

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 3 hour session with students at NTNU
Trondheim, September 3, 2012**

~/myprog/foo.hpp

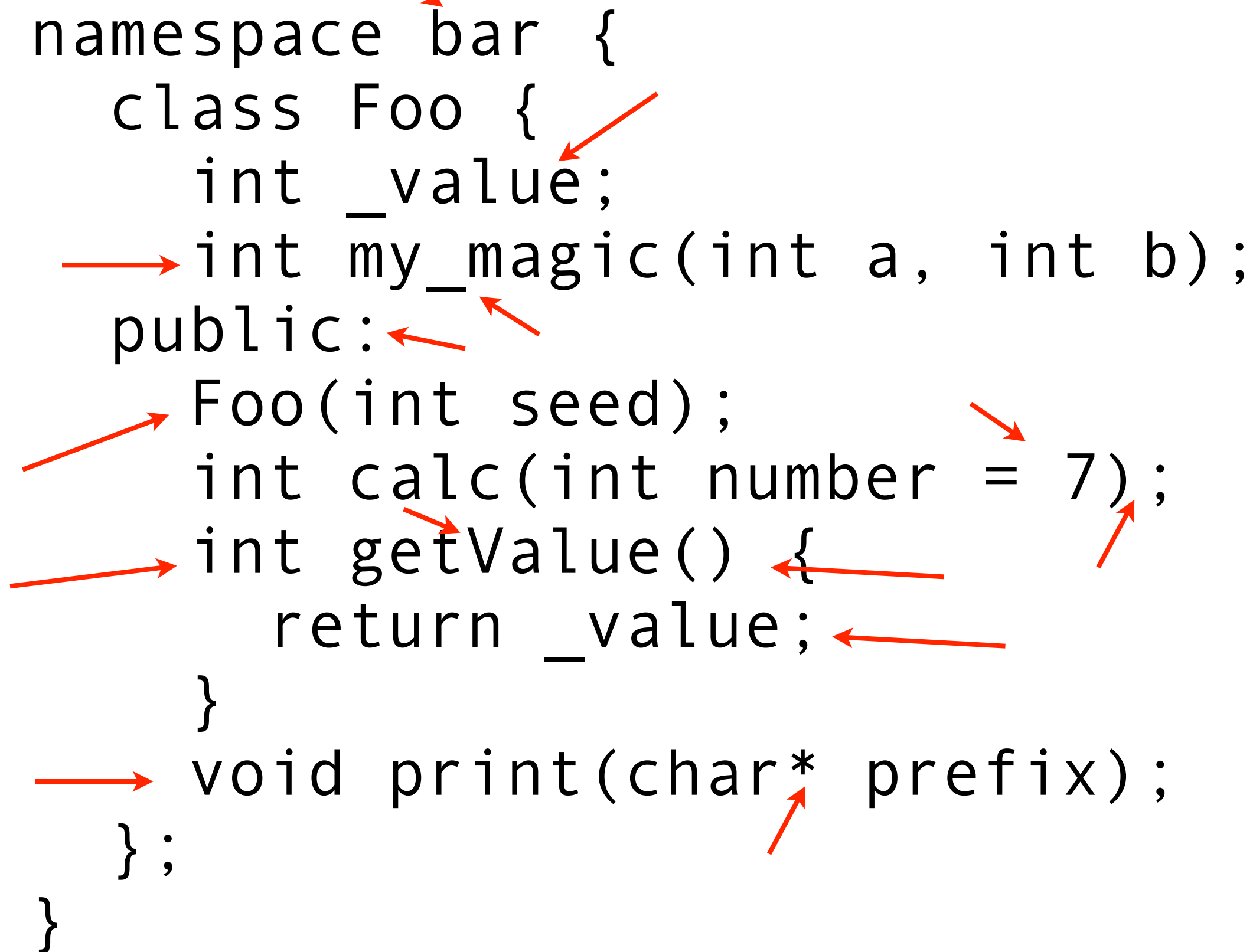
```
namespace bar {  
    class Foo {  
        int _value;  
        int my_magic(int a, int b);  
    public:  
        Foo(int seed);  
        int calc(int number = 7);  
        int getValue() {  
            return _value;  
        }  
        void print(char* prefix);  
    };  
}
```



~/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);  
    };  
}
```

~/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 from a header file. Red arrows point to the following elements: the opening curly brace of the namespace, the namespace name 'bar', the class name 'Foo', the member variable '_value', the member function 'my_magic', the 'public:' access specifier, the constructor 'Foo', the default argument '7' in the 'calc' function, the 'getValue' function, the 'return' statement, the pointer asterisk '*' in the 'print' function, and the closing curly brace of the namespace.

~/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);  
    };  
}
```

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

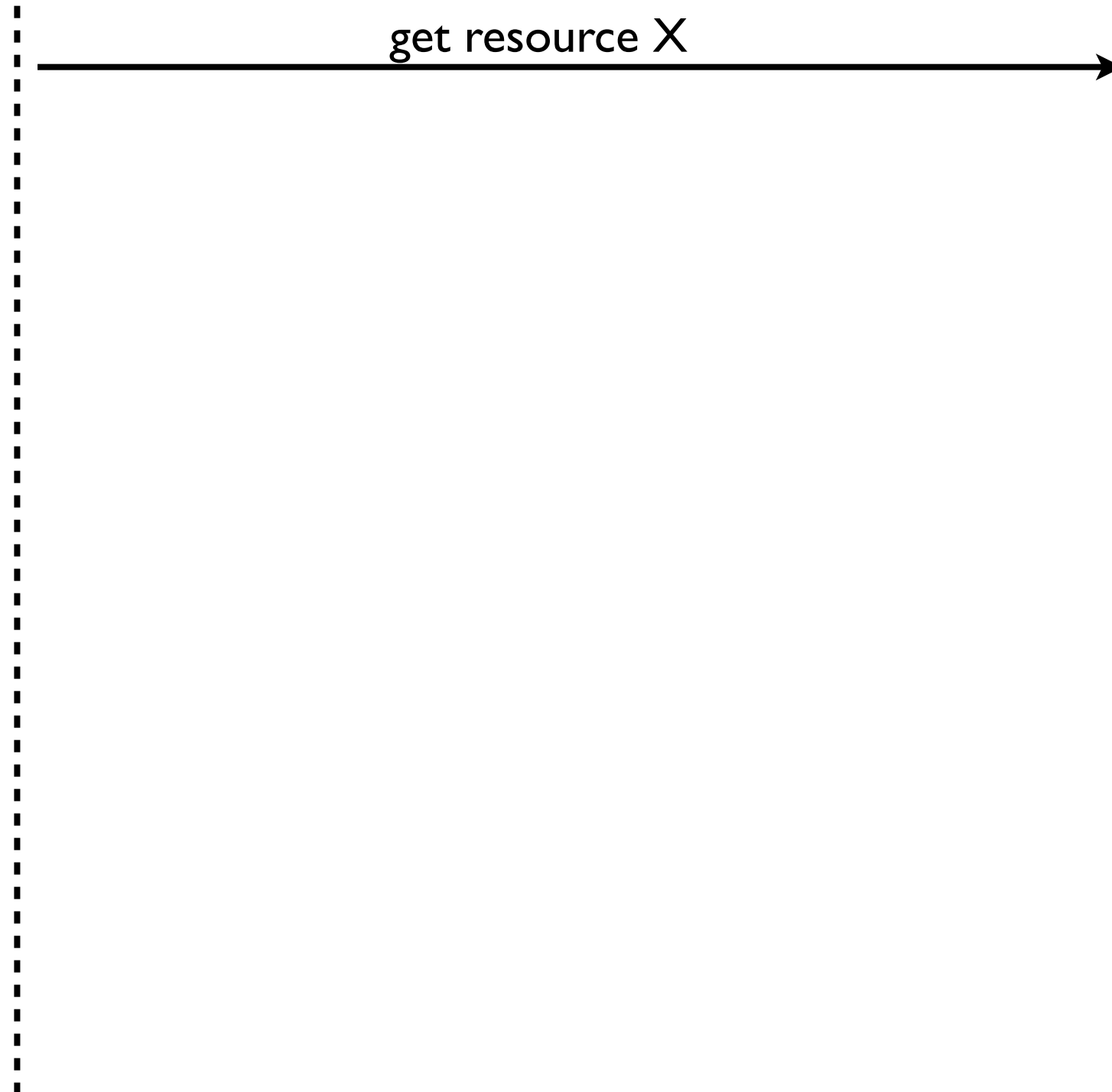
Server



The NTLM Protocol (simplified)

Client

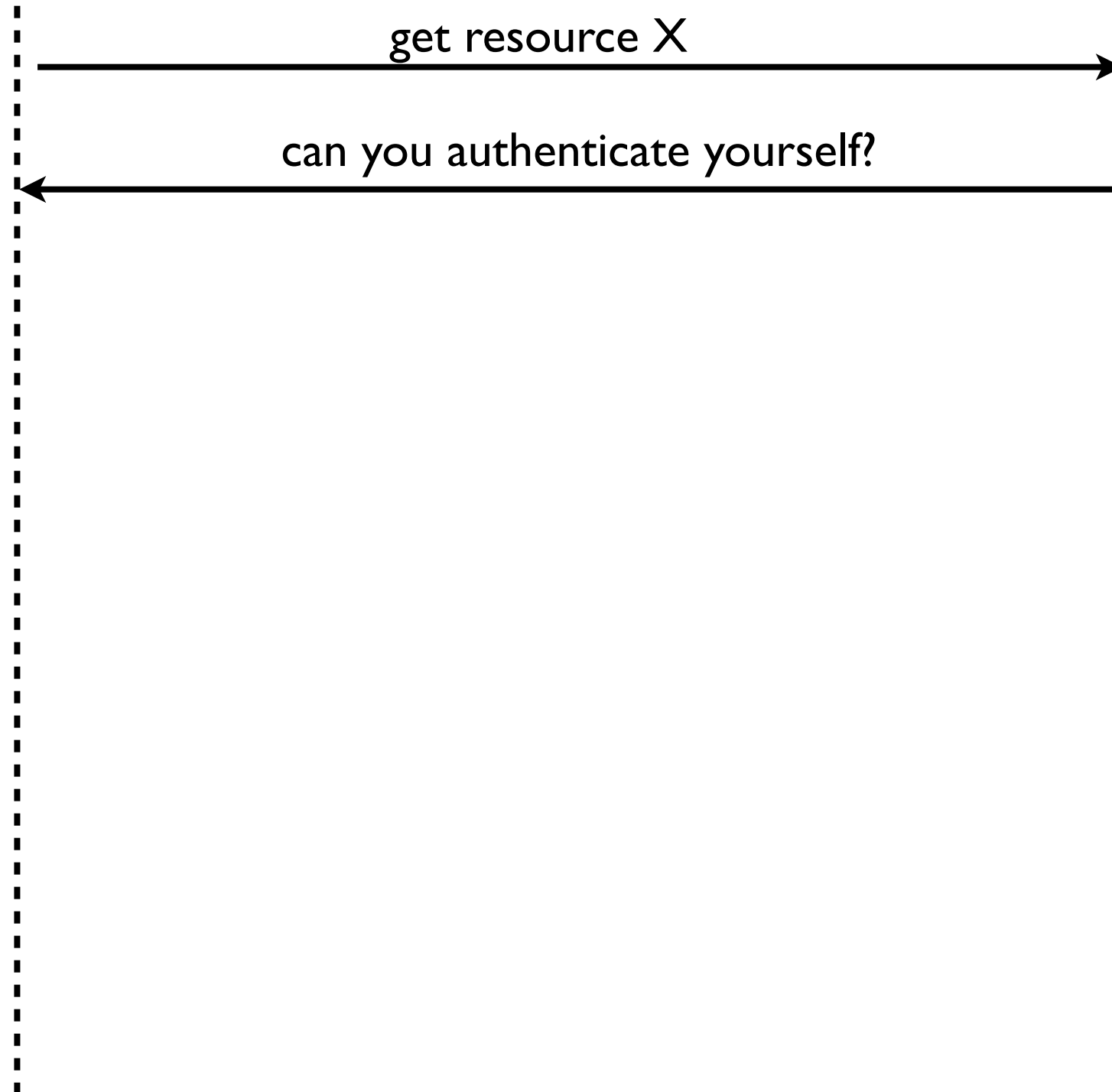
Server



The NTLM Protocol (simplified)

Client

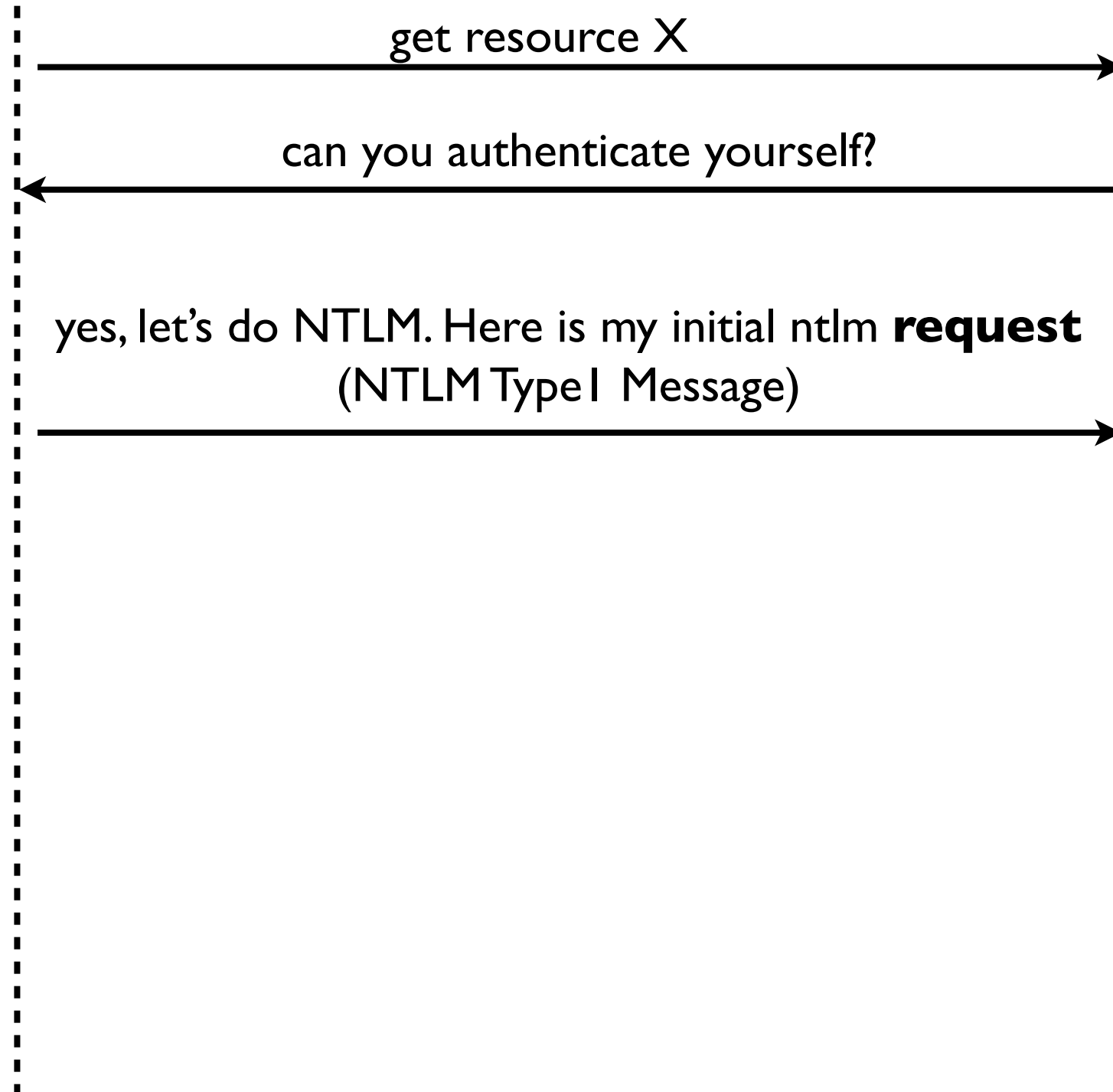
Server



The NTLM Protocol (simplified)

Client

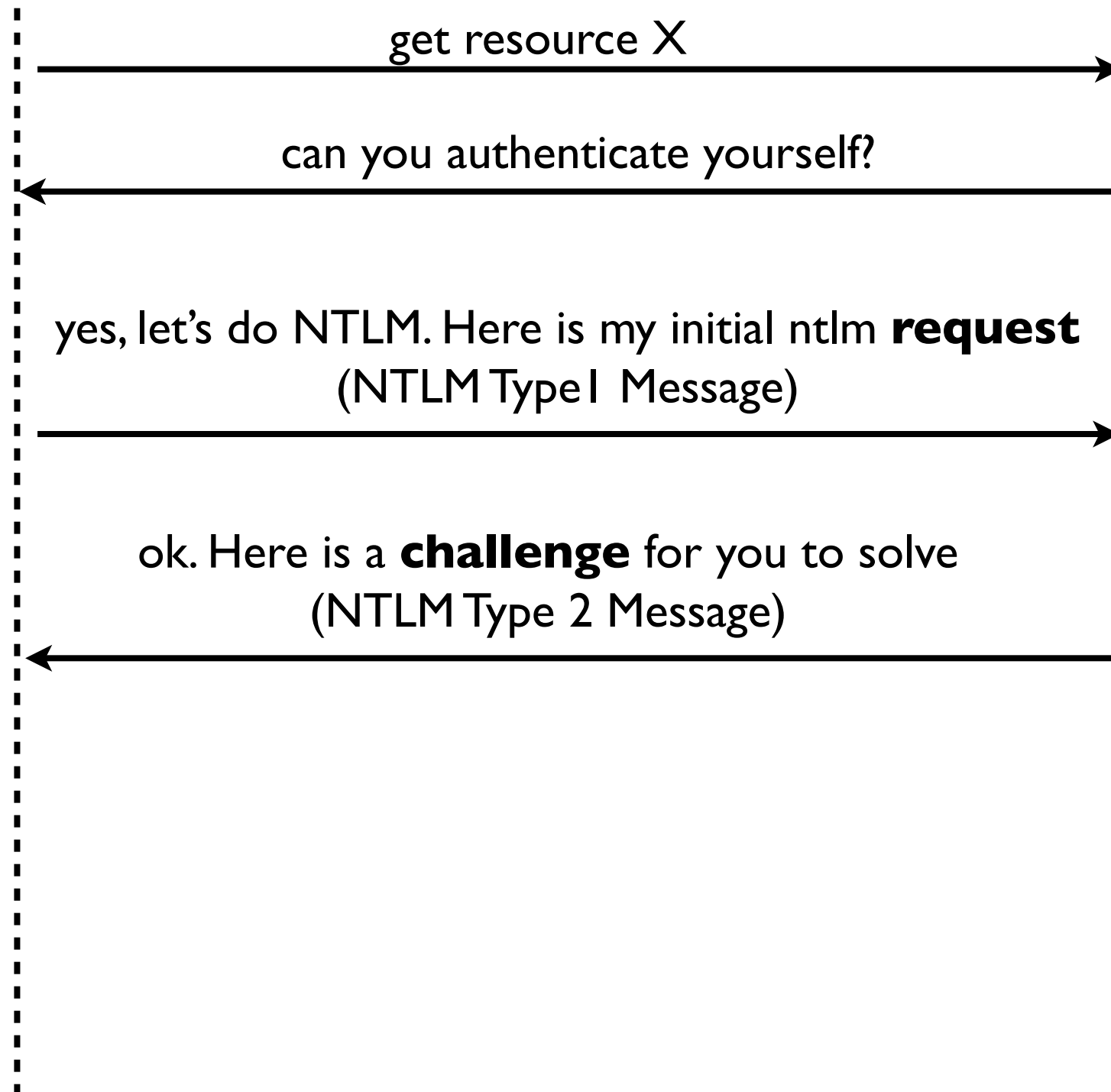
Server



The NTLM Protocol (simplified)

Client

Server



The NTLM Protocol (simplified)

Client

Server

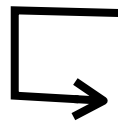
get resource X

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

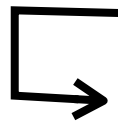
can you authenticate yourself?

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

get resource X

can you authenticate yourself?

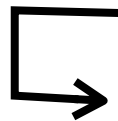
yes, let's do NTLM. Here is my initial ntlm **request**
(NTLM Type 1 Message)

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

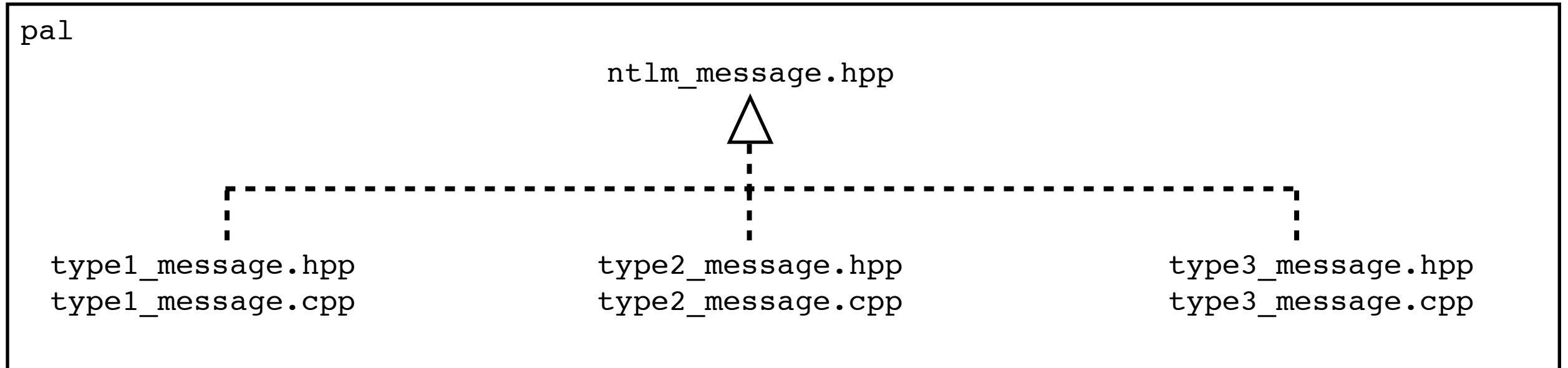
I solved the challenge, here is my **response**
(NTLM Type 3 Message)

Authentication accepted. Here is resource X

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



Code under discussion

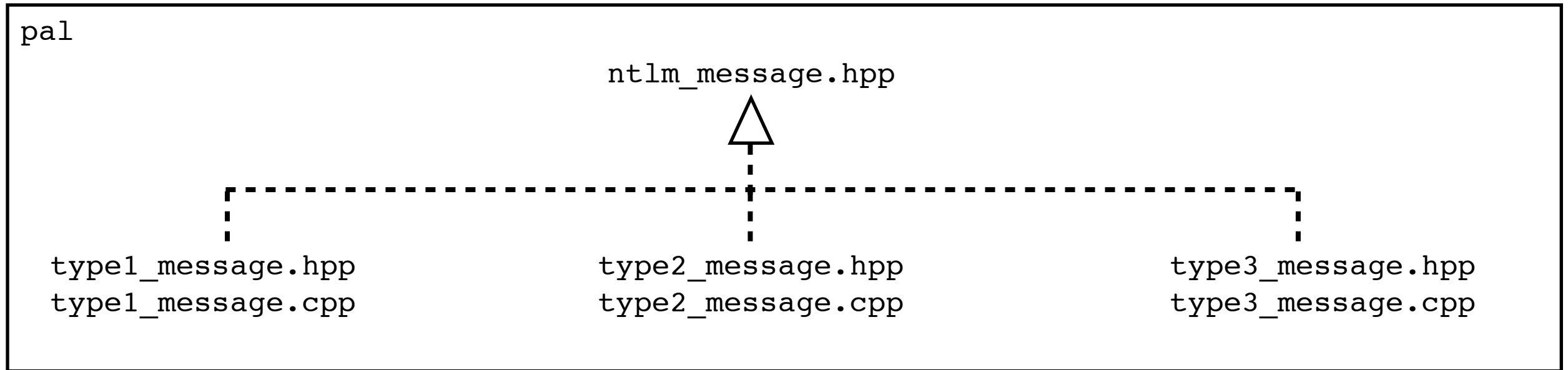


Note: *the code under discussion compiles just fine and does exactly what it is supposed to do... but can you suggest improvements?*

Handouts

(Do not look ahead, wait for instructions)

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. (pewh...)

Here are some (imaginary) additional requirements:

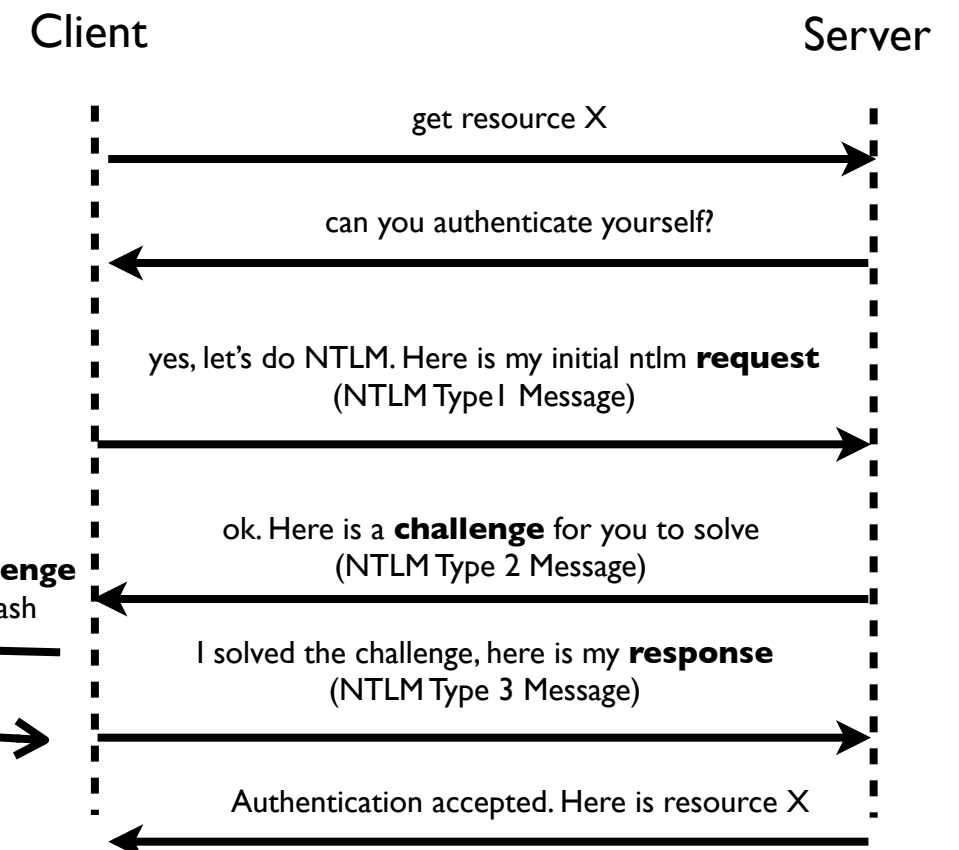
- target typically an embedded system
- it should be possible and convenient to create a <100kb client using the PAL library
- must use C++ (due to PHB decision)
- due to compiler support tr1 and boost can not be used
- initially the library will only be used to communicate HTTP with a Windows 2003 Server 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)



```
#ifndef NTML
#define NTML

#include <vector>

namespace pal {

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

}

#endif // NTLM
```

```
#ifndef NTML
#define NTML

#include <vector>

namespace pal {

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

}

#endif // NTLM
```

```
#ifndef NTML   
#define NTML  
  
#include <vector>  
  
namespace pal {  
    class ntlm_message {  
    public:  
         ~ntlm_message() {}  
        virtual std::vector<uint8_t> as_bytes() const = 0;  
    };  
  
}  
  
#endif // NTLM
```

```
#ifndef NTML
#define NTML

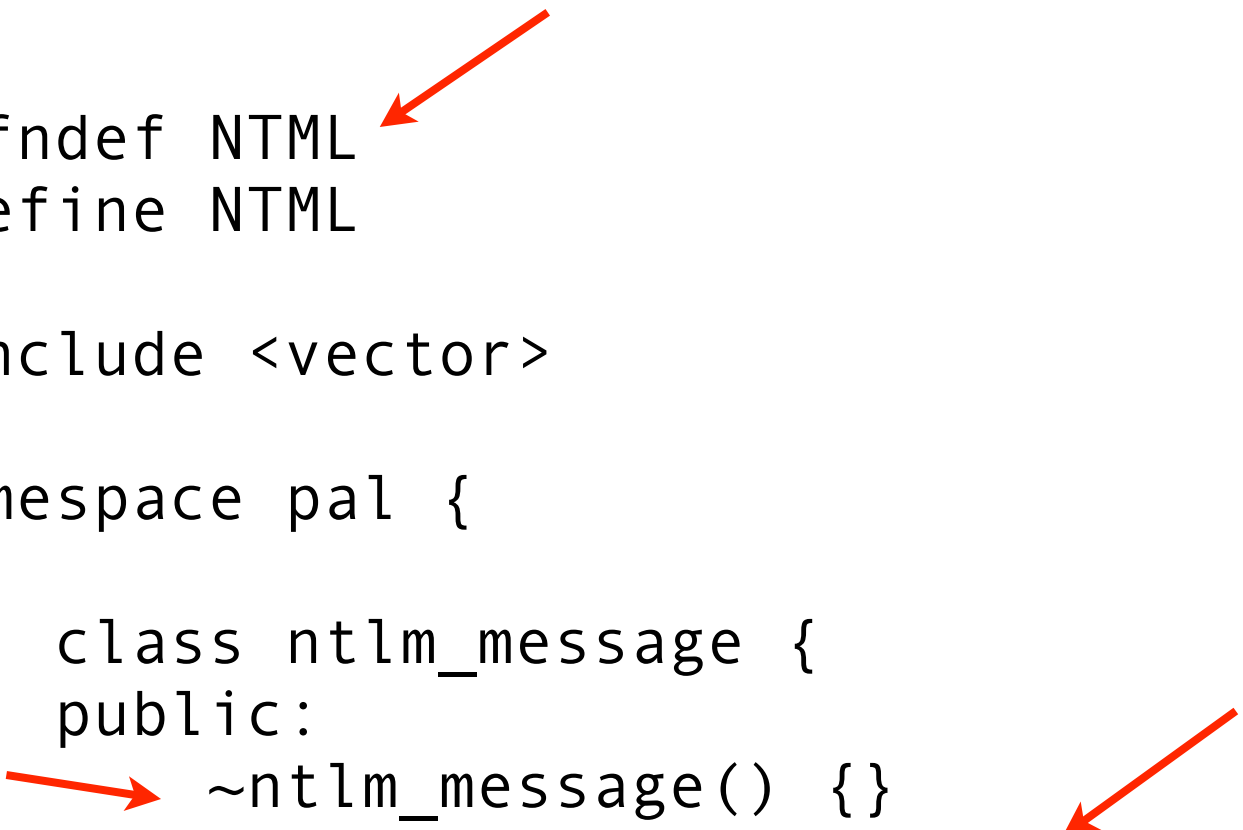
#include <vector>

namespace pal {

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

}

#endif // NTLM
```

Two red arrows are present in the code. The first arrow points from the top right towards the line '#ifndef NTML'. The second arrow points from the top right towards the line 'virtual std::vector<uint8_t> as_bytes() const = 0;'.

```
#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;
    };

}
```




```
#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;  
    };  
};
```

```
}
```




```
#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;
```

```
    };
```

```
}
```



```
#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;
```

```
    };
```

```
}
```



```
#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;
```

```
    };
```

```
}
```



```
#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;
```

```
    };
```

```
}
```

```
#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;
```

```
namespace pal {
```

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

```
    vector<uint8_t> 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
        };
```

```
        write_little_endian_from_uint32(&message[12], 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}
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using namespace std; 

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        ssp_flags_ = ssp_flags;
    }

    vector<uint8_t> 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
        };
        write_little_endian_from_uint32(&message[12], ssp_flags_);
        return vector<uint8_t>(message, message + sizeof message);
    }

}

```

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#include "type1_message.hpp"
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#include "tools.hpp"
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 * See http://davenport.sourceforge.net/ntlm.html
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 * 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)
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using namespace std;
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namespace pal {
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```
    type1_message::type1_message(uint32_t ssp_flags)
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        ssp_flags_ = ssp_flags;
    }
```

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

```
}
```



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

```
#include "tools.hpp"
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```
/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 1 Message
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 * 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)
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 */
```

```
using namespace std;
```

```
namespace pal {
```

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

```
    vector<uint8_t> 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
        };
```

```
        write_little_endian_from_uint32(&message[12], 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;
```

```
namespace pal {
```

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

```
    vector<uint8_t> 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
        };
```

```
        write_little_endian_from_uint32(&message[12], 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"

#include <stdexcept>

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer)
            throw(invalid_argument);
        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"

#include <stdexcept>

using namespace std; 

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer)
            throw(invalid_argument);
        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"

#include <stdexcept>

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer)
            throw(invalid_argument);
        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"

#include <stdexcept>

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer)
            throw(invalid_argument);
        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"

#include <stdexcept>

using namespace std;

namespace pal {

    class type2_message : public ntlm_message {
    public:
        explicit type2_message(vector<uint8_t> buffer)
            throw(invalid_argument);
        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)
 */

```



```

#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)
{
    enum { 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
{
    enum { ssp_flags_offset = 20 };
    return pal::read_uint32_from_little_endian(&buffer_[ssp_flags_offset]);
}

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

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

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    enum { 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
{
    enum { ssp_flags_offset = 20 };
    return pal::read_uint32_from_little_endian(&buffer_[ssp_flags_offset]);
}

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

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

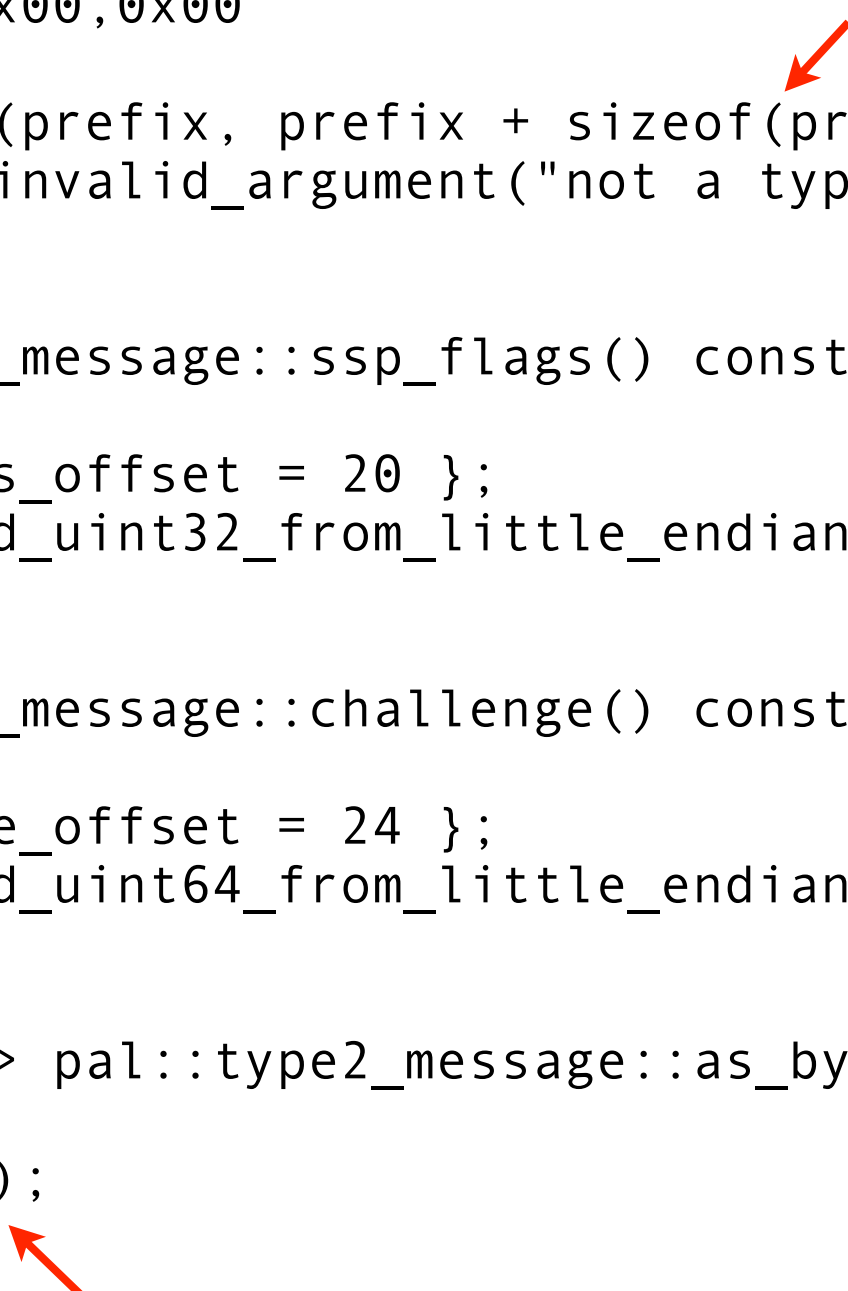


```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
{
    enum { min_type2_buffer_size = 32 };
    if (buffer.size() < min_type2_buffer_size)
        throw std::invalid_argument("not a type2 message, message too short");
    const uint8_t prefix[12] = {
        '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
{
    enum { ssp_flags_offset = 20 };
    return pal::read_uint32_from_little_endian(&buffer_[ssp_flags_offset]);
}

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

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
```

```
#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 <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 <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");  
}
```

...

...

```
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 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())
        << "lm_response = " << pal::as_hex_string(lm_response_)
        << "\nnt_response = " << pal::as_hex_string(nt_response_)
        << "\ndomain = " << domain_
        << "\nuser = " << user_
        << "\nworkstation = " << workstation_
        << "\nsession_key = " << pal::as_hex_string(session_key_)
        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
}
```

...

...

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

...

Recap

ntlm_message.hpp


```
#include <vector>
```

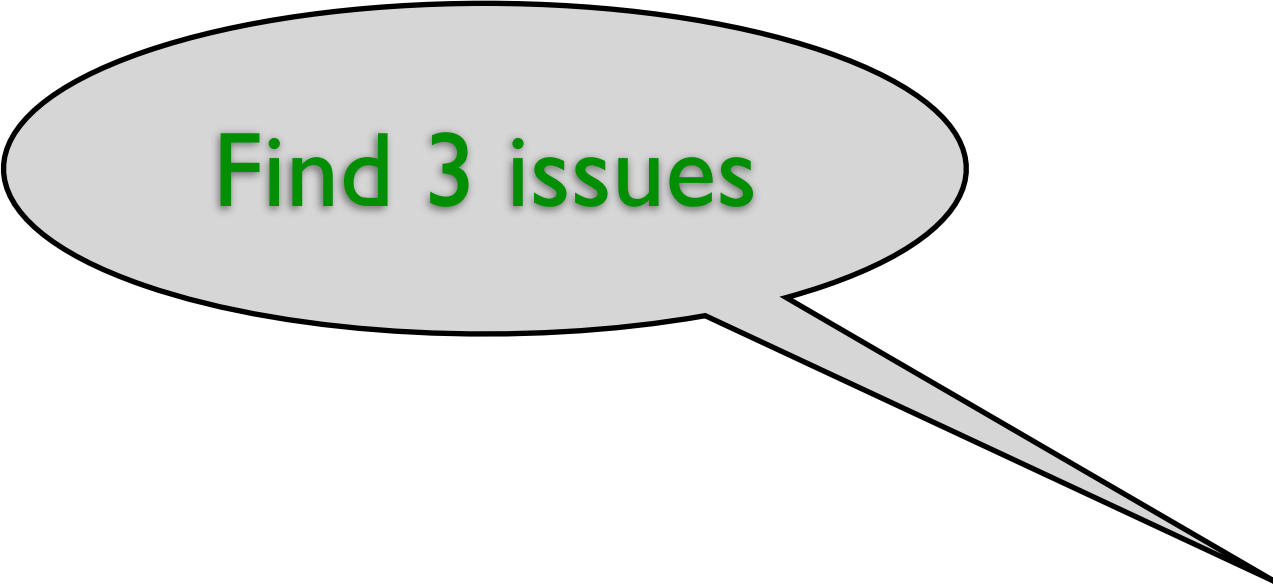
```
namespace pal {
```

```
    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 {
```

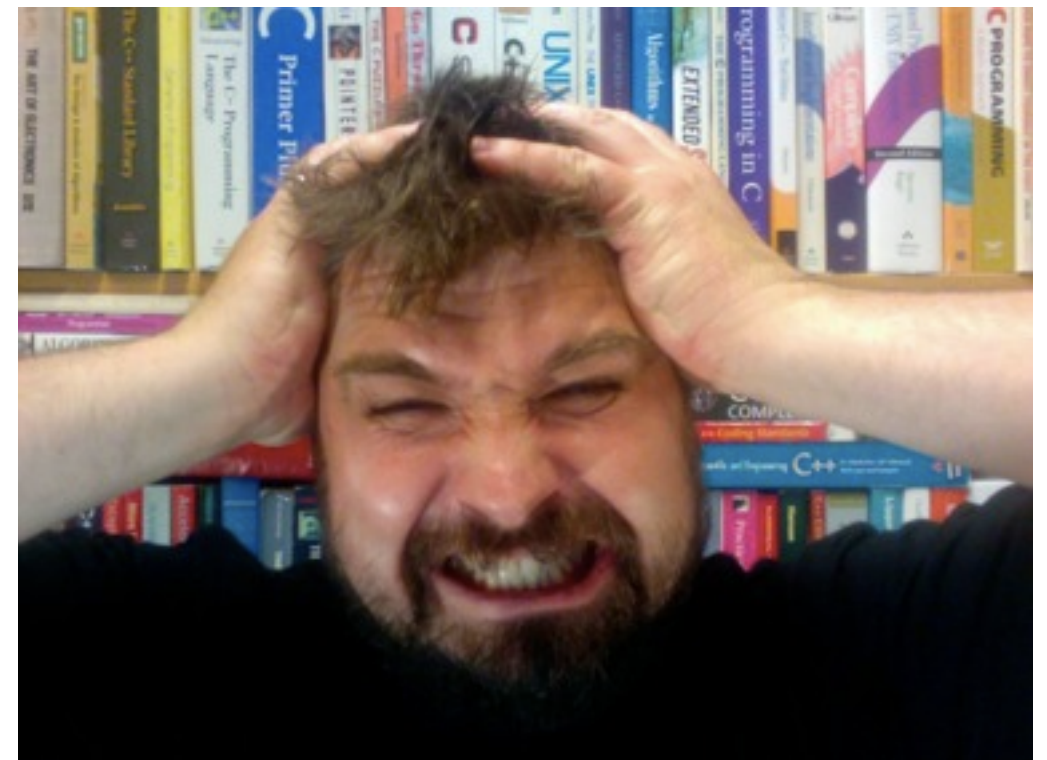
```
class ntlm_message {
```

public:

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

} ;

}



```
#include <vector>
```

```
namespace pal {
```

```
class ntlm_message {
```

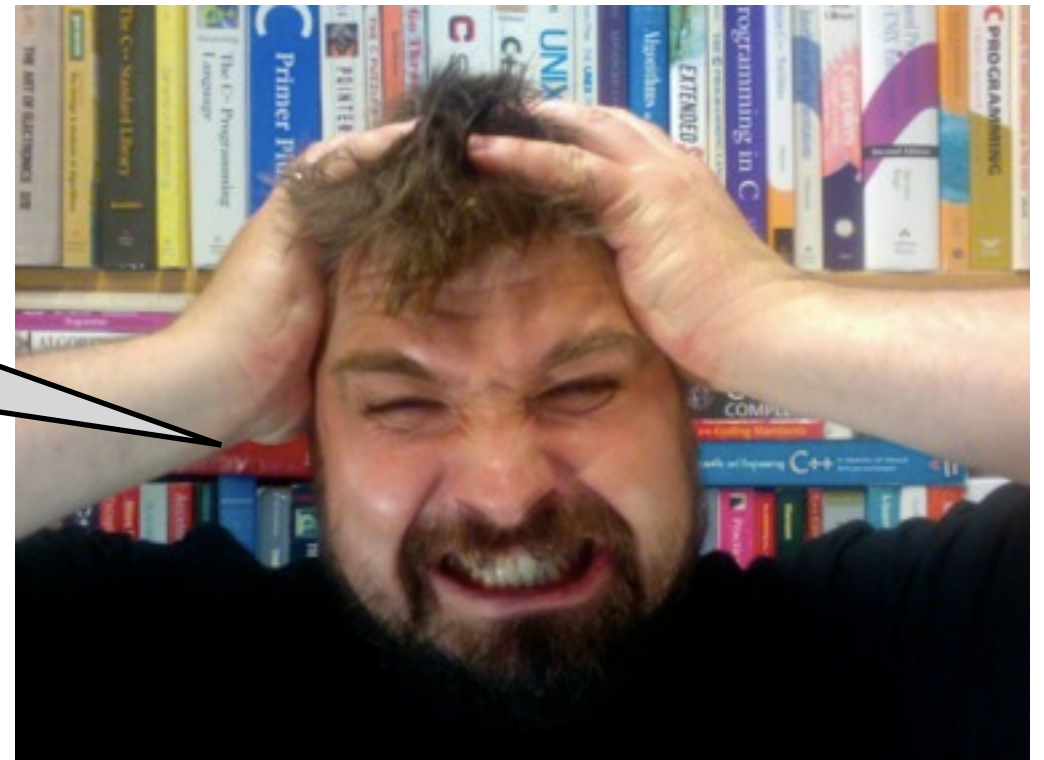
```
public:
```

```
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;
    };

}

#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
```



```
#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 {

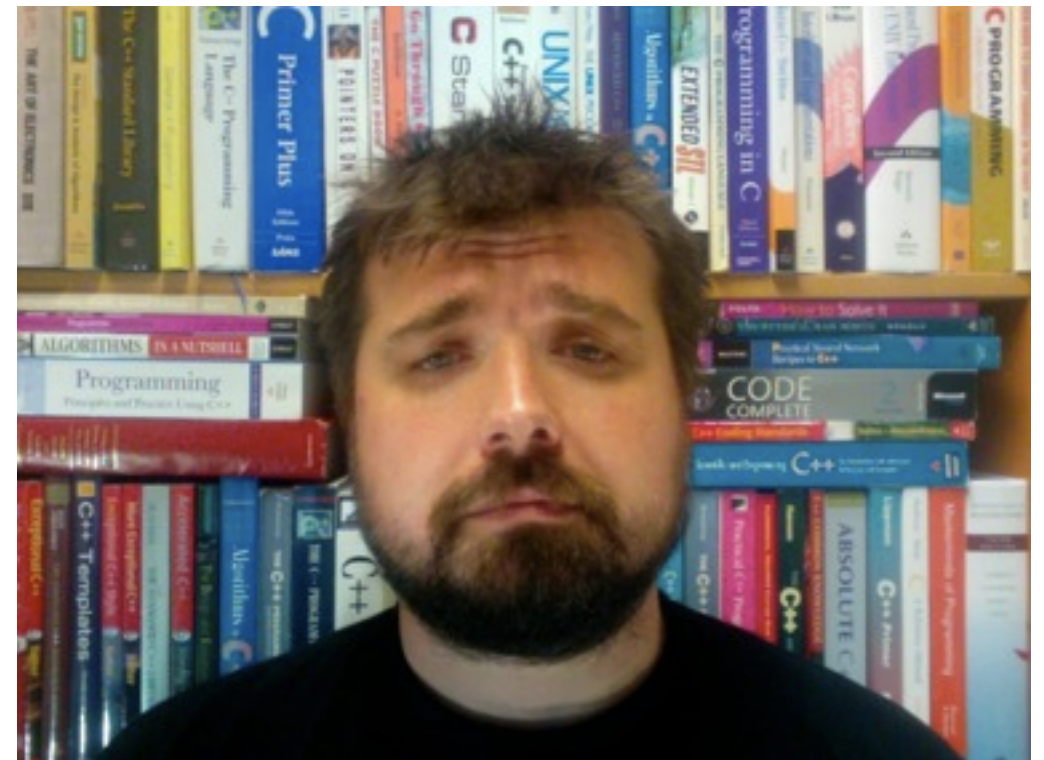
    class type1_message : public ntlm_message {
        uint32_t ssp_flags_;
    public:
        type1_message(uint32_t ssp_flags);
        virtual std::vector<uint8_t> as_bytes() const;
    };

}

#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
```

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





```
#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
```

**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);
        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 {
        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 {

        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
```

```
#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
```

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

}

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

}

#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 {
    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"
```

Find at least 3
issues here

```
/*  
 * 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"
 * 8    NTLM Message Type           {0x01, 0x02}
 * 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.h"
```

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

m.html

```
NTLMSSP
0x01, 0x0
uint32 as
(security
(security barrier)
```

```
* (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);
}
```



```
#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}  
 * 12 Flags uint32 as defined in RFC 2831  
 * (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  
 *  
 * Type 1 Message  
 *  
 * 0  NTLMSSP Signature  
 * 8  NTLM Message Type  
 * 12 Flags  
 * (16) Supplied Domain (optional)  
 * (24) Supplied Workstation (optional)  
 * (32) (start of datablock) if required  
 */
```

"NTLMSSP"
{0x01, 0x00, 0x00, 0x00}
uint32 as
(security barrier)

```
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  
 * 8 NTLM Message Type  
 * 12 Flags  
 * (16) Supplied Domain (optional)  
 * (24) Supplied Workstation (optional)  
 * (32) (start of datablock) if required  
 */
```

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

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

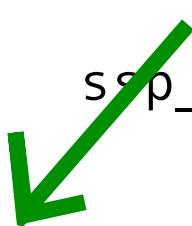
```
vector<uint8_t> pal::type1_message::as_bytes() const  
{  
    uint8_t message[16] = {  
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\\0',  
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
    };  
    const int ssp_flags_offset = 12;  
    pal::write_little_endian_from_uint32(&message[ssp_flags_offset],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



```
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;
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```
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);
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```
#include "type1_message.hpp"
```

```
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```
/*  
 * 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)  
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 */
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```
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std::vector<uint8_t> pal::type1_message::as_bytes() const  
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        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0  
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```
#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)
{
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}
```

```
std::vector<uint8_t> pal::type1_message::as_bytes() const
{
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        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0
    };
    const int ssp_flags_offset = 12;
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#include "tools.hpp"
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```
/*
 * 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)
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```
pal::type1_message::type1_message(uint32_t ssp_flags)
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        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);
}
```



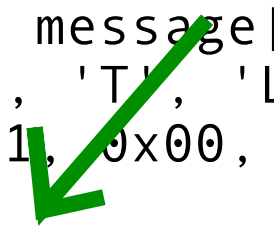
```
#include "type1_message.hpp"
```

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

```
/*
 * See http://davenport.sourceforge.net/ntlm.html
 *
 * Type 1 Message
 *
 * 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 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}  
 * 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)  
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    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);  
}
```

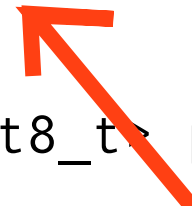
```
#include "type1_message.hpp"
```

```
#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)
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```

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




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

```
#include "tools.hpp"
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```
/*
 * 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 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}
 * 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
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        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x01, 0x00, 0x00, 0x00, 0, 0, 0, 0
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```
/*
 * 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 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}  
 * 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 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);  
}
```

[illegible]

This is better

```
"NTLMSSP"
{0x01, 0x00, 0x00, 0x00}
uint32 as
(security
(security buffer)
```

```
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);
}
```

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
```



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
```

```
#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"

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(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(      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

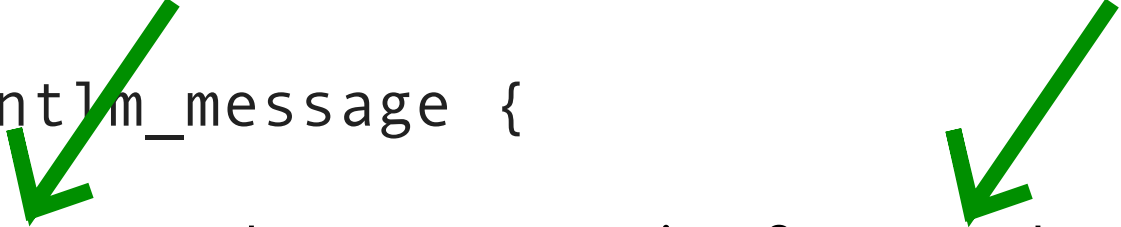
#include "ntlm_message.hpp"

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

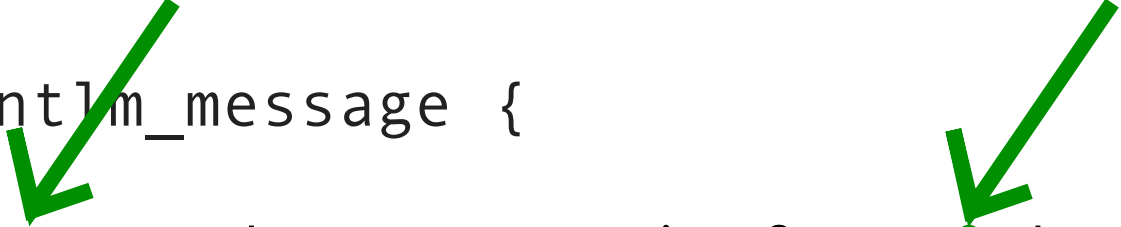
#include "ntlm_message.hpp"

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

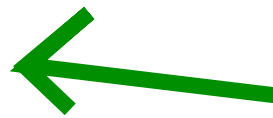
#include "ntlm_message.hpp"

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

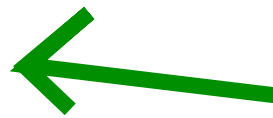
#include "ntlm_message.hpp"

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++

```
E2_MESSAGE_HPP_INCLUDED
E2_MESSAGE_HPP_INCLUDED
```

```
#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)
 * (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 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)
 */
```



... page 1 of 2

this is not a good way
to order the include files

```
#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)
 * (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 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)
 */
```

... 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)
 */
```

... 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_.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

magic numbers

```
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");
    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(

```

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

```
std::vector<uint8_t> pal::type2_message::as_b
{
    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_.data(), 8);
}
```

```
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
```

```
{
    return pal::read_uint64_from_little_endian
}
```

```
std::vector<uint8_t> pal::type2_message::as_b
```

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

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{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

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{
    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_);
}
```

... 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");
}

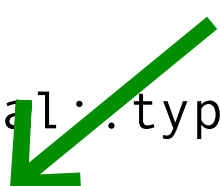
uint32_t pal::type2_message::ssp_flags() const
{
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

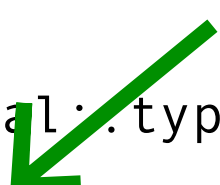
uint64_t pal::type2_message::challenge() const
{
    return pal::read_uint64_from_little_endian(&buffer_[24]);
}

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
{
    
    const std::size_t ssp_flags_offset = 20;
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

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

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

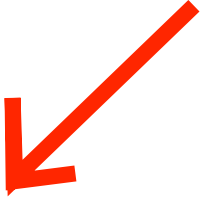
... page 2 of 2

```
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
{
    const std::size_t ssp_flags_offset = 20;
    return pal::read_uint32_from_little_endian(&buffer_[20]);
}

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

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



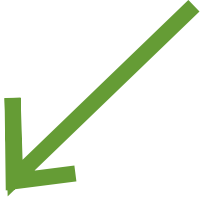
... page 2 of 2

```
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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    const uint8_t prefix[12] = {
        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
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{
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uint64_t pal::type2_message::challenge() const
{
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std::vector<uint8_t> pal::type2_message::as_bytes() const
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```



... page 2 of 2

```
pal::type2_message::type2_message(const std::vector<uint8_t> & buffer)
    : buffer_(buffer)
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uint32_t pal::type2_message::ssp_flags() const
{
    const std::size_t ssp_flags_offset = 20;
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uint64_t pal::type2_message::challenge() const
{
    const std::size_t challenge_offset = 24;
    return pal::read_uint64_from_little_endian(&buffer_[challenge_offset]);
}

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



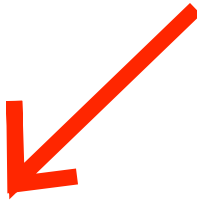
... page 2 of 2

```
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
{
    const std::size_t ssp_flags_offset = 20;
    return pal::read_uint32_from_little_endian(&buffer_[ssp_flags_offset]);
}

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

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



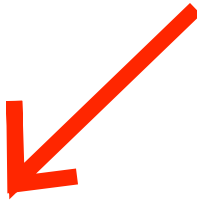
... page 2 of 2

```
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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        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof prefix, buffer.begin()))
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}

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

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

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



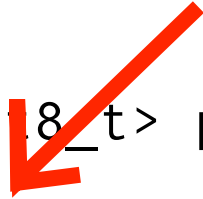
... page 2 of 2

```
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
{
    const std::size_t ssp_flags_offset = 20;
    return pal::read_uint32_from_little_endian(&buffer_[ssp_flags_offset]);
}

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

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



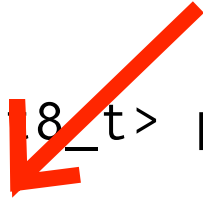
... page 2 of 2

```
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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        'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0',
        0x02, 0x00, 0x00, 0x00
    };
    if (!std::equal(prefix, prefix + sizeof prefix, buffer.begin()))
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}

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

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

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;
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        0x02, 0x00, 0x00, 0x00
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        throw std::invalid_argument("not a type2 message, invalid prefix");
}

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

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

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
{
    const std::size_t ssp_flags_offset = 20;
    return pal::read_uint32_from_little_endian(&buffer_[ssp_flags_offset]);
}

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

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

#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

```



Find 3 issues

include <iosfwd> instead

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

```
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 <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
```



SS
S
ge

this default argument is
probably not needed

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

```
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 <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_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,
        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
```

useless explicit specifier



```
#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 <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"

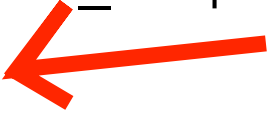
#include <string>
#include <iosfwd>

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"

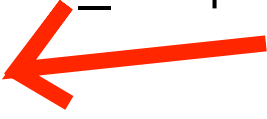
#include <string>
#include <iosfwd>

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
```


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");  
}
```

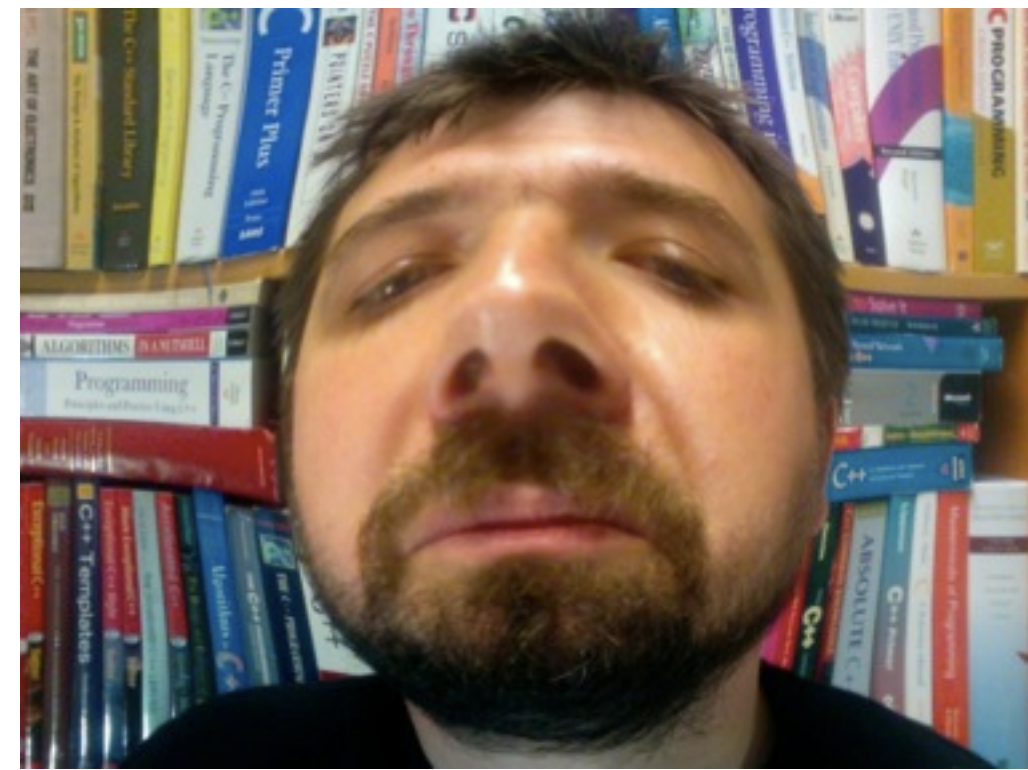
...



...

```
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

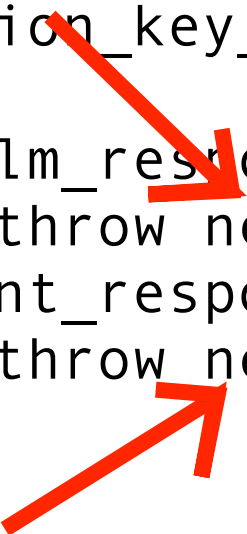
```
pal::type3_message::type3_message(
    const std::vector<uint8_t> & lm_response,
    const std::vector<uint8_t> & nt_response,
    const std::string & user,
    uint32_t ssp_flags)
:
    lm_response_(lm_response),
    nt_response_(nt_response),
    user_(user),
    ssp_flags_(ssp_flags),
    session_key_(session_key_size)
{
    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");
}
```

...



...

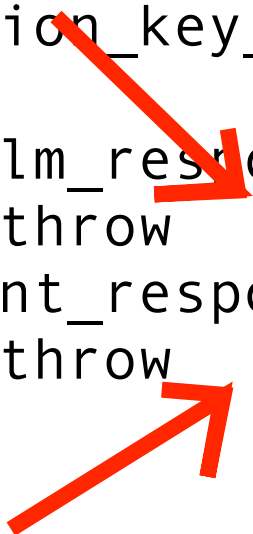
```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
    const std::vector<uint8_t> & nt_response,  
    const std::string & user,  
    uint32_t ssp_flags)  
:  
    lm_response_(lm_response),  
    nt_response_(nt_response),  
    user_(user),  
    ssp_flags_(ssp_flags),  
    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,  
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    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");  
}
```



...

...

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pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
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:  
    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)  
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pal::type3_message::type3_message(  
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:  
    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)  
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pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
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    lm_response_(lm_response),  
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    session_key_(session_key_size),  
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    if (lm_response_.size() != lm_response_size)  
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    ssp_flags_(ssp_flags)  
{  
    if (lm_response_.size() != lm_response_size)  
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...

...

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pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
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    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");  
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:  
    lm_response_(lm_response),  
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    domain_(),  
    user_(user),  
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{  
    if (lm_response_.size() != lm_response_size)  
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}
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...

...

Much better!

```
pal::type3_message::type3_message(  
    const std::vector<uint8_t> & lm_response,  
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:  
    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())
        << "lm_response = " << pal::as_hex_string(lm_response_)
        << "\nnt_response = " << pal::as_hex_string(nt_response_)
        << "\ndomain = " << domain_
        << "\nuser = " << user_
        << "\nworkstation = " << workstation_
        << "\nsession_key = " << pal::as_hex_string(session_key_)
        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
}
```

...

Any issues here?

...

```
void pal::type3_message::debug_print(std::ostream & out) const
{
    out << "### type3_message:" << '\n'
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```

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...

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        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
}
```

...

DO NOT MESS WITH BORROWED THINGS!



...

```
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...

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        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
}
```

...

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



...

```
void pal::type3_message::debug_print(std::ostream & out) const
{
    out << "### type3_message:" << '\n'
        << pal::as_hex_dump(as_bytes())
        << "lm_response = " << pal::as_hex_string(lm_response_)
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        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
}
```

...

...

```
std::string pal::type3_message::debug_print() const
{
    std::ostringstream buf;
    buf << "### type3_message:" << '\n'
        << pal::as_hex_dump(as_bytes())
        << "lm_response = " << pal::as_hex_string(lm_response_)
        << "\nnt_response = " << pal::as_hex_string(nt_response_)
        << "\ndomain = " << domain_
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        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
    return buf.str();
}
```

...



...

```
std::string pal::type3_message::debug_print() const
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    std::ostringstream buf;
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        << std::hex << std::setw(8) << std::setfill('0')
        << "\nssp_flags = " << ssp_flags_;
    return buf.str();
}
```

...

Big improvement!



...

```
std::string pal::type3_message::debug_print() const
{
    std::ostringstream buf;
    buf << "### type3_message:" << '\n'
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    return buf.str();
}
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...

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20. avoid default arguments (they are often not used anyway)

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20. avoid default arguments (they are often not used anyway)
21. do not throw pointers to exceptions (eg, not "throw new ...")

Issues discussed here

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2. header files should have header guards
3. make sure you include the proper header files, especially in header files
4. no need to include files included by the base class declaration
5. single argument constructors should be specified as explicit
6. focus on usage of class; public stuff first, then private stuff
7. always focus on readability, you spend more time reading code than writing it
8. importing a namespace in implementation files is usually not a good idea
9. "never" import a namespace in a header file
10. initialize objects properly, use the initialization list
11. prefer `std::size_t` when working with memory indexing and offsets
12. for non-trivial objects, prefer pass by const over pass by copy
13. query methods should be specified as const
14. order the include files like this; own, project/platform, standard
15. avoid magic numbers, use explanation variables
16. avoid superfluous use of `()`
17. prefer forward declarations when you can
18. do not use explicit on multi argument constructors
19. consider explainability, don't do things that needs elaborate explanations
20. avoid default arguments (they are often not used anyway)
21. do not throw pointers to exceptions (eg, not "throw new ...")
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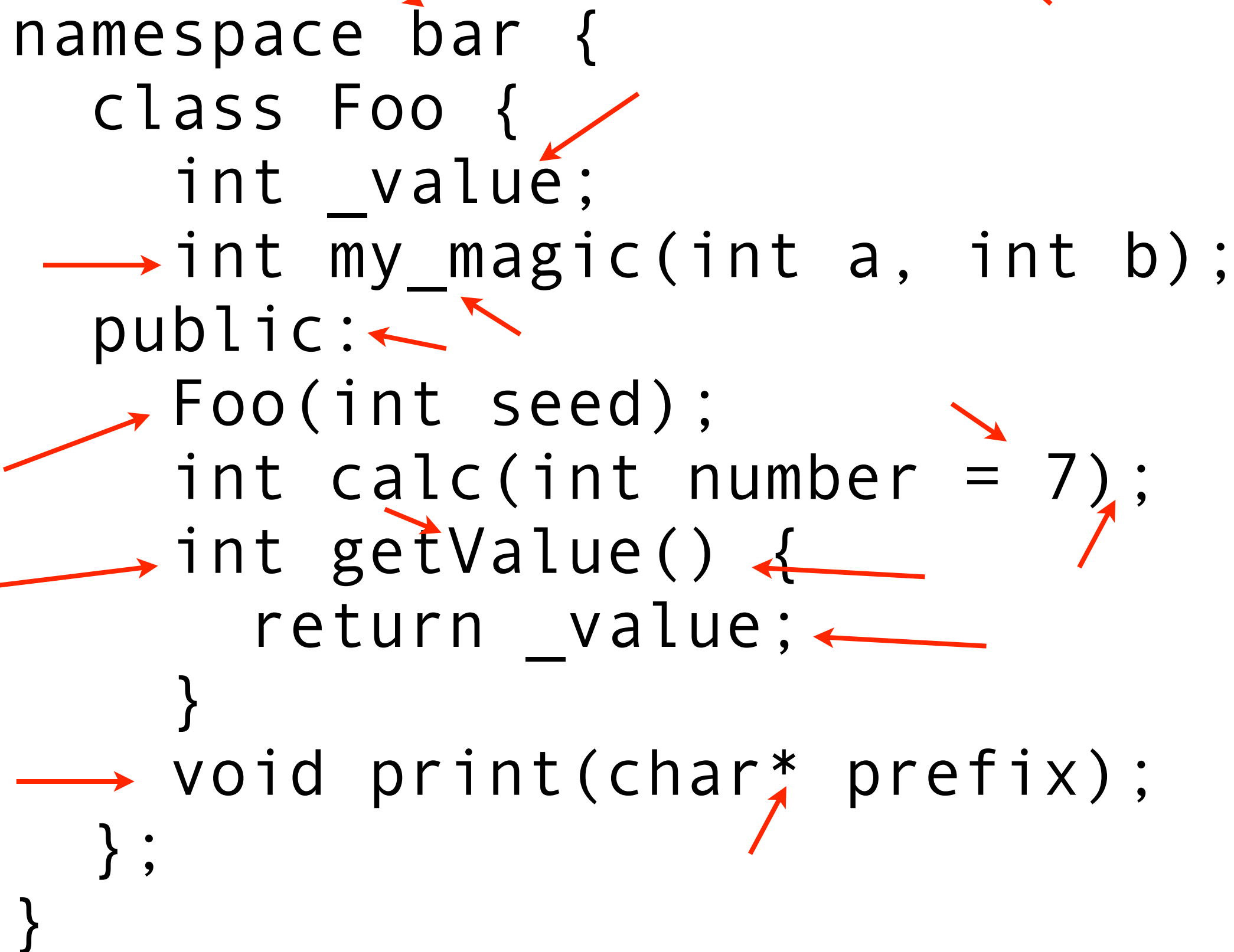
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25. always consider the sideeffects of what you do

are you now able to spot the “broken” C++?

~/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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        void print(char* prefix);  
    };  
}
```

The image shows a C++ code snippet with several red arrows pointing to specific parts of the code. The arrows point to the following elements:

- The opening curly brace of the `namespace bar` block.
- The `bar` namespace name.
- The `_value` member variable.
- The `my_magic` member function.
- The `public:` access specifier.
- The `Foo` class name in the constructor `Foo(int seed);`.
- The `number` parameter in the `calc` function `int calc(int number = 7);`.
- The `7` default value in the `calc` function.
- The `getValue` member function.
- The opening curly brace of the `getValue` function body.
- The `_value` member variable in the `return` statement.
- The `print` member function.
- The `char*` pointer type in the `print` function signature.



!