一道MMS工控协议CTF题的WriteUp

原创

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分类专栏： CTF 文章标签： 工控安全

本文链接：https://blog.csdn.net/cn_lyxc/article/details/94832631

0x01 赛题说明

> 赛题说明：
> 只能变电站通过 61850 规约进行监控层到间隔层的数据采集，请分析网络数据包，了解 MMS 规约，进一步发现数据中隐藏的 flag。

题目:question_1531222544_JYvFGmLP49PFC0R2.pcap.zip(下载见最下方的百度云传送门)

0x02 背景知识

MMS即制造报文规范，是ISO/IEC9506标准所定义的一套用于工业控制系统的通信协议。

此处不介绍关于 MMS 协议的具体内容，只做报文简单讲解。

如果有兴趣，可以阅读此文：MMS（见最下方的百度云传送门）

1、Initiate

```
MMSPdu Received ::=
A8 25 80 02 08 00 81 01 05 82 01 05 83 01 05 A4 16 80 01 01 81 03 05 F8 00 82 0C 03 EE 19 00 18 00 02 00 00 00 F
D 18

Tag Length Value -- Tag definition

--------------------------------------------------------------------------------------------
```

```
[8] A8  25  -- initiate-RequestPDU,

    A8 = 1010 1000;

    bit7,6 = Tag type, 00 = Universal tag, 10 = Context specific

    bit5 = , 0 = Primitive, 1 =  Contructed

    (

         00 0 = INTEGER, BITSTRING, BOOLEAN

         00 1 = SEQUENCE, SEQUENCE OF

         10 0 = IMPLICIT

         10 1 = IMPLICIT SEQUENCE, IMPLICIT SEQUENCE OF

     )

    bit4-0 = Value, for primitive Universal tags, value defined in ASN.1, other use [x] in MMS.



{

        [0] 80  02  08 00 -  localDetailCalling (maxProposedMMSPduSize) = 2048 bytes

        [1] 81 01 05  --  proposedMaxServOutstandingCalling

        [2] 82 01 05  --   proposedMaxServOutstandingCalled

        [3] 83 01 05  --  proposedDataStructureNestingLevel

        [4] A4 16 --  mmsInitRequestDetail

    {

            [0] 80 01 01  --  proposedVersionNumber, MMS ISO IS 9506

            [1] 81 03 05 F8 00  --  proposedParameterCBB,

            BitString(11 bits used)

            05 = indicate number of unused bit

            F8 00

            {

                    str1 (bit 0 / array support / MSB of F8)  --  supported

                    str2 (bit 1 / structure support)  --  supported

                    vnam (bit 2 / named variable support)  --  supported

                    valt(bit 3 /alternate access support)  --  supported
```

```
                    vadr(bit 4/ unnamed variable support)  --  supported

                    viscera(bit 5/ scattered access support)  --  not-supported

                    toy(bit 6/ third party operations support)  --  not-supported

                    villas(bit 7/ named variable list support)  --  not-supported

                    real(bit 8 / ASN.1 real data type support)  --  not-supported

                    ache(bit 9/ acknowledge event conditionsupport)  --  not-supported

                    chi(bit 10 / condition event support)  --  not-supported

            }

    [2] 82 0C 03 EE 19 00 18 00 02 00 00 00 FD 18 --  servicesSupportedCalling, see ISO/IEC-9506

    }

}
```

2、Initiate-Response

```
MMSPdu Received ::=

A9 25 80 02 08 00 81 01  05 82 01 05 83 01 05 A416 80 01 01 81 03 05 F8  00 82 0C 03 EE 19 00 18 00 02 00 00 00
FD 18



[9] A9 25  --  Initiate-ResponsePDU

{

        [0] 80 02 08 00  --  localDetailCalled

        [1] 81 01 05  --  negotiatedMaxServOutstandingCalling

        [2] 82 01 05  --  negotiatedMaxServOutstandingCalled

        [3] 83 01 05  --  negotiatedDataStructureNestingLevel

        [4] A4 16

        {

                [0] 80 01 01  --  negotiatedVersionNumber

                [1] 81 03 05 F8 00  --  negotiatedParameterCBB

                [2] 82 0C 03 EE 19 00 18 00 02 00 00 00 FD 18  --  servicesSupportedCalled

        }

}
```

3、Identify

MMSPdu Received ::=

A0 05 02 01 01 82 00

[0] A0 05 -- Confirmed-RequestPDU

{

    02 01 01 -- invokeID

    (02 = 000 0 0010, Universal Primitive tag, Tag Value = 2 = Integer.)

    [2] 82 00 -- ConfirmedServiceRequest, 82 = Request identify

}

where, invokeID ::=01

4、Identify-Response

MMSPdu Received ::=

A1 2A 02 01 01 A2 25 80 0B 53 49 53 43 4F 2C 2049 6E 63 2E 81 10 41 58 53 34 2D 4D 4D 53 2D 3133 32 2D 30 31 3
8 82 04 32 2E 30 30

[1] A1 2A -- Confirmed-ResponsePDU

{

    02 01 01 -- invokeID, Integer

    [2] A2 25 -- ConfirmedServiceResponse, A2 = Response identify.

    {

            [0] 80 0B 53 49 53 43 4F 2C 20 49 6E 63 2E -- vendorName

            [1] 81 10 41 58 53 34 2D 4D 4D 53 2D 31 33 32 2D 30 31 38 --   modelName

            [2] 82 04 32 2E 30 30 -- revision

    }

}

where,

invokeID::=01 note: matching of response to is done by matching invokeID with response invokeID.

vendorName::="SISCO, Inc"

modelName::="AXS4-MMS-132-018"

revision::="2.00"

check [MMS and ASN.1 Encoding] page 10.

5、Read-Request

```
MMSPdu Received ::=

A0 1E 02 01 0A A4 19 A1  17 A0 15 30 13 A0 11 80 0F 66 65 65 64 65 72 31  5F 33 5F 70 68 61 73 65


[0]  A0 1E  --  ConfirmedRequestPDU

{

    02 01 0A  --  invokeID

    [4] A4 19  --  ConfirmedServiceRequest, A4 = Read

    {

        [1] A1 17  --  variableAccessSpecification

        {

            [0] 30 13  --  listOfVariable

            (30 = 00 1 10000, Universal Constructed)

            {

                [0] A0 11  --  variableSpecification

                {

                    [0] 80 0F 66 65 65 64 65 72 31 5f 33 5f 70 68 61 73 65  --  name

                }

            }

        }

    }

}

where,

invokeID::=0A

Identifier (name of variable to read)::="feeder1_3_phase"
```

6、Read -Response

```
Assume

    typedef struct var_def

    {

        int a;

        int b;
```

```
    } VAR_DEF;

    VAR_DEF feeder1_3_phase;
```

MMS Data Production

```
    Data ::= CHOICE

    {

            [1] IMPLICIT SEQUENCE OF,-- arrayed data

            [2] IMPLICIT SEQUENCE OF,-- structured data

            [3] IMPLICIT BOOLEAN,

            [4] IMPLICIT  BIT STRING,

            [5] IMPLICIT INTEGER,-- signed int

            [6] IMPLICIT INTEGER,-- unsigned int

            [7] IMPLICIT Floating Point,

            [9] IMPLICIT OCTET STRING,

            [10] IMPLICIT VisibleString,

            [11] IMPLICIT GeneralizedTime,

            [12] IMPLICIT TimeofDay,

            [13] IMPLICIT INTEGER,-- BCD

            [14] IMPLICIT BIT STRING,-- boolean array

            [15] IMPLICIT OBJECT IDENTIFIER

    }
```

The encoded structure of the encoded data can be determined via VAR_DEF

```
        VAR_DEF::=          TAG

        ----------------------------------------

        struct {               A2

            inta;              85

            intb;              85

        }
```

```
MMSPdu Received ::=

A1 0F 02 01 0A A4 0A A1  08 A2 06 85 01 00 85 0100

[1] A1 0F  --  ConfirmedResponsePDU

{

    02 01 0A  --  invokeID

    [4] A4 0A  --  ConfirmedServiceResponse, A4 = Read

    {

        [1] OF A1 08  --  listOfAccessResult

            {
                A2 06  --  success, Data of struct

                {
                    85 01 00  --  int a;
                    85 01 00  --  int b;
            }

        }

    }

}

where,

invokeID::=0A

value of a::=00, value of b::=00
```

这里例举了 3 种MMS 报文。

通过分析这三种报文得知MMS协议的规约中的一些结构，如下：

Initiate

initiate-RequestPD结构包含：

- localDetailCalling
- proposedMaxServOutstandingCalling
- proposedMaxServOutstandingCalled
- proposedDataStructureNestingLevel
- mmsInitRequestDetail
- proposedVersionNumber
- proposedParameterCBB
- servicesSupportedCalling等信息

Initiate-ResponsePDU结构包含：

- localDetailCalled
- negotiatedMaxServOutstandingCalling
- negotiatedMaxServOutstandingCalled
- negotiatedDataStructureNestingLevel
- negotiatedVersionNumber
- negotiatedParameterCBB
- servicesSupportedCalled等信息

Identify：

Confirmed-RequestPDU结构包含：

- invokeID
- tag
- ConfirmedServiceRequest等信息

Confirmed-ResponsePDU结构包含：

- invokeID
- ConfirmedServiceResponse
- vendorName
- modelName
- revision等信息

Read：

ConfirmedRequestPDU结构包含：

- invokeID
- ConfirmedServiceRequest
- variableAccessSpecification
- listOfVariable
- variableSpecification
- name等信息

ConfirmedResponsePDU结构包含：

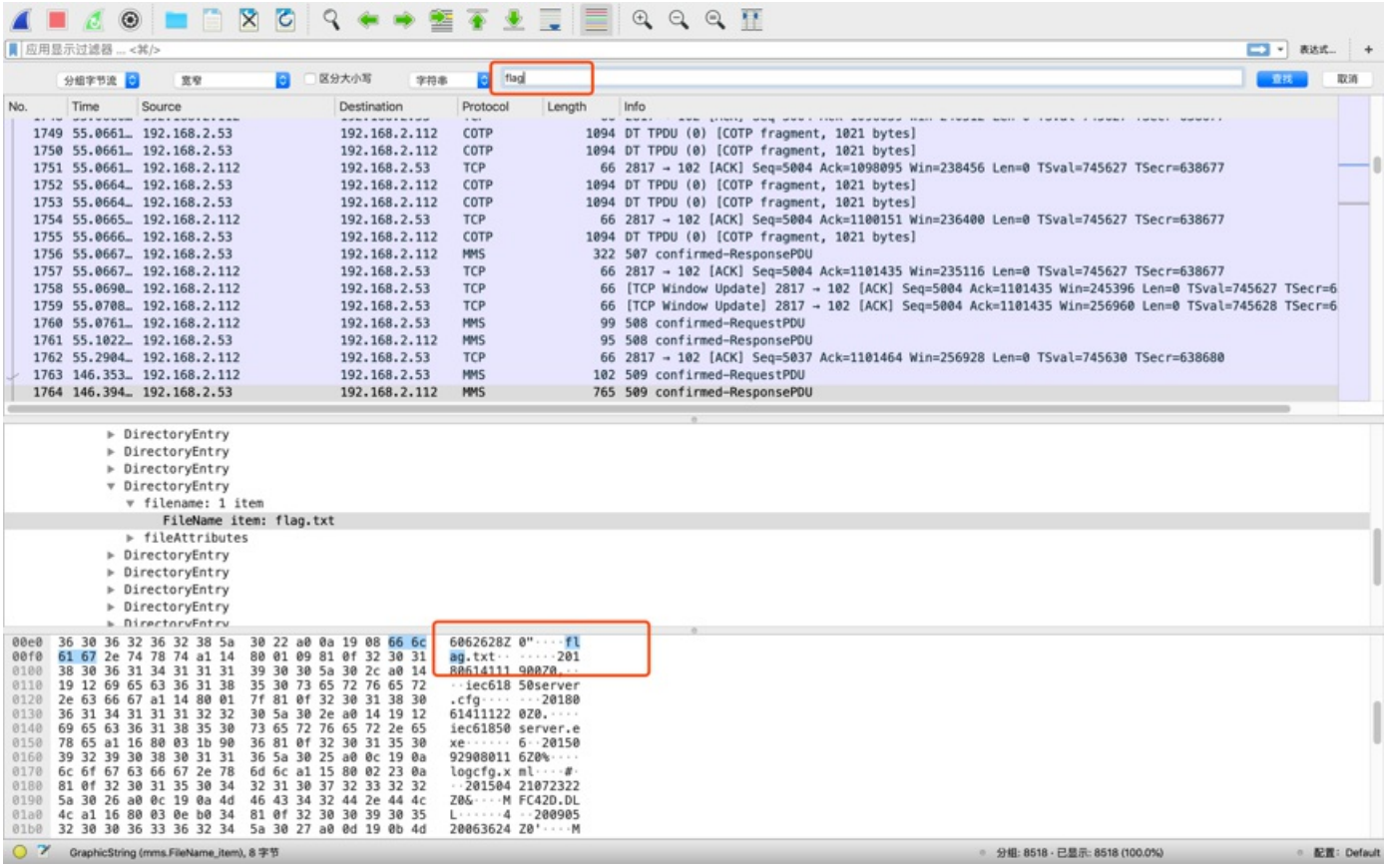
- invokeID
- ConfirmedServiceResponse
- listOfAccessResult等信息

这里仅作简单说明，实际上以上的三种报文并非包含所有的MMS协议的协议数据单元，也没有包含所有的结构

如果有新兴趣研究具体内容，可以下载阅读此文件：GBT16720.2-2005_工业自动化系统_制造报文规范_第2部分_协议规范.pdf（下载见最下方的百度云传送门）

0x03 解题

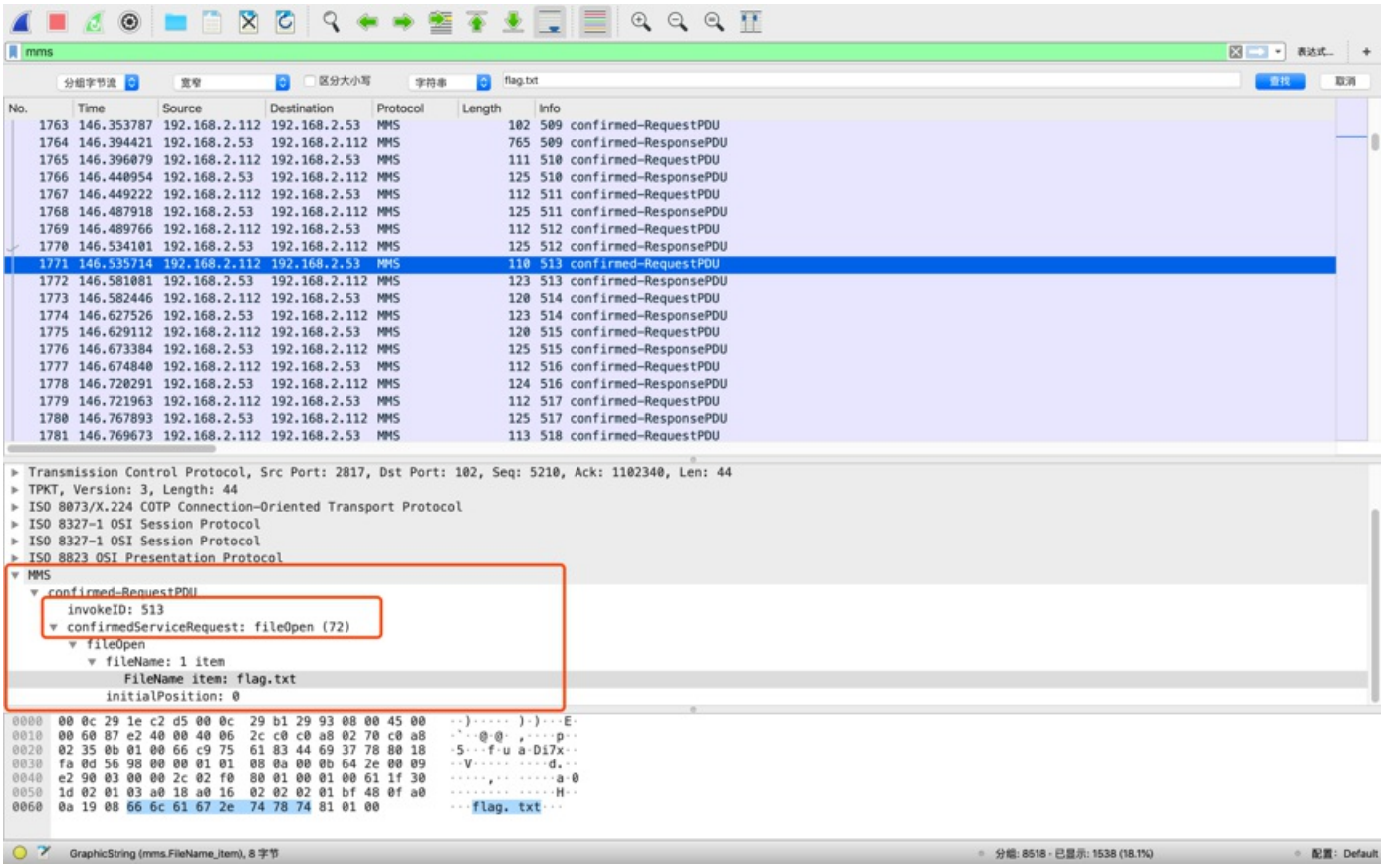
对于数据包分析的 CTF 题目，第一件做的事情就是搜索关键字：flag



通过关键字的搜索可以发现存在 flag.txt，进一步查询此关键字：
在

```
1771 146.535714 192.168.2.112 192.168.2.53 MMS 110 513 confirmed-RequestPDU
```

发现：



如上图所示，这是一个RequestPDU，请求的内容如下：

```
MMS
    confirmed-RequestPDU
        invokeID: 513
        confirmedServiceRequest: fileOpen (72)
            fileOpen
                fileName: 1 item
                    FileName item: flag.txt
                initialPosition: 0
```

对应的是RequestPDU结构

那么根据上文中的知识，存在着对应的 ResponsePDU

但是注意，我们需要的并不是fileOpen（72） 的数据流

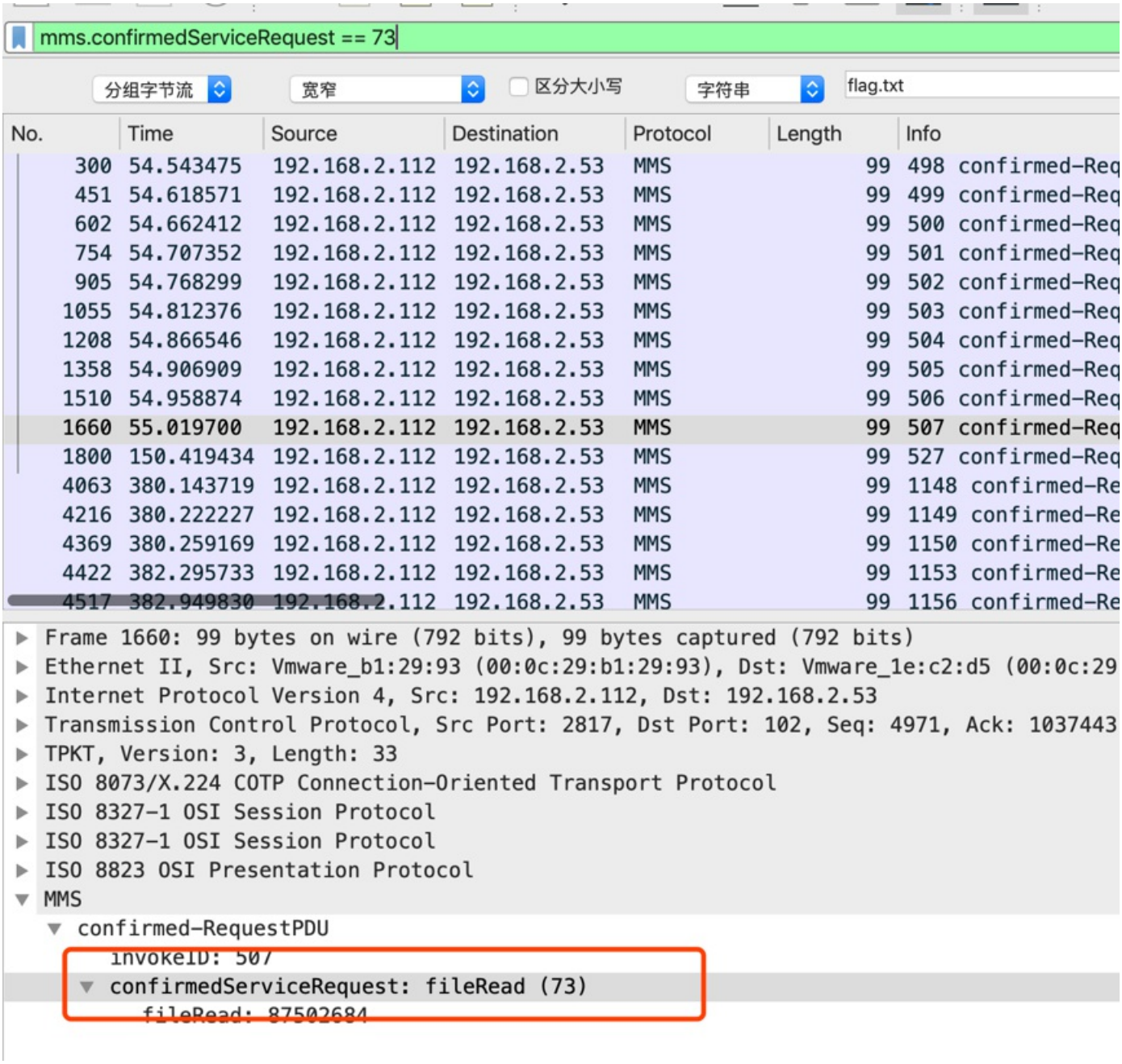
fileOpen 的数据告诉我们的仅仅是打开文件的名字

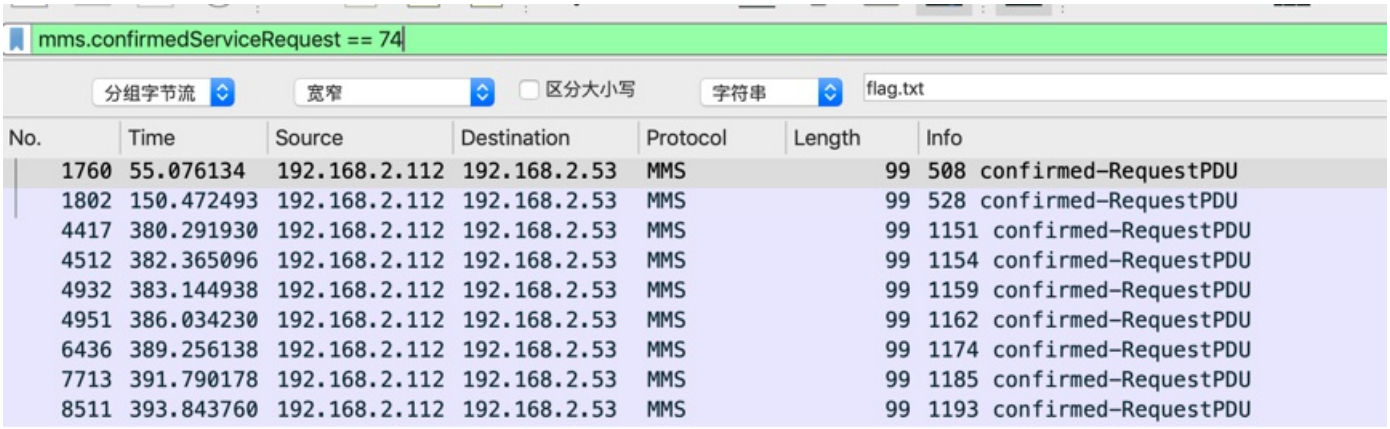
这些文件中存在一个文件名叫 flag.txt的文件，而我们需要的是 fileRead 或是 fileWrite

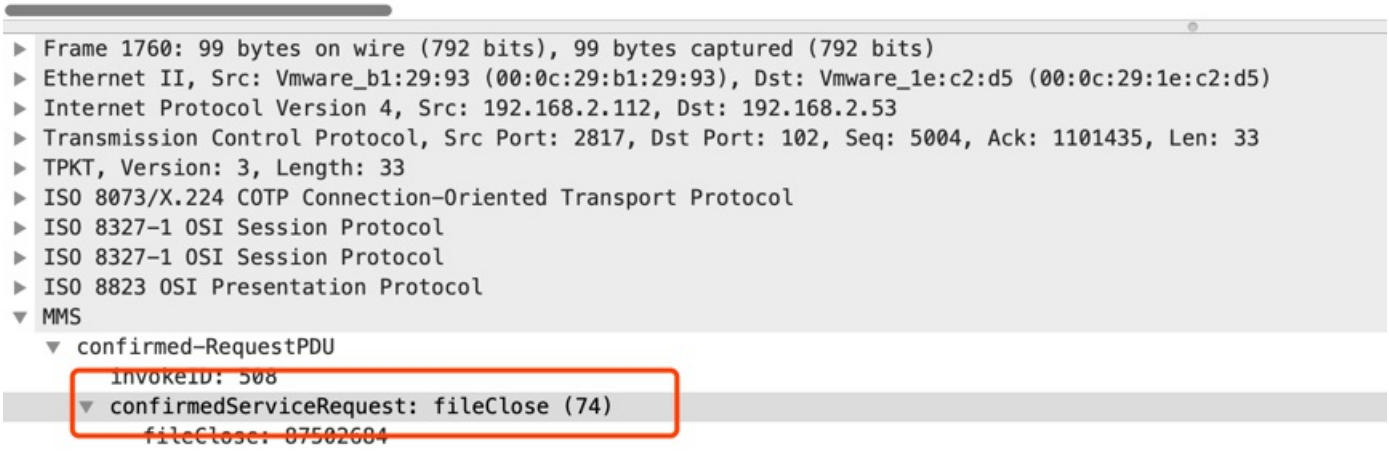
根据上图中，flag.txt所在行 为 1771，那么我们只需要用筛选器筛选出 fileRead 或者 fileWrite 的ResponsePDU

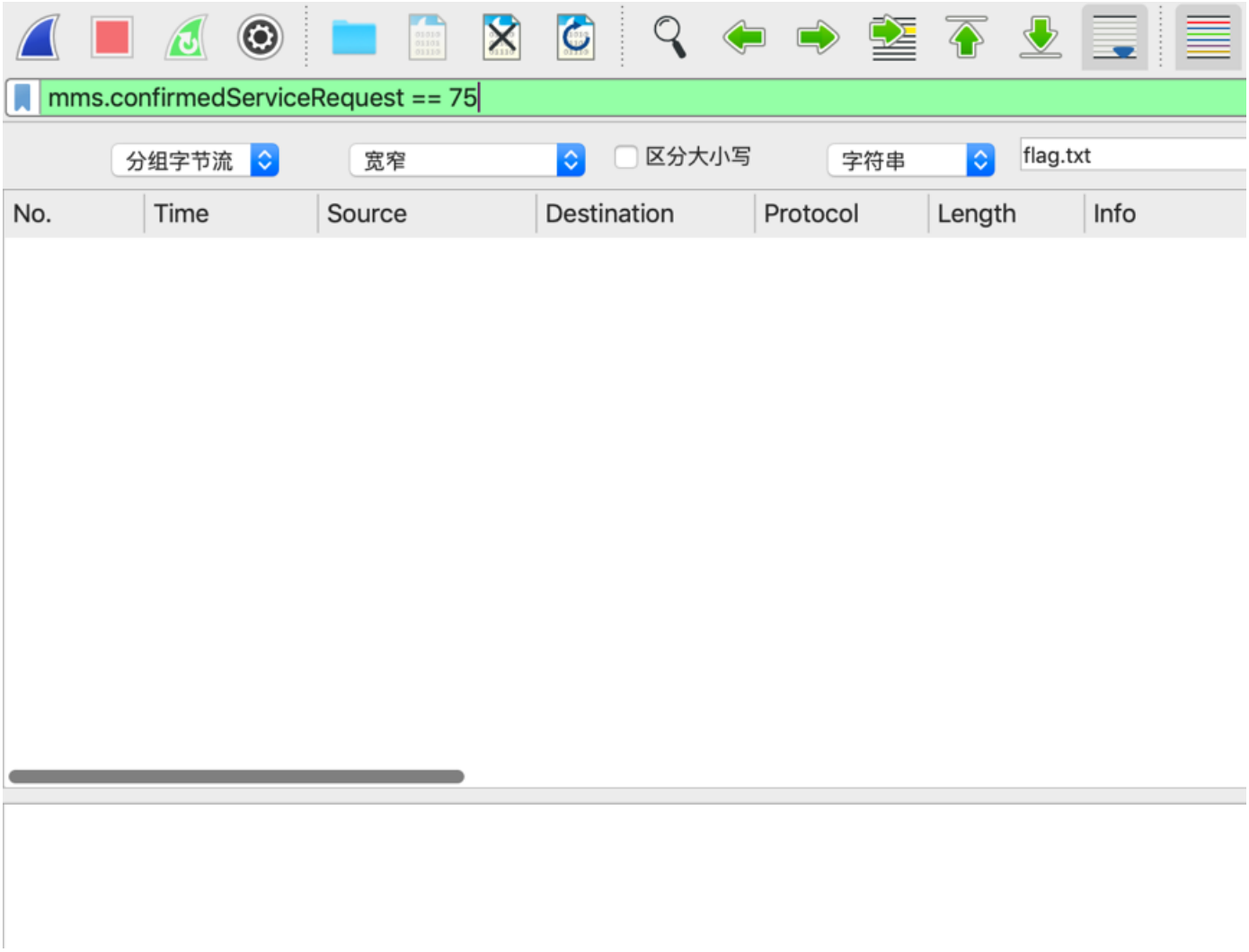
就应该在 1771 后 N 行找到 flag

根据 fileOpen 为 72 来看，73 应该为 fileRead，74 应该为 fileWrite，75 应该为 fileClose
但是发现


mms.confirmedServiceRequest == 73
分组字节流
宽窄
区分大小写
字符串
flag.txt
No. Time Source Destination Protocol Length Info
300 54.543475 192.168.2.112 192.168.2.53 MMS 99 498 confirmed-Req
451 54.618571 192.168.2.112 192.168.2.53 MMS 99 499 confirmed-Req
602 54.662412 192.168.2.112 192.168.2.53 MMS 99 500 confirmed-Req
754 54.707352 192.168.2.112 192.168.2.53 MMS 99 501 confirmed-Req
905 54.768299 192.168.2.112 192.168.2.53 MMS 99 502 confirmed-Req
1055 54.812376 192.168.2.112 192.168.2.53 MMS 99 503 confirmed-Req
1208 54.866546 192.168.2.112 192.168.2.53 MMS 99 504 confirmed-Req
1358 54.906909 192.168.2.112 192.168.2.53 MMS 99 505 confirmed-Req
1510 54.958874 192.168.2.112 192.168.2.53 MMS 99 506 confirmed-Req
1660 55.019700 192.168.2.112 192.168.2.53 MMS 99 507 confirmed-Req
1800 150.419434 192.168.2.112 192.168.2.53 MMS 99 527 confirmed-Req
4063 380.143719 192.168.2.112 192.168.2.53 MMS 99 1148 confirmed-Re
4216 380.222227 192.168.2.112 192.168.2.53 MMS 99 1149 confirmed-Re
4369 380.259169 192.168.2.112 192.168.2.53 MMS 99 1150 confirmed-Re
4422 382.295733 192.168.2.112 192.168.2.53 MMS 99 1153 confirmed-Re
4517 382.949830 192.168.2.112 192.168.2.53 MMS 99 1156 confirmed-Re
Frame 1660: 99 bytes on wire (792 bits), 99 bytes captured (792 bits)
Ethernet II, Src: Vmware_b1:29:93 (00:0c:29:b1:29:93), Dst: Vmware_1e:c2:d5 (00:0c:29
Internet Protocol Version 4, Src: 192.168.2.112, Dst: 192.168.2.53
Transmission Control Protocol, Src Port: 2817, Dst Port: 102, Seq: 4971, Ack: 1037443
TPKT, Version: 3, Length: 33
ISO 8073/X.224 COTP Connection-Oriented Transport Protocol
ISO 8327-1 OSI Session Protocol
ISO 8327-1 OSI Session Protocol
ISO 8823 OSI Presentation Protocol
MMS
confirmed-RequestPDU
invokeID: 507
confirmedServiceRequest: fileRead (73)
fileRead: 87502684

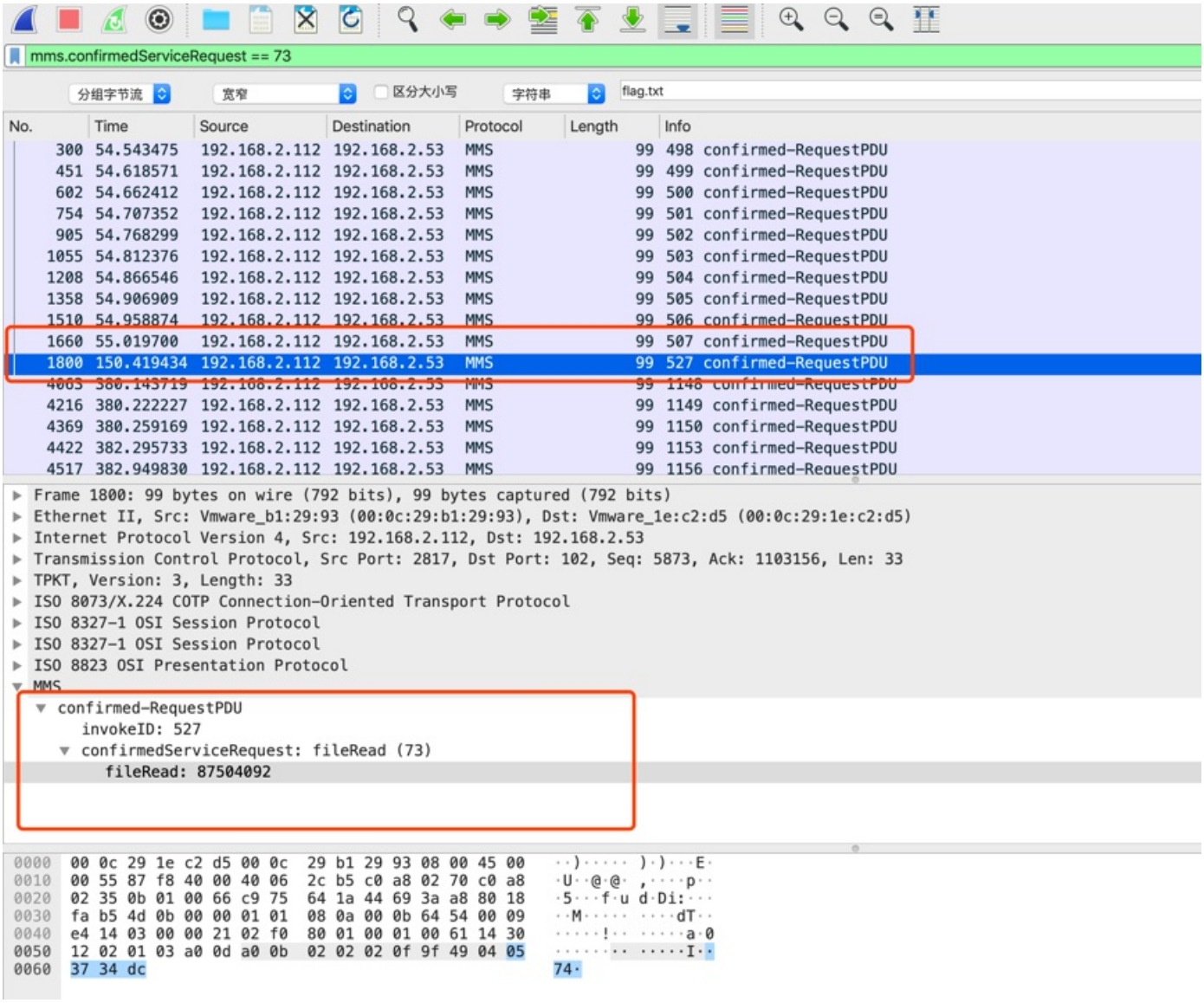

mms.confirmedServiceRequest == 74
分组字节流
宽窄
区分大小写
字符串
flag.txt
No. Time Source Destination Protocol Length Info
1760 55.076134 192.168.2.112 192.168.2.53 MMS 99 508 confirmed-RequestPDU
1802 150.472493 192.168.2.112 192.168.2.53 MMS 99 528 confirmed-RequestPDU
4417 380.291930 192.168.2.112 192.168.2.53 MMS 99 1151 confirmed-RequestPDU
4512 382.365096 192.168.2.112 192.168.2.53 MMS 99 1154 confirmed-RequestPDU
4932 383.144938 192.168.2.112 192.168.2.53 MMS 99 1159 confirmed-RequestPDU
4951 386.034230 192.168.2.112 192.168.2.53 MMS 99 1162 confirmed-RequestPDU
6436 389.256138 192.168.2.112 192.168.2.53 MMS 99 1174 confirmed-RequestPDU
7713 391.790178 192.168.2.112 192.168.2.53 MMS 99 1185 confirmed-RequestPDU
8511 393.843760 192.168.2.112 192.168.2.53 MMS 99 1193 confirmed-RequestPDU


Frame 1760: 99 bytes on wire (792 bits), 99 bytes captured (792 bits)
Ethernet II, Src: Vmware_b1:29:93 (00:0c:29:b1:29:93), Dst: Vmware_1e:c2:d5 (00:0c:29:1e:c2:d5)
Internet Protocol Version 4, Src: 192.168.2.112, Dst: 192.168.2.53
Transmission Control Protocol, Src Port: 2817, Dst Port: 102, Seq: 5004, Ack: 1101435, Len: 33
TPKT, Version: 3, Length: 33
ISO 8073/X.224 COTP Connection-Oriented Transport Protocol
ISO 8327-1 OSI Session Protocol
ISO 8327-1 OSI Session Protocol
ISO 8823 OSI Presentation Protocol
MMS
confirmed-RequestPDU
invokeID: 508
confirmedServiceRequest: fileClose (74)
fileClose: 07502604

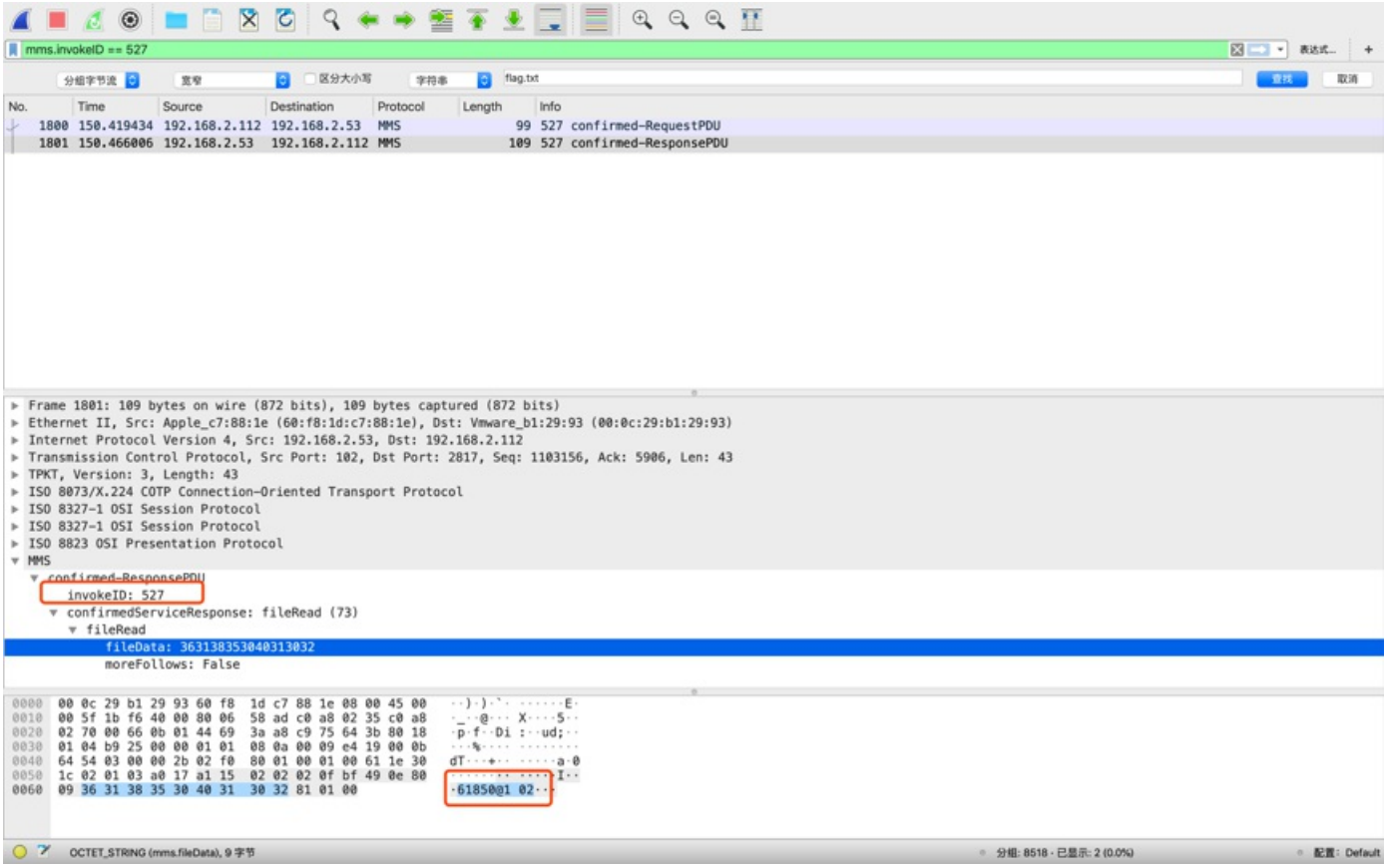


73 为 fileRead 没错，但是 74 为 fileClose ，75 返回的内容为空，即说明不存在 write 的操作。

那么简单明了，做过滤器mms.confirmedServiceRequest == 73，且在 1771 行后寻找读 flag.txt 的filedata



发现在 1771 行后最近的一行为 1800，这行为 RequestPDU，于是找到其对应 invokeID=527 的 ResponsePDU：



根据结果，发现其 fileData 内容为：363138353040313032

对应的 ASCII 内容为： 61850@102

即是最终的 flag

0x04 总结

此题大佬的解法很简单，只要知道对应的MMS协议的规约中Confirmed-RequestPDU和Confirmed-ResponsePDU的结构然后找到对应的服务，直接一个脚本搞定。
如下：

```
import pyshark

def flag():
    try:
        captures = pyshark.FileCapture("question_1531222544_JYvFGmLP49PFC0R2.pcap")
        flag_frsm = False
        flag_frsm_id = None
        flag_read = False
        for capture in captures:
            for pkt in capture:
                if pkt.layer_name == "mms":
                    # file open
                    if hasattr(pkt, "confirmedservicerequest") and int(pkt.confirmedservicerequest) == 72:
                        if hasattr(pkt, "filename_item"):
                            filename_items = pkt.filename_item.fields
                            for f in filename_items:
                                file_name = str(f.get_default_value())
                                if file_name == "flag.txt":
                                    flag_frsm = True
                    if hasattr(pkt, "confirmedserviceresponse") and int(pkt.confirmedserviceresponse) == 72 and
flag_frsm:
                        # print(pkt.field_names)
                        if hasattr(pkt, "frsmid"):
                            flag_frsm_id = pkt.frsmid
                        flag_frsm = False
                    # file read
                    if hasattr(pkt, "confirmedservicerequest") and int(pkt.confirmedservicerequest) == 73 and fl
ag_frsm_id:
                        if hasattr(pkt, "fileread"):
                            if str(pkt.fileread) == str(flag_frsm_id):
                                flag_read = True
                        flag_frsm_id = None
                    if hasattr(pkt, "confirmedserviceresponse") and int(pkt.confirmedserviceresponse) == 73 and
flag_read:
                        if hasattr(pkt, "filedata"):
                            data = str(pkt.filedata).replace(":", "")
                            print(hex_to_ascii(data))
                        flag_read = False
    except Exception as e:
        print(e)


def hex_to_ascii(data):
    data = data.decode("hex")
    flags = []
    for d in data:
        _ord = ord(d)
        if (_ord > 0) and (_ord < 128):
            flags.append(chr(_ord))
    return ''.join(flags)


if __name__ == '__main__':
flag()
```

工控协议有很多，代表性的除了 MMS 外还有Modbus、DNP3、Melsec-Q、S7、Ethernet/IP 等，

出题的方式也有很多，主要还是对这个协议比较熟悉，那么解什么题都很容易了

刚研究工控安全，如果文字描述有误，还望斧正，另外，如果有兴趣的小伙伴可以一起研究工控安全的内容~

0x04 参考

MMS报文分析示例

2018年工业信息安全技能大赛（东北赛区）解题报告——工业网络数据分析

ICS_CTF Contest

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传送门：

链接:https://pan.baidu.com/s/1wl_1fErCAvvQlF_DYPlOiQ

密码:9mb8