 0x73, 0x74, 0x75, 0x76, 0x77, 0x78, 0x79, 0x7A, 0x7B, 0x7C, 0x7D, 0x7E, 0x7F, 0x80, 0x81, 0x82, 0x83, 0x84, 0x85, 0x86, 0x87, 0x88, 0x89, 0x8A, 0x8B, 0x8C, 0x8D, 0x8E, 0x8F, 0x90, 0x91, 0x92, 0x93, 0x94, 0x95, 0x96, 0x97, 0x98, 0x99, 0x9A, 0x9B, 0x9C, 0x9D, 0x9E, 0x9F, 0xA0, 0xA1, 0xA2, 0xA3, 0xA4, 0xA5, 0xA6, 0xA7, 0xA8, 0xA9, 0xAA, 0xAB, 0xAC, 0xAD, 0xAE, 0xAF, 0xB0, 0xB1, 0xB2, 0xB3, 0xB4, 0xB5, 0xB6, 0xB7, 0xB8, 0xB9, 0xBA, 0xBB, 0xBC, 0xBD, 0xBE, 0xBF, 0xC0, 0xC1, 0xC2, 0xC3, 0xC4, 0xC5, 0xC6, 0xC7, 0xC8, 0xC9, 0xCA, 0xCB, 0xCC, 0xCD, 0xCE, 0xCF, 0xD0, 0xD1, 0xD2, 0xD3, 0xD4, 0xD5, 0xD6, 0xD7, 0xD8, 0xD9, 0xDA, 0xDB, 0xDC, 0xDD, 0xDE, 0xDF, 0xE0, 0xE1, 0xE2, 0xE3, 0xE4, 0xE5, 0xE6, 0xE7, 0xE8, 0xE9, 0xEA, 0xEB, 0xEC, 0xED, 0xEE, 0xEF, 0xF0, 0xF1, 0xF2, 0xF3, 0xF4, 0xF5, 0xF6, 0xF7, 0xF8, 0xF9, 0xFA, 0xFB, 0xFC, 0xFD, 0xFE, 0xFF}  
 * 12 Flags uint32 as security barrier  
 * (16) Supplied Domain (optional) (security barrier)  
 * (24) Supplied Workstation (optional) (security barrier)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```




```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://...  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP"  
 * 8 NTLM Message Type {0x01, 0x00, 0x00, 0x00}  
 * 12 Flags uint32 as  
 * (16) Supplied Domain (optional) (security barrier)  
 * (24) Supplied Workstation (optional) (security barrier)  
 * (32) (start of datablock) if required  
 */
```

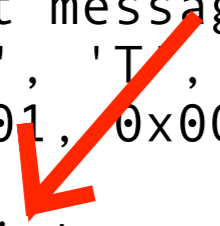
use std::size_t when appropriate



```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```



```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std; ←
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```



```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
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```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)
```

```
{  
    ssp_flags_ = ssp_flags;  
}
```

```
std::vector<uint8_t> pal::type1_message::as_bytes() const
```

```
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
std::vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
std::vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return std::vector<uint8_t>(message, message + sizeof message);  
}
```



```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
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 * (16) Supplied Domain (optional) (security buffer)  
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    };  
    const int ssp_flags_offset = 12;  
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    return std::vector<uint8_t>(message, message + sizeof message);  
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#include "type1_message.hpp"
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 * See http://davenport.sourceforge.net/ntlm.html  
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 * Type 1 Message  
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 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
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    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return std::vector<uint8_t>(message, message + sizeof message);  
}
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#include "type1_message.hpp"
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```
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```
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 * See http://davenport.sourceforge.net/ntlm.html  
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```
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 * See http://davenport.sourceforge.net/ntlm.html  
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 * 0 NTLMSSP Signature "NTLMSSP\0"  
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    };  
    const std::size_t ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return std::vector<uint8_t>(message, message + sizeof message);  
}
```

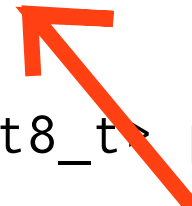
```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
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        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
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    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
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#include "type1_message.hpp"
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    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const std::size_t ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return std::vector<uint8_t>(message, message + sizeof message);  
}
```

```
#include "type1_message.hpp"
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```
#include "tools.hpp"
```

```
/*  
 * See http://davenport  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP"  
 * 8 NTLM Message Type {0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07, 0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F, 0x10, 0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17, 0x18, 0x19, 0x1A, 0x1B, 0x1C, 0x1D, 0x1E, 0x1F, 0x20, 0x21, 0x22, 0x23, 0x24, 0x25, 0x26, 0x27, 0x28, 0x29, 0x2A, 0x2B, 0x2C, 0x2D, 0x2E, 0x2F, 0x30, 0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39, 0x3A, 0x3B, 0x3C, 0x3D, 0x3E, 0x3F, 0x40, 0x41, 0x42, 0x43, 0x44, 0x45, 0x46, 0x47, 0x48, 0x49, 0x4A, 0x4B, 0x4C, 0x4D, 0x4E, 0x4F, 0x50, 0x51, 0x52, 0x53, 0x54, 0x55, 0x56, 0x57, 0x58, 0x59, 0x5A, 0x5B, 0x5C, 0x5D, 0x5E, 0x5F, 0x60, 0x61, 0x62, 0x63, 0x64, 0x65, 0x66, 0x67, 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F, 0x70, 0x71, 0x72, 0x73, 0x74, 0x75, 0x76, 0x77, 0x78, 0x79, 0x7A, 0x7B, 0x7C, 0x7D, 0x7E, 0x7F, 0x80, 0x81, 0x82, 0x83, 0x84, 0x85, 0x86, 0x87, 0x88, 0x89, 0x8A, 0x8B, 0x8C, 0x8D, 0x8E, 0x8F, 0x90, 0x91, 0x92, 0x93, 0x94, 0x95, 0x96, 0x97, 0x98, 0x99, 0x9A, 0x9B, 0x9C, 0x9D, 0x9E, 0x9F, 0xA0, 0xA1, 0xA2, 0xA3, 0xA4, 0xA5, 0xA6, 0xA7, 0xA8, 0xA9, 0xAA, 0xAB, 0xAC, 0xAD, 0xAE, 0xAF, 0xB0, 0xB1, 0xB2, 0xB3, 0xB4, 0xB5, 0xB6, 0xB7, 0xB8, 0xB9, 0xBA, 0xBB, 0xBC, 0xBD, 0xBE, 0xBF, 0xC0, 0xC1, 0xC2, 0xC3, 0xC4, 0xC5, 0xC6, 0xC7, 0xC8, 0xC9, 0xCA, 0xCB, 0xCC, 0xCD, 0xCE, 0xCF, 0xD0, 0xD1, 0xD2, 0xD3, 0xD4, 0xD5, 0xD6, 0xD7, 0xD8, 0xD9, 0xDA, 0xDB, 0xDC, 0xDD, 0xDE, 0xDF, 0xE0, 0xE1, 0xE2, 0xE3, 0xE4, 0xE5, 0xE6, 0xE7, 0xE8, 0xE9, 0xEA, 0xEB, 0xEC, 0xED, 0xEE, 0xEF, 0xF0, 0xF1, 0xF2, 0xF3, 0xF4, 0xF5, 0xF6, 0xF7, 0xF8, 0xF9, 0xFA, 0xFB, 0xFC, 0xFD, 0xFE, 0xFF}  
 * 12 Flags uint32 as  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
    : ssp_flags_(ssp_flags)  
{  
}
```

```
std::vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const std::size_t ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return std::vector<uint8_t>(message, message + sizeof message);  
}
```

This is better



type2_message.hpp

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer);
        virtual vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const vector<uint8_t> buffer_;
    };

}

#endif
```

Find 3 issues

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer);
        virtual vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const vector<uint8_t> buffer_;
    };

}

#endif
```

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
```

```
#include "ntlm_message.hpp"
```

```
using namespace std; ←
```

```
namespace pal {
```

```
    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer);
        virtual vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const vector<uint8_t> buffer_;
    };
};
```

```
}
```

```
#endif
```



Ouch, do not
import namespaces in
header files!

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED  
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
```

```
#include "ntlm_message.hpp"
```

```
using namespace std; ←
```

```
namespace pal {
```

```
    class type2_message : public ntlm_message {  
    public:  
        explicit type2_message(vector<uint8_t> buffer);  
        virtual vector<uint8_t> as_bytes() const;  
        uint32_t ssp_flags();  
        uint64_t challenge();  
    private:  
        const vector<uint8_t> buffer_;  
    };
```

```
}
```

```
#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
```

```
#include "ntlm_message.hpp"
```

```
using namespace std;
```

```
namespace pal {
```

```
class type2_message : public ntlm_message {
public:
    explicit type2_message(vector<uint8_t> buffer);
    virtual vector<uint8_t> as_bytes() const;
    uint32_t ssp_flags();
    uint64_t challenge();
private:
    const vector<uint8_t> buffer_;
};
```

```
}
```

```
#endif
```



pass this vector as
const &

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED  
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
```

```
#include "ntlm_message.hpp"
```

```
using namespace std;
```

```
namespace pal {
```

```
class type2_message : public ntlm_message {  
public:  
    explicit type2_message(vector<uint8_t> buffer);  
    virtual vector<uint8_t> as_bytes() const;  
    uint32_t ssp_flags();  
    uint64_t challenge();  
private:  
    const vector<uint8_t> buffer_;  
};
```

```
}
```

```
#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

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using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer);
        virtual vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const vector<uint8_t> buffer_;
    };

}

#endif
```



this looks like query methods, they should probably be const

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
```

```
#include "ntlm_message.hpp"
```

```
using namespace std;
```

```
namespace pal {
```

```
class type2_message : public ntlm_message {
public:
```

```
    explicit type2_message(vector<uint8_t> buffer);
```

```
    virtual vector<uint8_t> as_bytes() const;
```

```
    uint32_t ssp_flags();
```

```
    uint64_t challenge();
```

```
private:
```

```
    const vector<uint8_t> buffer_;
```

```
};
```

```
}
```

```
#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
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```
#include "ntlm_message.hpp"
```

```
using namespace std; ←
```

```
namespace pal {
```

```
    class type2_message : public ntlm_message {
```

```
    public:
```

```
        explicit type2_message(vector<uint8_t> buffer);
```

```
        virtual vector<uint8_t> as_bytes() const;
```

```
        uint32_t ssp_flags();
```

```
        uint64_t challenge();
```

```
    private:
```

```
        const vector<uint8_t> buffer_;
```

```
};
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```
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#endif
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        const vector<uint8_t> buffer_;
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    private:
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```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(        vector<uint8_t> buffer);
        virtual        vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const        vector<uint8_t> buffer_;
    };

}

#endif
```

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(std::vector<uint8_t> buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(std::vector<uint8_t> buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(std::vector<uint8_t> buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(std::vector<uint8_t> buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

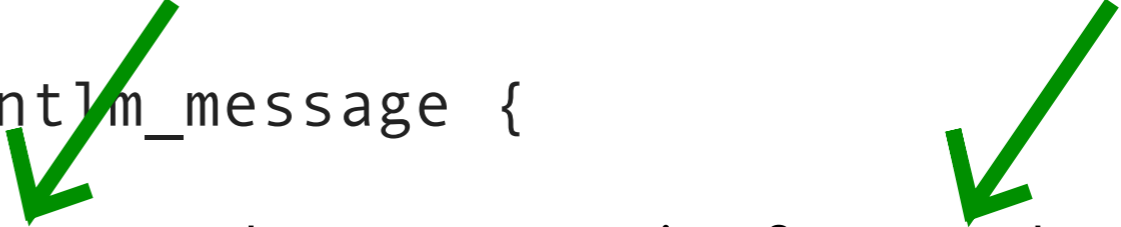
#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(          std::vector<uint8_t>      buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

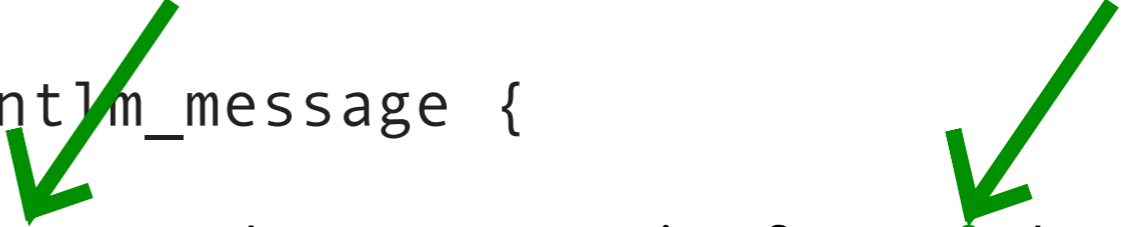
#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(const std::vector<uint8_t> & buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED


#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(const std::vector<uint8_t> & buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(const std::vector<uint8_t> & buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags() const;
        uint64_t challenge() const;
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```



```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(const std::vector<uint8_t> & buffer);
        virtual std::vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags() const;
        uint64_t challenge() const;
    private:
        const std::vector<uint8_t> buffer_;
    };

}

#endif
```



This looks like Solid C++

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED
```

```
#include "ntlm_message.hpp"
```

```
namespace pal {
```

```
    class type2_message : public ntlm_message {
    public:
```

```
        explicit type2_message(const std::vector<uint8_t> & buffer);
```

```
        virtual std::vector<uint8_t> as_bytes() const;
```

```
        uint32_t ssp_flags() const;
```

```
        uint64_t challenge() const;
```

```
    private:
```

```
        const std::vector<uint8_t> buffer_;
```

```
};
```

```
}
```

```
#endif
```



type2_message.cpp

... page 1 of 2

```
#include <cstdint>
#include <algorithm>
#include <stdexcept>
```

```
#include "tools.hpp"
```

```
#include "type2_message.hpp"
```

```
/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0  NTLMSSP Signature           {'N','T','L','M','S','S','P','\0'}
 * 8  NTLM Message Type         {0x02,0x00,0x00,0x00}
 * 12 Target Name                (security buffer)
 * 20 Flags                      uint32 as little endian
 * 24 Challenge                  8 bytes / uint64 as little endian
 * (32) Context (optional)       8 bytes (2xlong)
 * (40) Target Information       (security buffer)
 * (48) (start of datablock)
 *     targetname
 *     targetinfo
 *         server (type=0x0100, len, data)
 *         domain (type=0x0200, len, data)
 *         dnsserver (type=0x0300, len, data)
 *         dnsdomain (type=0x0400, len, data)
 *         type5 (type=0x0500, len, data) // unknown role
 *         <terminator> (type=0, len=0)
 */
```

```
#include <cstdint>
#include <algorithm>
#include <stdexcept>

#include "tools.hpp"

#include "type2_message.hpp"

/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0  NTLMSSP Signature           {'N','T','L','M','S','S','P','\0'}
 * 8  NTLM Message Type         {0x02,0x00,0x00,0x00}
 * 12 Target Name                (security buffer)
 * 20 Flags                      uint32 as little endian
 * 24 Challenge                  8 bytes / uint64 as little endian
 * (32) Context (optional)       8 bytes (2xlong)
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 *         dnsserver (type=0x0300, len, data)
 *         dnsdomain (type=0x0400, len, data)
 *         type5 (type=0x0500, len, data) // unknown role
 *         <terminator> (type=0, len=0)
 */
```

... page 1 of 2

```
#include <cstddef>
#include <algorithm>
#include <stdexcept>
```

```
#include "tools.hpp"
```

```
#include "type2_message.hpp"
```

```
/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0 NTLMSSP Signature {'N','T','L','M','S','S','P','\0'}
 * 8 NTLM Message Type {0x02,0x00,0x00,0x00}
 * 12 Target Name (security buffer)
 * 20 Flags uint32 as little endian
 * 24 Challenge 8 bytes / uint64 as little endian
 * (32) Context (optional) 8 bytes (2xlong)
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 * targetname
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 * server (type=0x0100, len, data)
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 * dnsdomain (type=0x0400, len, data)
 * type5 (type=0x0500, len, data) // unknown role
 * <terminator> (type=0, len=0)
 */
```



... page 1 of 2

this is not a good way
to order the include files

```
#include <cstdint>
#include <algorithm>
#include <stdexcept>
```

```
#include "tools.hpp"
```

```
#include "type2_message.hpp"
```

```
/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0 NTLMSSP Signature {'N','T','L','M','S','S','P','\0'}
 * 8 NTLM Message Type {0x02,0x00,0x00,0x00}
 * 12 Target Name (security buffer)
 * 20 Flags uint32 as little endian
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 * type5 (type=0x0500, len, data) // unknown role
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 */
```



... page 1 of 2

```
#include <cstdint>
#include <algorithm>
#include <stdexcept>
```

```
#include "tools.hpp"
```

```
#include "type2_message.hpp"
```

```
/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0  NTLMSSP Signature           {'N','T','L','M','S','S','P','\0'}
 * 8  NTLM Message Type         {0x02,0x00,0x00,0x00}
 * 12 Target Name                (security buffer)
 * 20 Flags                      uint32 as little endian
 * 24 Challenge                  8 bytes / uint64 as little endian
 * (32) Context (optional)       8 bytes (2xlong)
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 *     targetname
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 *         server (type=0x0100, len, data)
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 *         dnsserver (type=0x0300, len, data)
 *         dnsdomain (type=0x0400, len, data)
 *         type5 (type=0x0500, len, data) // unknown role
 *         <terminator> (type=0, len=0)
 */
```

... page 1 of 2

```
#include <cstdint>
#include <algorithm>
#include <stdexcept>

#include "tools.hpp"

#include "type2_message.hpp"

/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0  NTLMSSP Signature           {'N','T','L','M','S','S','P','\0'}
 * 8  NTLM Message Type         {0x02,0x00,0x00,0x00}
 * 12 Target Name                (security buffer)
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 *         dnsdomain (type=0x0400, len, data)
 *         type5 (type=0x0500, len, data) // unknown role
 *         <terminator> (type=0, len=0)
 */
```


... page 1 of 2

```
#include "type2_message.hpp"
```

```
#include "tools.hpp"
```

```
#include <cstdint>
```

```
#include <algorithm>
```

```
#include <stdexcept>
```

```
/*
```

```
* See http://davenport.sourceforge.net/ntlm.html
```

```
*
```

```
* Type 2 Message
```

```
*
```

```
* 0 NTLMSSP Signature
```

```
{'N','T','L','M','S','S','P','\0'}
```

```
* 8 NTLM Message Type
```

```
{0x02,0x00,0x00,0x00}
```

```
* 12 Target Name
```

```
(security buffer)
```

```
* 20 Flags
```

```
uint32 as little endian
```

```
* 24 Challenge
```

```
8 bytes / uint64 as little endian
```

```
* (32) Context (optional)
```

```
8 bytes (2xlong)
```

```
* (40) Target Information
```

```
(security buffer)
```

```
* (48) (start of datablock)
```

```
* targetname
```

```
* targetinfo
```

```
* server (type=0x0100, len, data)
```

```
* domain (type=0x0200, len, data)
```

```
* dnsserver (type=0x0300, len, data)
```

```
* dnsdomain (type=0x0400, len, data)
```

```
* type5 (type=0x0500, len, data) // unknown role
```

```
* <terminator> (type=0, len=0)
```

```
*/
```



... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}

uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}

std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return (buffer_);
}
```

... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}

uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}

std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return (buffer_);
}
```

Any issues here?

... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t>
    : buffer_(buffer))
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix),
        &buffer[0]))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}
```

```
uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}
```

```
uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}
```

```
std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return (buffer_);
}
```



... page 2 of 2

magic numbers

```
pal::type2_message::type2_message(const buffer_t &buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}

uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}

std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return (buffer_);
}
```



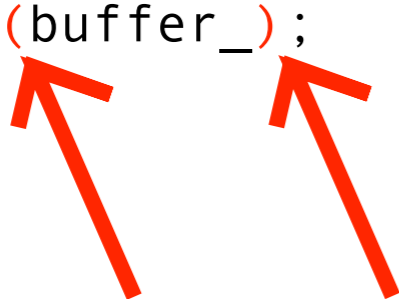
... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}
```

```
uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(buffer_);
}
```

```
uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(buffer_);
}
```

```
std::vector<uint8_t> pal::type2_message::as_buffer() const
{
    return (buffer_);
}
```



... page 2 of 2

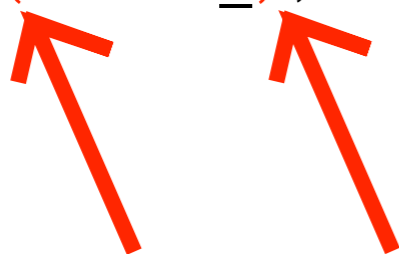
```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}
```

```
uint32_t pal::type2_message::ssp_flags() const
{
    return pal::
```

superfluous use of ()

```
uint64_t pal::type2_message::read_uint64_from_little_endian() const
{
    return pal::read_uint64_from_little_endian(buffer_);
}
```

```
std::vector<uint8_t> pal::type2_message::as_buffer() const
{
    return (buffer_);
}
```



... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}
```

```
uint32_t pal::type2_message::ssp_flags() const
{
    return pal::
}
```

```
uint64_t pal::type2_message::read_uint64_from_little_endian() const
{
    return pal::read_uint64_from_little_endian(buffer_, offset_);
}
```

```
std::vector<uint8_t> pal::type2_message::as_buffer() const
{
    return (buffer_);
}
```

superfluous use of ()



... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof((prefix)), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}
```

```
uint32_t pal::type2_message::ssp_flags() const
{
    return
}
```

```
uint64_t pal::type2_message::read_uint64_from_little_endian() const
{
    return pal::read_uint64_from_little_endian(buffer_, offset_);
}
```

```
std::vector<uint8_t> pal::type2_message::as_buffer() const
{
    return (((buffer_)));
}
```

so you really like () do you?
Why not add a few more?



... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = (32);
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof((prefix)), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}
```

```
uint32_t pal::type2_message::ssp_flags() const
{
    return
}
```

```
uint64_t pal::type2_message::read_uint64_from_little_endian() const
{
    return pal::read_uint64_from_little_endian(buffer_, offset_);
}
```

```
std::vector<uint8_t> pal::type2_message::as_buffer() const
{
    return (((buffer_)));
}
```

so you really like () do you?
Why not add a few more?



... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}

uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}

std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return (buffer_);
}
```

... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
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    return pal::read_uint64_from_little_endian(&buffer_[24]);
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... page 2 of 2

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... page 2 of 2

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... page 2 of 2

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pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
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uint32_t pal::type2_message::ssp_flags() const
{
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}

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    const std::size_t challenge_offset = 24;
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std::vector<uint8_t> pal::type2_message::as_bytes() const
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    return (buffer_);
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... page 2 of 2

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pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
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... page 2 of 2

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... page 2 of 2

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... page 2 of 2

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... page 2 of 2

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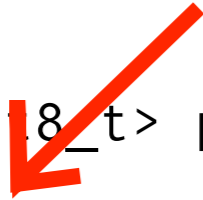
... page 2 of 2

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pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
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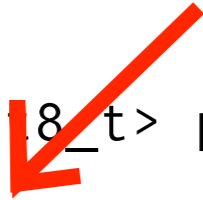
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... page 2 of 2

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... page 2 of 2

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std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return buffer_;
}
```



type3_message.hpp

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iostream>

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

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#include <string>
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namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
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    const std::vector<uint8_t> lm_response_;
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    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```



Find 3 issues

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iostream> ←

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```



```
#ifndef PAL_TYPE3_MESS
#define PAL_TYPE3_MES
```

```
#include "ntlm_message
```

```
#include <string>
#include <iostream>
```

```
namespace pal {
```

```
class type3_message : public ntlm_message {
public:
```

```
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
```

```
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
```

```
private:
```

```
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
```

```
};
```

```
}
```

```
#endif
```

include <iosfwd> instead



```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iostream>

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
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    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```



```
#ifndef PAL_TYPE3_MESSAGE
#define PAL_TYPE3_MESSAGE
```

```
#include "ntlm_message.h"
```

```
#include <string>
#include <iostream>
```

```
namespace pal {
```

```
class type3_message : public ntlm_message {
public:
```

```
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
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```
    virtual std::vector<uint8_t> as_bytes() const;
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```

```
private:
```

```
    const std::vector<uint8_t> lm_response_;
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    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
```

```
};
```

```
}
```

```
#endif
```

this default argument is probably not needed



```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iostream>

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
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    const std::string user_;
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    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```




```
#ifndef PAL_TYPE3_MESSAGE_H
#define PAL_TYPE3_MESSAGE_H
```

```
#include "ntlm_message.h"
```

```
#include <string>
#include <iostream>
```

```
namespace pal {
```

```
class type3_message : public ntlm_message {
public:
```

```
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
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        uint32_t ssp_flags = 0x202);
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```
    virtual std::vector<uint8_t> as_bytes() const;
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```

```
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```

```
    const std::vector<uint8_t> lm_response_;
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    const std::string domain_;
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    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
```

```
};
```

```
}
```

```
#endif
```

useless explicit specifier



```
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#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

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    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iostream> ←

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd> ←

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"


#include <string>
#include <iosfwd>

namespace pal {

    class type3_message : public ntlm_message {
    public:
        type3_message(
            const std::vector<uint8_t> & lm_response,
            const std::vector<uint8_t> & nt_response,
            const std::string & user,
            uint32_t ssp_flags = 0x202);
        virtual std::vector<uint8_t> as_bytes() const;
        void debug_print(std::ostream & out) const;
    private:
        const std::vector<uint8_t> lm_response_;
        const std::vector<uint8_t> nt_response_;
        const std::string domain_;
        const std::string user_;
        const std::string workstation_;
        const std::vector<uint8_t> session_key_;
        const uint32_t ssp_flags_;
    };

}

#endif
```



```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```



```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags    );
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```



```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iosfwd>

namespace pal {

class type3_message : public ntlm_message {
public:
    type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

A man with a beard and a speech bubble saying "Not too bad!". The man is looking slightly to the right with a neutral expression. The speech bubble is grey with a black outline and contains the text "Not too bad!". The background shows a bookshelf with various books, including titles like "UNIX", "C++", and "CODE COMPLETE".

Not too bad!

type3_message.cpp

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...

Find 3 issues

```
...  
  
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...



...

WTF?



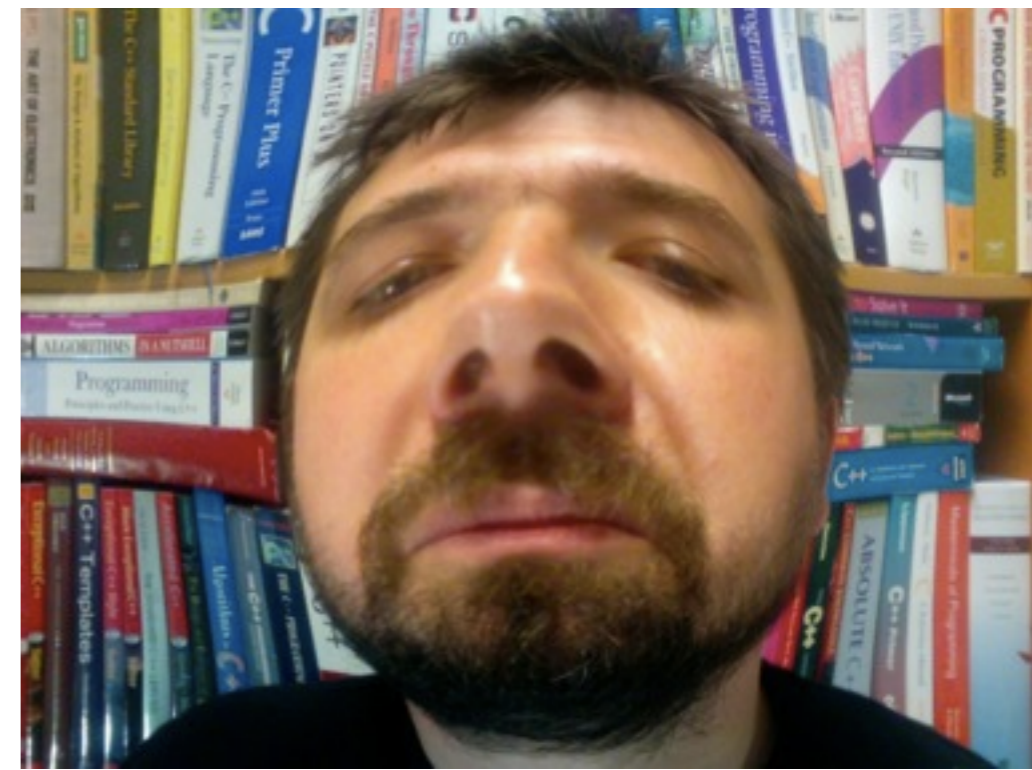
```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
:  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...



...

Does not match initialization order...



```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```



...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...



...
... but this indicates a deeper problem, the user is not compiling with `-Wall` and `-Wextra`, or even worse... they do not care about warnings!

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```



...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```



...



...

It's often a good idea to explicitly initialize all object members. Consider the `-Weffc++` flag

```
pal::type3_message::type3_message(
    const std::vector<uint8_t> & lm_response,
    const std::vector<uint8_t> & nt_response,
    const std::string & user,
    uint32_t ssp_flags)
:
    lm_response_(lm_response),
    nt_response_(nt_response),
    user_(user),
    ssp_flags_(ssp_flags),
    session_key_(session_key_size)
{
    if (lm_response_.size() != lm_response_size)
        throw new std::invalid_argument("invalid size of lm_response");
    if (nt_response_.size() != nt_response_size)
        throw new std::invalid_argument("invalid size of nt_response");
}
```



...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
:  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    session_key_(session_key_size),  
    ssp_flags_(ssp_flags)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
:  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    session_key_(session_key_size),  
    ssp_flags_(ssp_flags)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
:  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    domain_(),  
    user_(user),  
    workstation_(),  
    session_key_(session_key_size),  
    ssp_flags_(ssp_flags)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

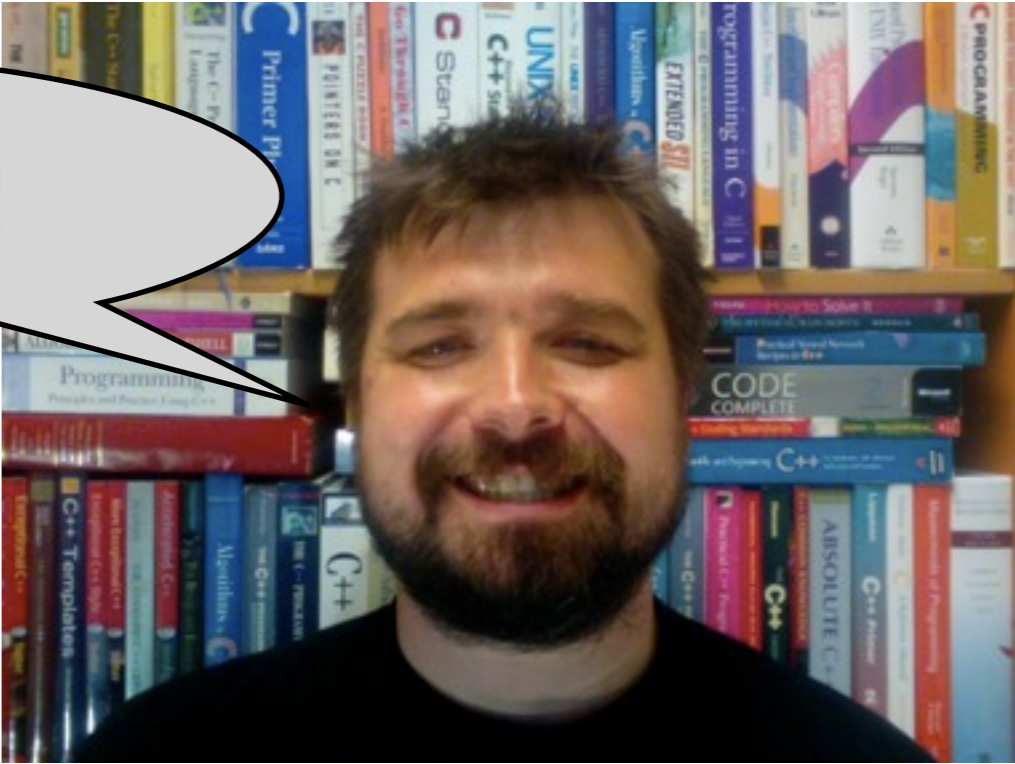
...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
:  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    domain_(),  
    user_(user),  
    workstation_(),  
    session_key_(session_key_size),  
    ssp_flags_(ssp_flags)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

Much better!



```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    domain_(),  
    user_(user),  
    workstation_(),  
    session_key_(session_key_size),  
    ssp_flags_(ssp_flags)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
void pal::type3_message::debug_print(std::ostream & out) const
{
    out << "### type3_message:" << '\n'
        << pal::as_hex_dump(as_bytes())
        << "\n\nlm_response = " << pal::as_hex_string(lm_response_)
        << "\n\nnt_response = " << pal::as_hex_string(nt_response_)
        << "\n\nndomain = " << domain_
        << "\n\nuser = " << user_
        << "\n\nworkstation = " << workstation_
        << "\n\nsession_key = " << pal::as_hex_string(session_key_)
        << std::hex << std::setw(8) << std::setfill('0')
        << "\n\nssp_flags = " << ssp_flags_;
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Any issues here?

...

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...

DO NOT MESS WITH BORROWED THINGS!



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...

No easy way to fix this! Probably better to build into a local stringstream and return it.



...

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Big improvement!



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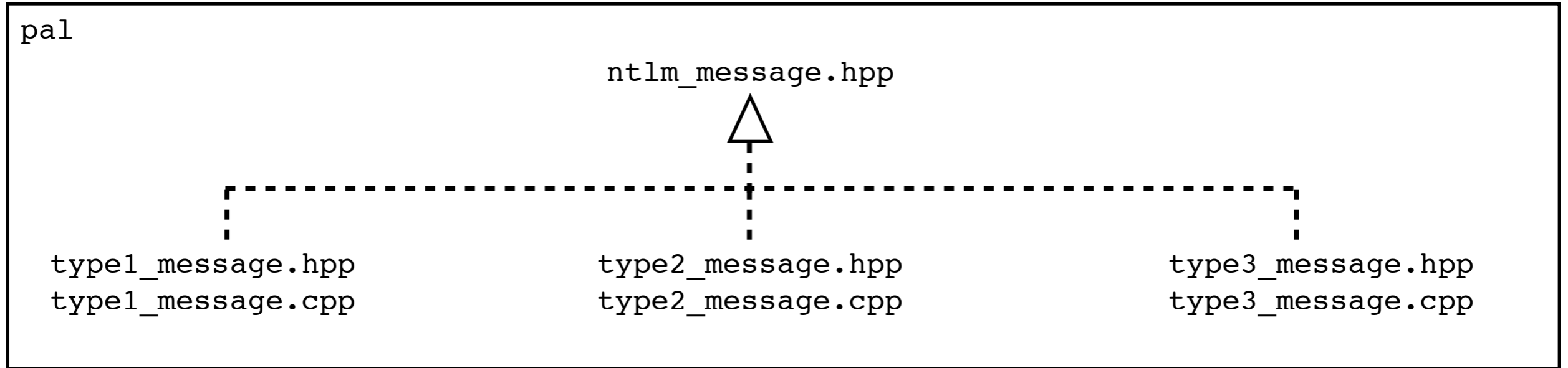
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25. always consider the sideeffects of what you do

!

Handouts

Code under discussion



Note: the following code compiles just fine and does exactly what it is supposed to do... can you improve it?

As a client, when prompted for ntlm authentication by the server, I want a tool/library that can help me to create the initial ntlm **request** (type 1 message) that I can send to the server to receive a **challenge** (type 2 message) that needs to be solved by applying my username and password to create an ntlm **response** that I can send to the server. (pew...)

Here are some (imaginary) additional requirements:

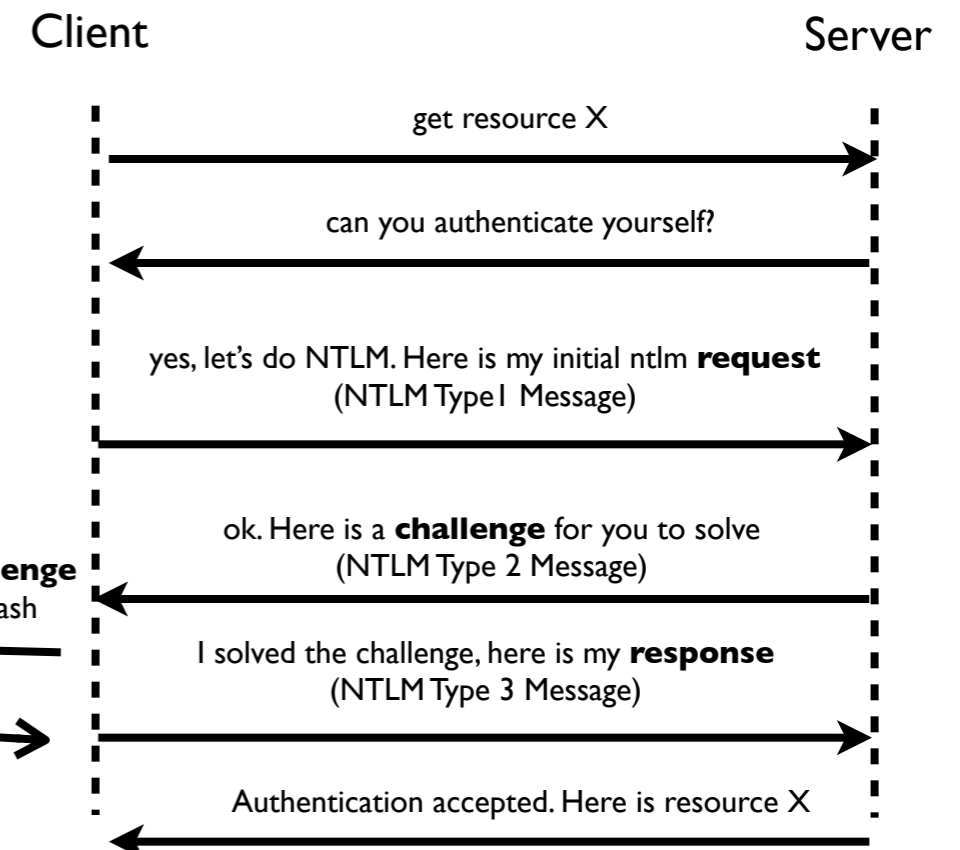
- target typically an embedded system
- it should be possible and convenient to create a <100kb client using the PAL library
- must use C++ (due to PHB decision)
- due to compiler support tr1 and boost can not be used
- initially the library will only be used to communicate HTTP with a Windows 2003 Server SP2, currently no need to support other servers

For more info:

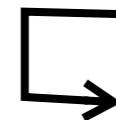
PAL - a Primitive Authentication Library in C++ for educational purposes

<http://github.com/olvemaudal/pal>

The NTLM Protocol (simplified)



use password to "solve" the **challenge** and create an lm/nt response hash



```
#include <vector>

namespace pal {

    class ntlm_message {
    public:
        virtual std::vector<uint8_t> as_bytes() const = 0;
    };

}
```



```
#ifndef PAL_TYPE1_MESSAGE_HPP_INCLUDED
#define PAL_TYPE1_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <vector>

namespace pal {

    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#endif
```

```
#include "type1_message.hpp"
```

```
#include "tools.hpp"
```

```
/*  
 * See http://davenport.sourceforge.net/ntlm.html  
 *  
 * Type 1 Message  
 *  
 * 0 NTLMSSP Signature "NTLMSSP\0"  
 * 8 NTLM Message Type {0x01,0x00,0x00,0x00}  
 * 12 Flags uint32 as little endian  
 * (16) Supplied Domain (optional) (security buffer)  
 * (24) Supplied Workstation (optional) (security buffer)  
 * (32) (start of datablock) if required  
 */
```

```
using namespace std;
```

```
pal::type1_message::type1_message(uint32_t ssp_flags)  
{  
    ssp_flags_ = ssp_flags;  
}
```

```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset], ssp_flags_);  
    return vector<uint8_t>(message, message + sizeof message);  
}
```

```
#ifndef PAL_TYPE2_MESSAGE_HPP_INCLUDED
#define PAL_TYPE2_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer);
        virtual vector<uint8_t> as_bytes() const;
        uint32_t ssp_flags();
        uint64_t challenge();
    private:
        const vector<uint8_t> buffer_;
    };

}

#endif
```

```
#include <cstdint>
#include <algorithm>
#include <stdexcept>

#include "tools.hpp"

#include "type2_message.hpp"

/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 2 Message
 *
 * 0  NTLMSSP Signature           {'N','T','L','M','S','S','P','\0'}
 * 8  NTLM Message Type          {0x02,0x00,0x00,0x00}
 * 12 Target Name                 (security buffer)
 * 20 Flags                       uint32 as little endian
 * 24 Challenge                   8 bytes / uint64 as little endian
 * (32) Context (optional)        8 bytes (2xlong)
 * (40) Target Information         (security buffer)
 * (48) (start of datablock)
 *     targetname
 *     targetinfo
 *         server (type=0x0100, len, data)
 *         domain (type=0x0200, len, data)
 *         dnsserver (type=0x0300, len, data)
 *         dnsdomain (type=0x0400, len, data)
 *         type5 (type=0x0500, len, data) // unknown role
 *         <terminator> (type=0, len=0)
 */
```

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    const std::size_t min_type2_buffer_size = 32;
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof(prefix), buffer.begin()))
        throw std::invalid_argument("not a type2 message, invalid prefix");
}

uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}

std::vector<uint8_t> pal::type2_message::as_bytes() const
{
    return (buffer_);
}
```

```
#ifndef PAL_TYPE3_MESSAGE_HPP_INCLUDED
#define PAL_TYPE3_MESSAGE_HPP_INCLUDED

#include "ntlm_message.hpp"

#include <string>
#include <iostream>

namespace pal {

class type3_message : public ntlm_message {
public:
    explicit type3_message(
        const std::vector<uint8_t> & lm_response,
        const std::vector<uint8_t> & nt_response,
        const std::string & user,
        uint32_t ssp_flags = 0x202);
    virtual std::vector<uint8_t> as_bytes() const;
    void debug_print(std::ostream & out) const;
private:
    const std::vector<uint8_t> lm_response_;
    const std::vector<uint8_t> nt_response_;
    const std::string domain_;
    const std::string user_;
    const std::string workstation_;
    const std::vector<uint8_t> session_key_;
    const uint32_t ssp_flags_;
};

}

#endif
```

...

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
    :  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    session_key_(session_key_size)  
{  
    if (lm_response_.size() != lm_response_size)  
        throw new std::invalid_argument("invalid size of lm_response");  
    if (nt_response_.size() != nt_response_size)  
        throw new std::invalid_argument("invalid size of nt_response");  
}
```

...

...

```
void pal::type3_message::debug_print(std::ostream & out) const
{
    out << "### type3_message:" << '\n'
        << pal::as_hex_dump(as_bytes())
        << "\n\nlm_response = " << pal::as_hex_string(lm_response_)
        << "\n\nnt_response = " << pal::as_hex_string(nt_response_)
        << "\n\nndomain = " << domain_
        << "\n\nuser = " << user_
        << "\n\nworkstation = " << workstation_
        << "\n\nsession_key = " << pal::as_hex_string(session_key_)
        << std::hex << std::setw(8) << std::setfill('0')
        << "\n\nssp_flags = " << ssp_flags_;
}
```

...