黑客眼中的工控4.0

——工控系统安全威胁与应对探索

by Kimon

关于我

- 中国科技大学苏研院
- ADF安全研究团队
- 物联网安全、工控安全

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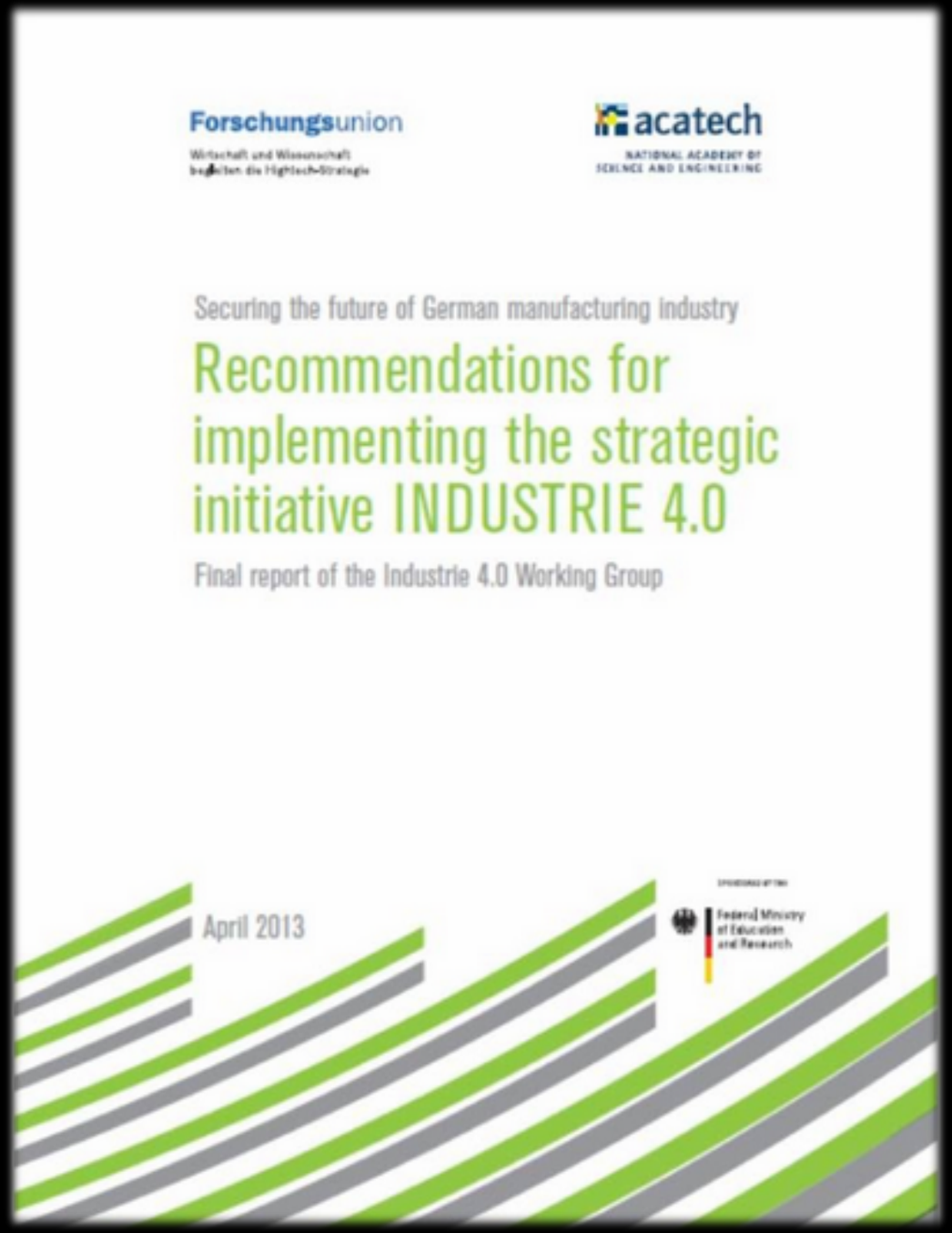
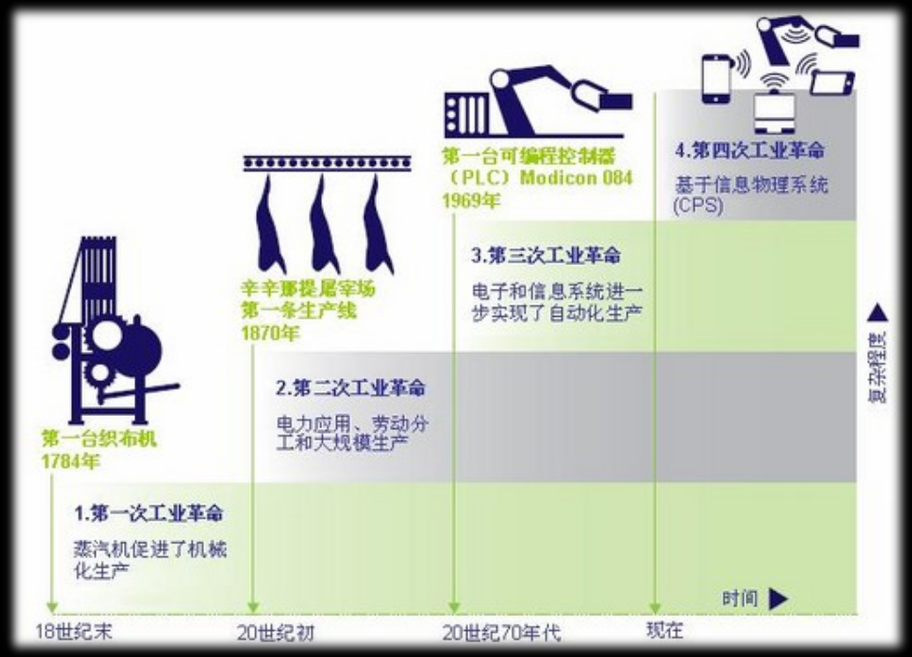
13758178689

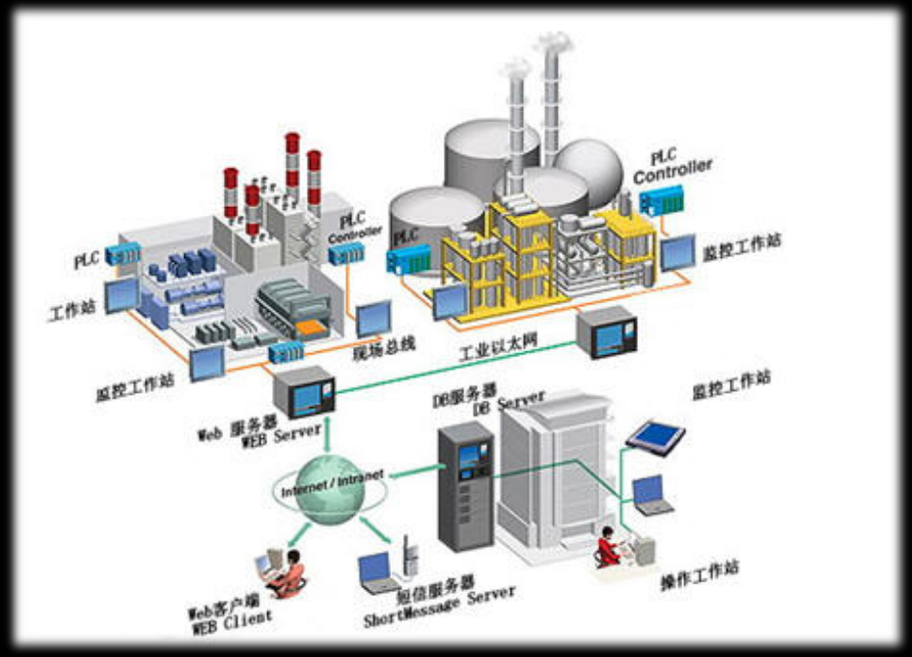
提纲

- 工控背景
- 工控系统
- 入侵方式
- 应对探索

工业4.0与两化融合


Forschungsunion
acatech
Securing the future of German manufacturing industry
Recommendations for implementing the strategic initiative INDUSTRIE 4.0
Final report of the Industrie 4.0 Working Group
April 2013
Federal Ministry of Education and Research

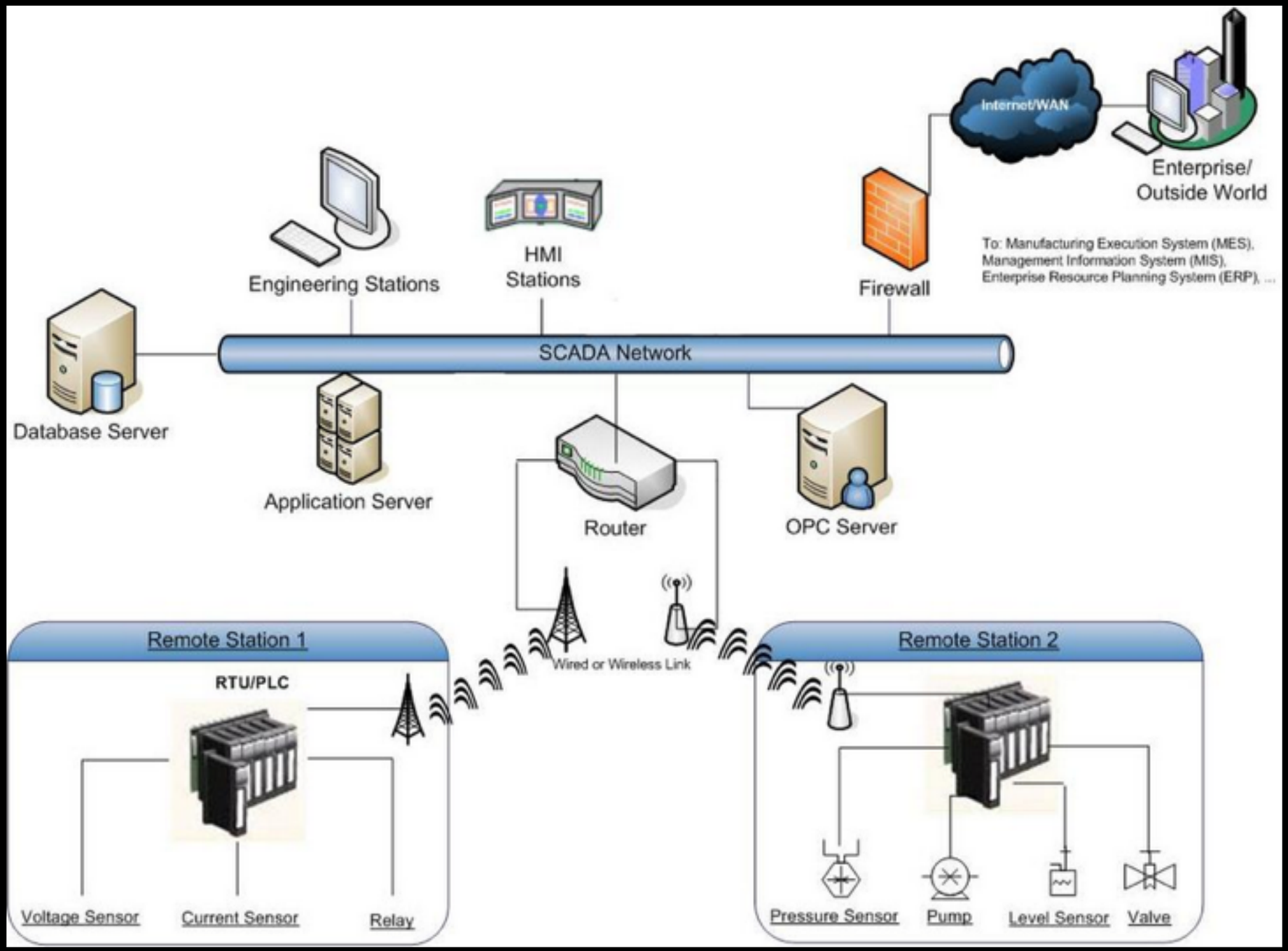

第一台织布机
1784年
1.第一次工业革命
蒸汽机促进了机械化生产
辛辛那提屠宰场
第一条生产线
1870年
2.第二次工业革命
电力应用、劳动分工和大规模生产
第一台可编程控制器（PLC）Modicon 084
1969年
3.第三次工业革命
电子和信息系统进一步实现了自动化生产
4.第四次工业革命
基于信息物理系统(CPS)
复杂程度
时间
18世纪末
20世纪初
20世纪70年代
现在


PLC
Controller
监控工作站
现场总线
工业以太网
Web 服务器
WEB Server
DB服务器
DB Server
Internet / Intranet
Web客户端
WEB Client
短信服务器
ShortMessage Server
操作工作站

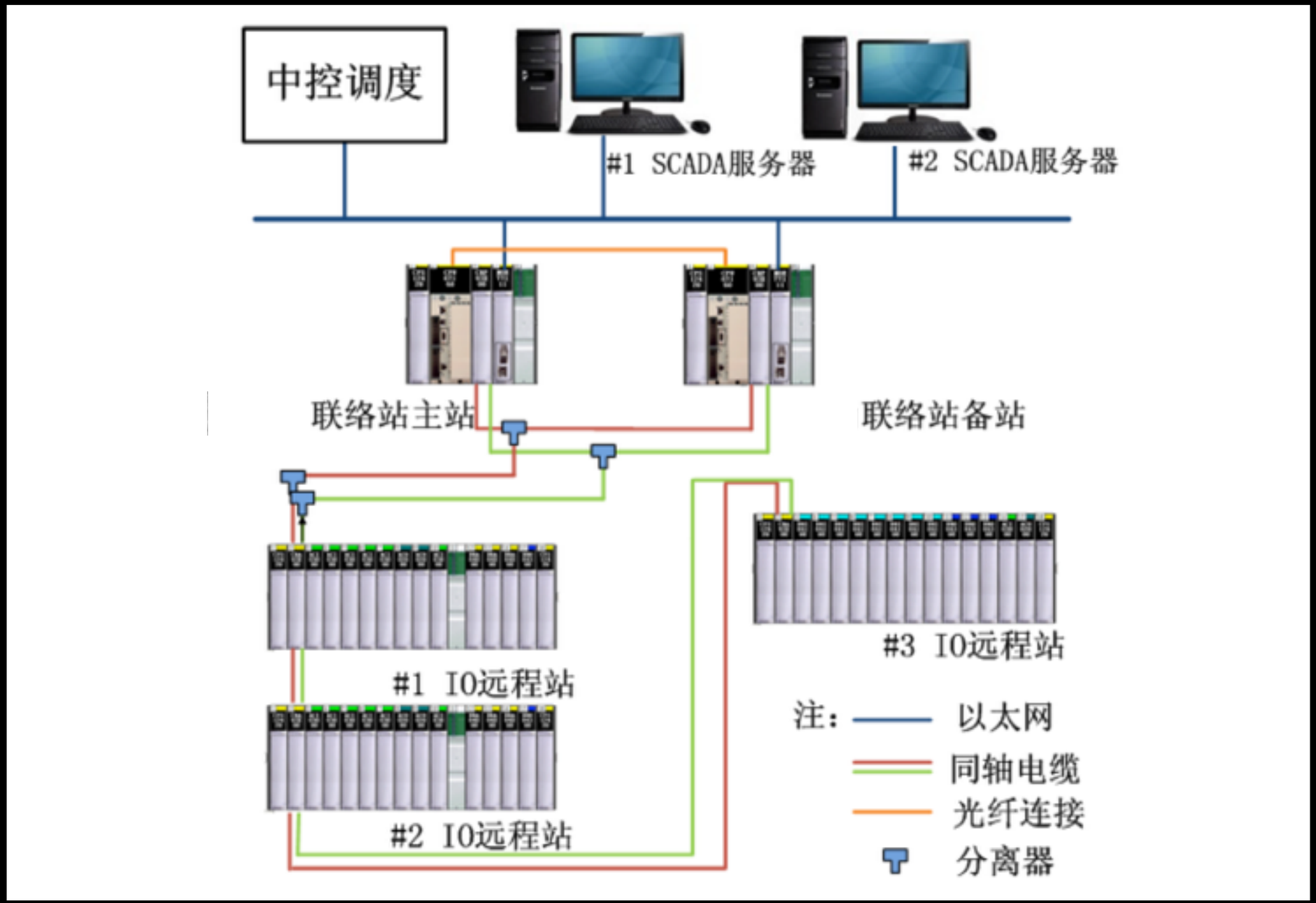
工控系统

- ICS 工业控制系统
- SCADA 数据采集与监控系统
- DCS 分散式控制系统

SCADA系统

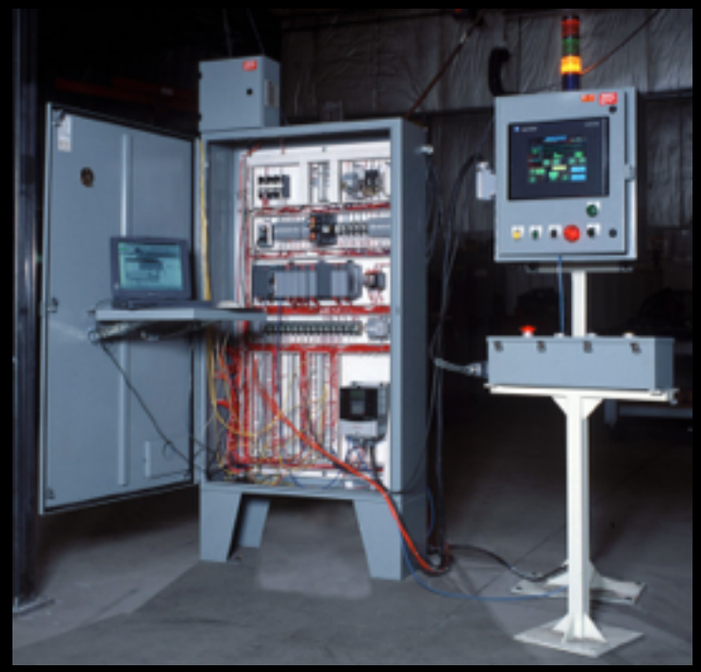

Internet/WAN
Enterprise/
Outside World
To: Manufacturing Execution System (MES),
Management Information System (MIS),
Enterprise Resource Planning System (ERP), ...
Engineering Stations
HMI
Stations
Firewall
SCADA Network
Database Server
Application Server
Router
OPC Server
Wired or Wireless Link
Remote Station 1
RTU/PLC
Voltage Sensor
Current Sensor
Relay
Remote Station 2
Pressure Sensor
Pump
Level Sensor
Valve

SCADA系统


中控调度
#1 SCADA服务器
#2 SCADA服务器
联络站主站
联络站备站
#1 IO远程站
#2 IO远程站
#3 IO远程站
注：
以太网
同轴电缆
光纤连接
分离器

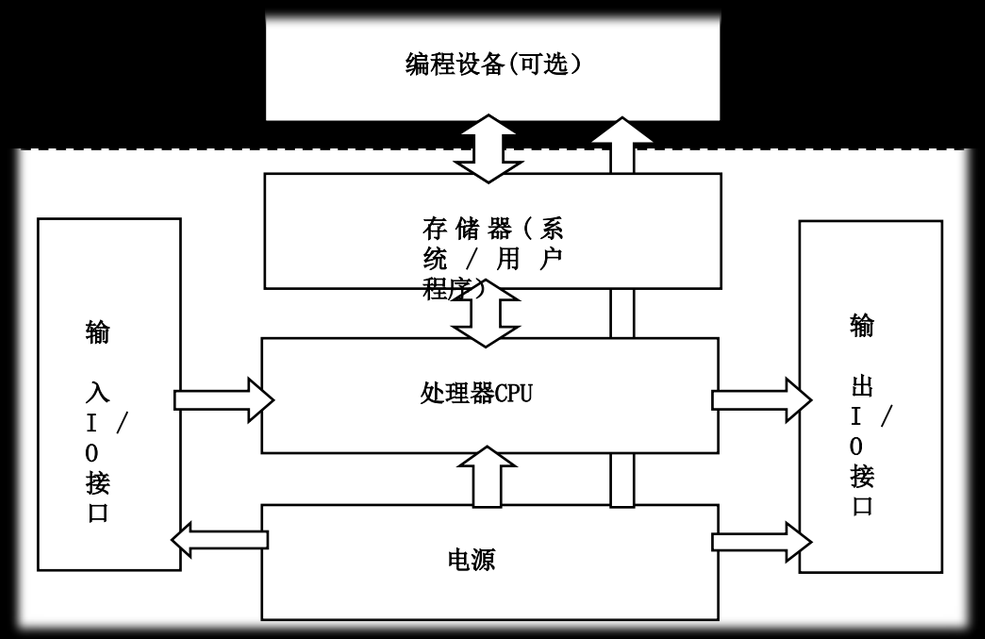
工控组件

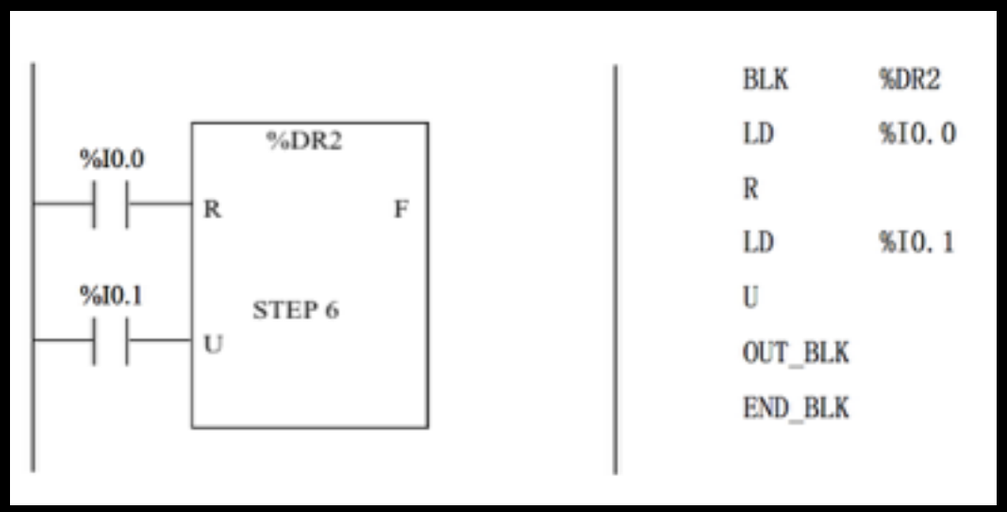
- PLC可编程逻辑控制器
- RTU远程控制单元
- HMI人机交互界面
- 现场设备



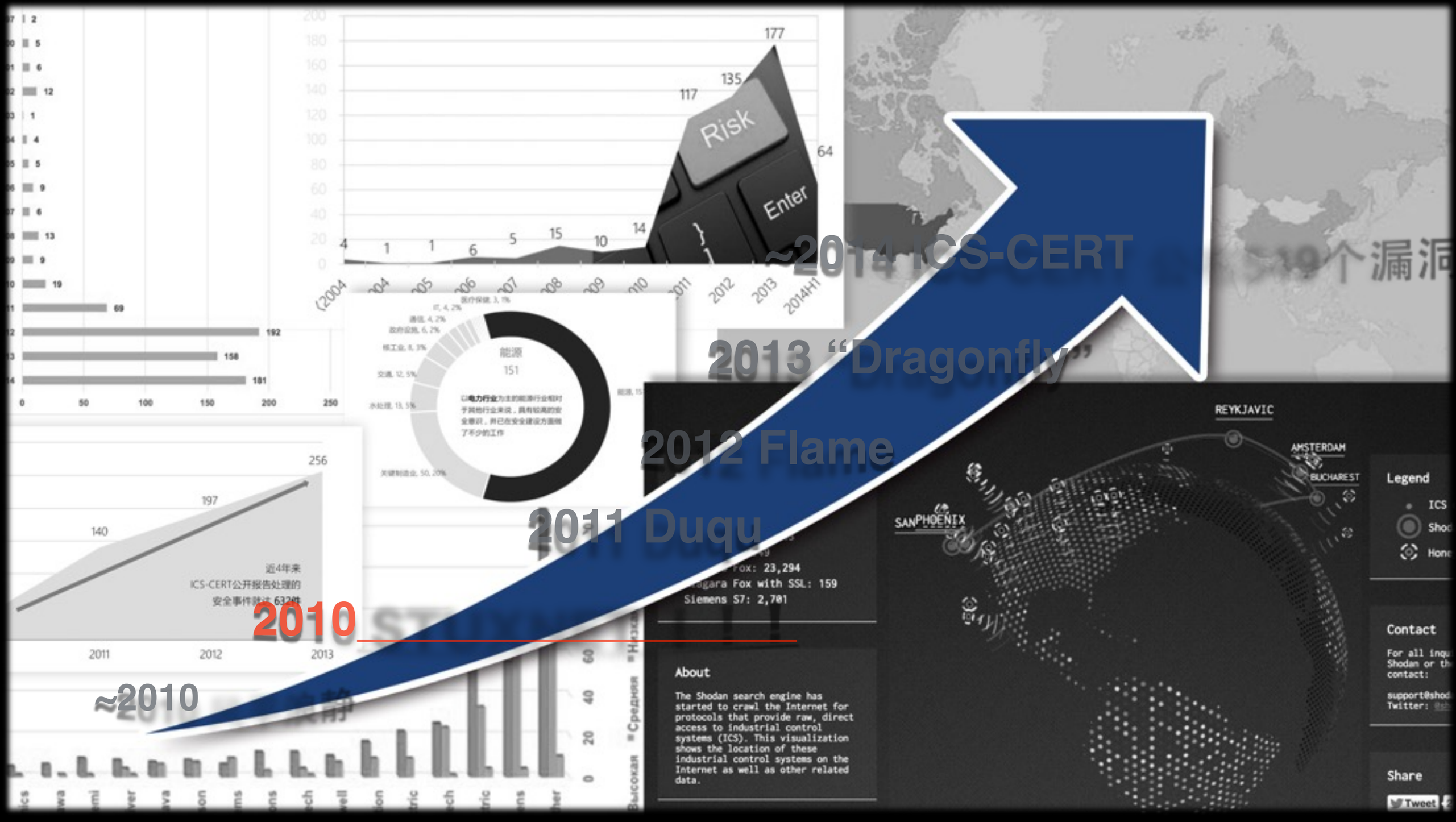
PLC

- PLC实质是一种用于工业的计算机
- CPU、存储器、输入输出接口电路、功能模块、通信模块、电源
- 输入采样阶段、用户程序执行阶段、数据刷新阶段
- 梯形图LAD
  顺序流程图SFC
  指令表IL





威胁趋势


~2014 ICS-CERT
2013 "Dragonfly"
2012 Flame
2011 Duqu
2010
≈2010
Risk
Enter
177
135
117
64
14
10
15
5
6
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1
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2004
2005
2006
2007
2008
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2011
2012
2013
2014H1
256
197
140
近4年来
ICS-CERT公开报告处理的
安全事件跃过 632件
2011
2012
2013
能源
151
REYKJAVIC
AMSTERDAM
BUCHAREST
SANPHOENIX
Fox: 23,294
Siemens S7: 159
Legend
Contact
Share
Tweet
About
The Shodan search engine has started to crawl the Internet for protocols that provide raw, direct access to industrial control systems (ICS). This visualization shows the location of these industrial control systems on the Internet as well as other related data.

威胁来源

协议安全

网络隔离

安全意识

漏洞管理

工业网络协议

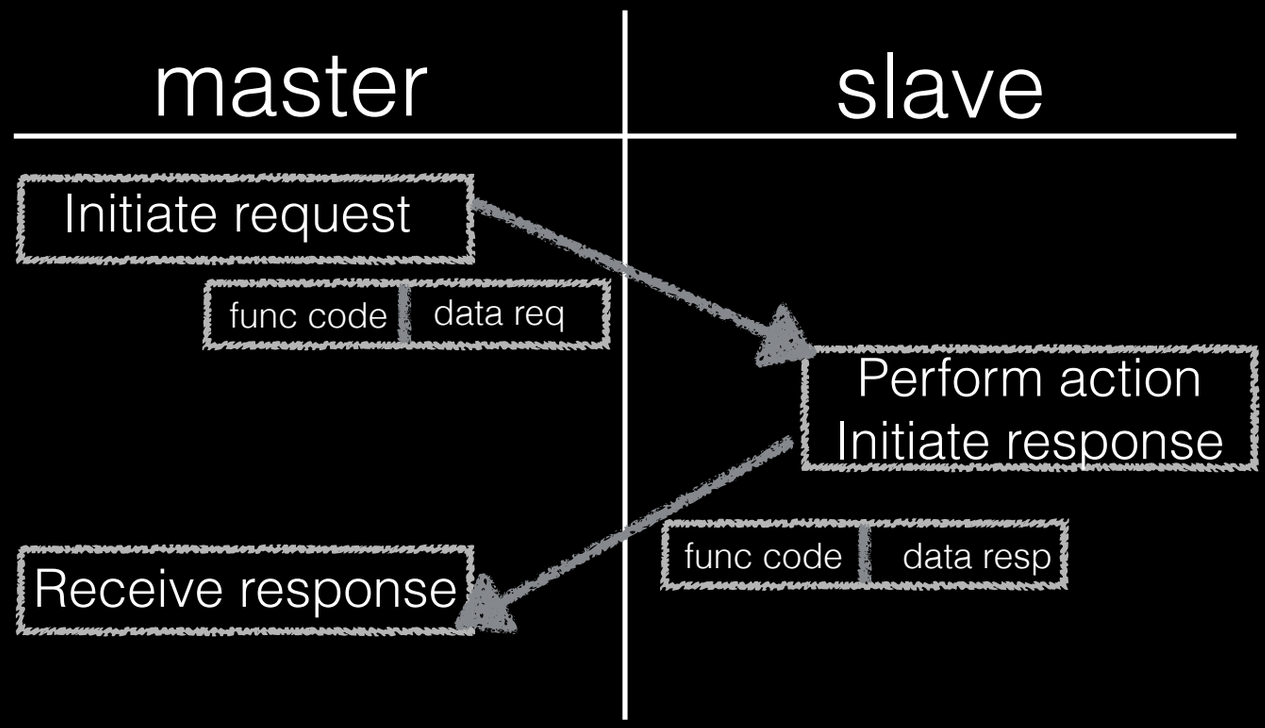
- Modbus
- S3/S5/S7
- DNP3
- Profinet
- Ethernet/IP
- …

Modbus协议

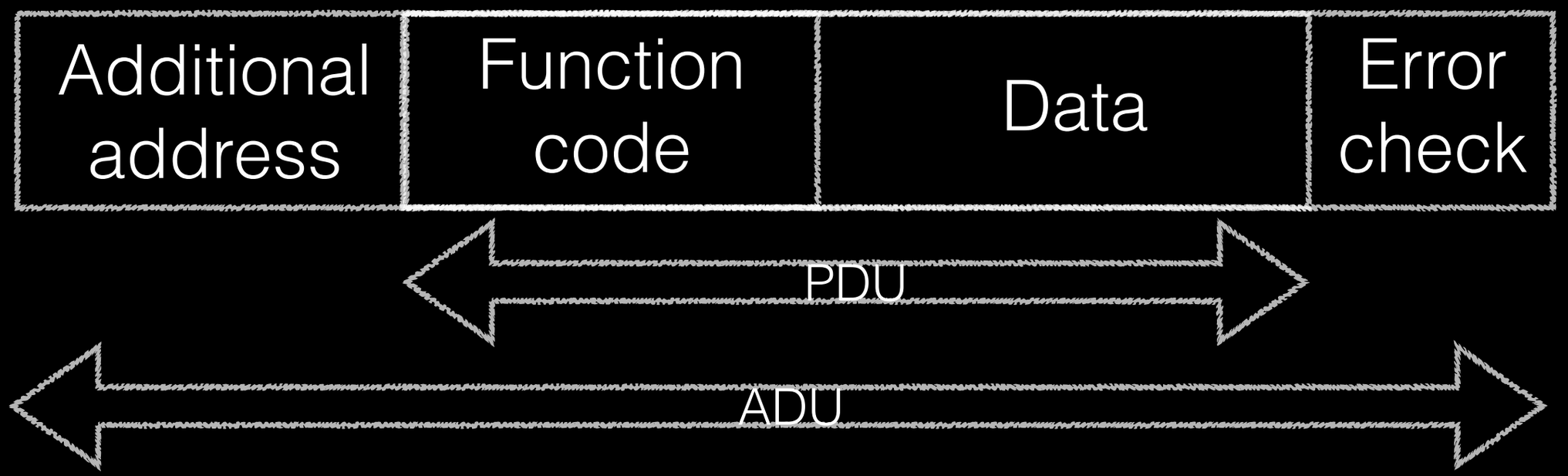
- 全球第一个真正用于工业现场的总线协议
- 施耐德电子（Schneider Electric）发布于1979年
- 标准开放，免费使用
- 目前作为工业标准工业网络传输协议之一

Modbus协议

- Master/Slave模式
- 8位地址长度，每个Master可支持247个Slave
- 简单清晰的协议内容
- 无加密与身份认证

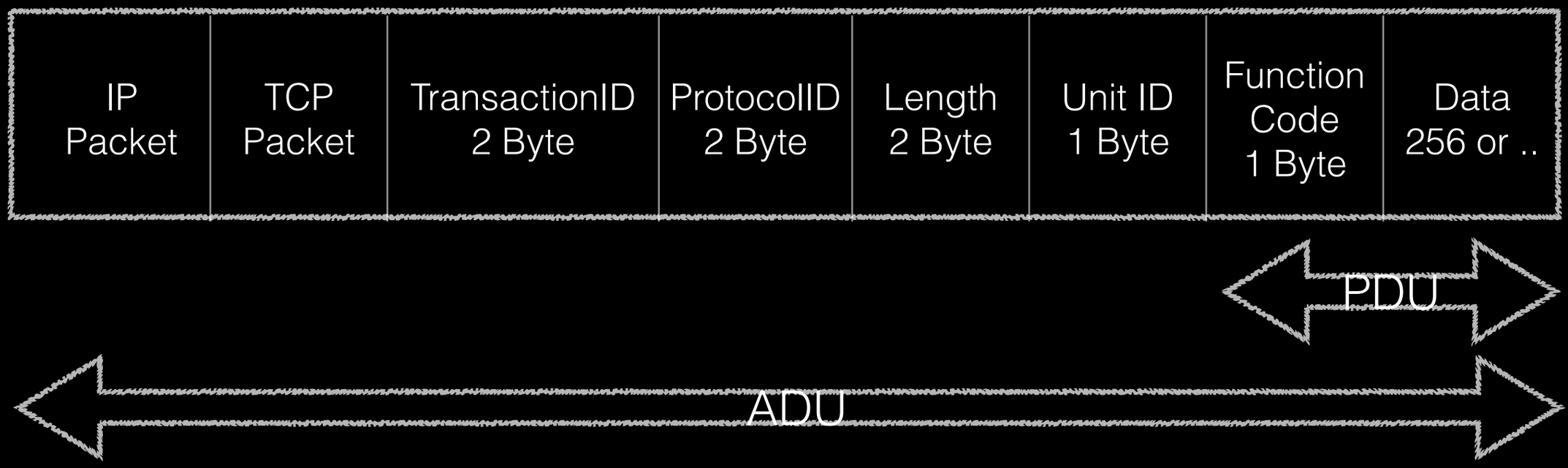


Modbus协议



Modbus Frame

Modbus协议



Modbus TCP Frame

Modbus协议

Function Name	Function Code
Read Coils	0x01
Write Single Coil	0x05
Write Multiple Coils	0x15
Read Input Register	0x04
Write Single Register	0x06
Read/Write Multiple Register	0x23

Modbus协议

Function type			Function name	Function code
Data Access	Bit access	Physical Discrete Inputs	**Read Discrete Inputs**	2
		Internal Bits or Physical Coils	**Read Coils**	1
			Write Single Coil	5
			Write Multiple Coils	15
	16-bit access	Physical Input Registers	**Read Input Registers**	4
		Internal Registers or Physical Output Registers	**Read Holding Registers**	3
			Write Single Register	6
			Write Multiple Registers	16
			Read/Write Multiple Registers	23
			Mask Write Register	22
			Read FIFO Queue	24
	File Record Access		Read File Record	20
			Write File Record	21
Diagnostics			Read Exception Status	7
			Diagnostic	8
			Get Com Event Counter	11
			Get Com Event Log	12
			Report Slave ID	17
			Read Device Identification	43
Other			Encapsulated Interface Transport	43

维基百科——Modbus所有功能码

http://en.wikipedia.org/wiki/Modbus

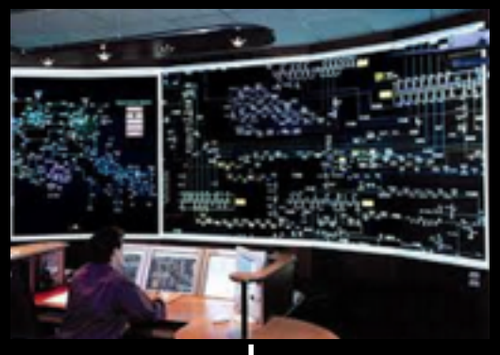
Modbus协议

```
Modbus/TCP
    Transaction Identifier: 0
    Protocol Identifier: 0
    Length: 5
    Unit Identifier: 255
Modbus
    Function Code: Encapsulated Interface Transport (43)
    MEI type: Read Device Identification (14)
    Read Device ID: Basic Device Identification (1)
    Object ID: VendorName (0)
```

```
0000  00 0c 29 28 1c ff 00 50  56 c0 00 08 08 00 45 00   ..)(...P V.....E.
0010  00 3f 03 8a 40 00 40 06  0b 55 c0 a8 d5 01 c0 a8   .?..@.@. .U......
0020  d5 87 fb 3e 01 f6 59 b5  6d 16 e0 bc 71 1e 80 18   ...>..Y. m...q...
0030  10 15 30 6f 00 00 01 01  08 0a 13 01 bc e6 05 88   ..0o.... ........
0040  11 ce 00 00 00 00 00 05  ff 2b 0e 01 00           ........ .+...
```

TransactionID　ProtocolID　Length　UnitID　FunctionCode　Data

Modbus协议



RS-232/RS-485

Network

Modbus TCP

入侵方式

工业化信息化融合推进

工控组件脆弱性

设备升级维护成本高

安全意识薄弱

攻击面

更脆弱的系统
更多的攻击面

模拟环境

探索发现目标

协议分析

设备识别

攻击工具/框架

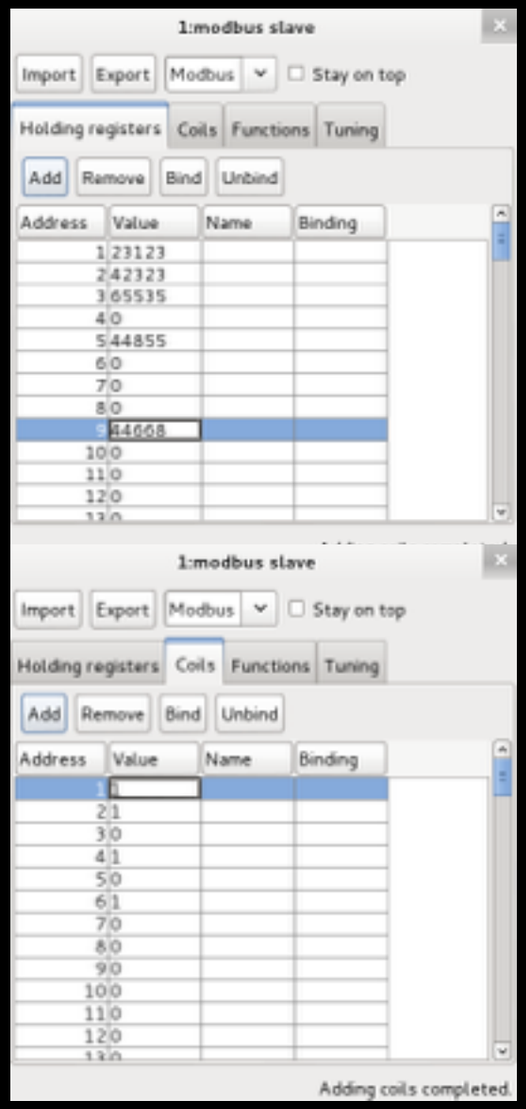
手动攻击测试

模拟环境

[ModbusPal]

Slave节点仿真模拟

http://modbuspal.sourceforge.net/

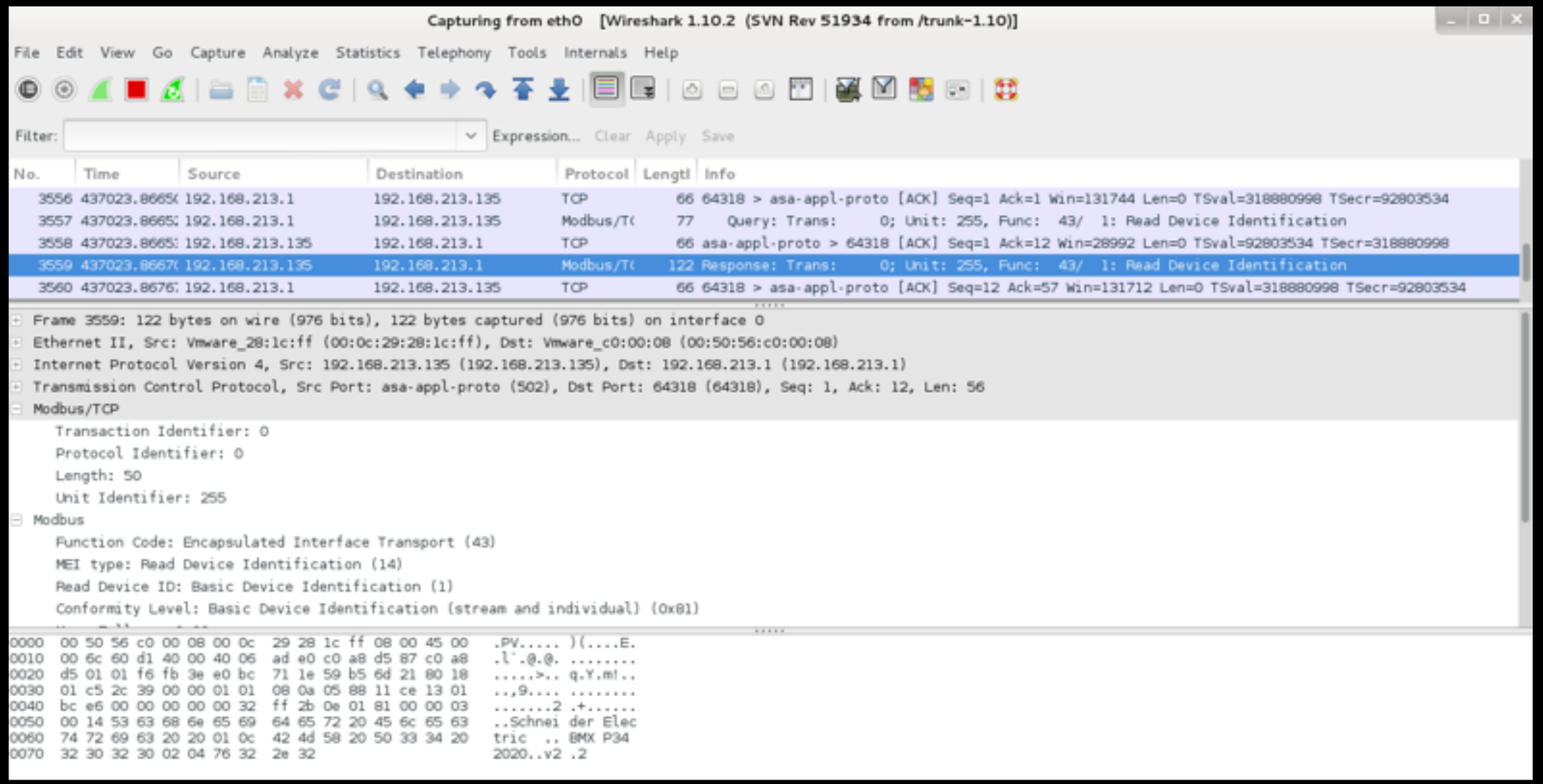


网络分析

[Wireshark]

https://www.wireshark.org/

Modbus/S7/DNP3协议解析



本地模拟攻防

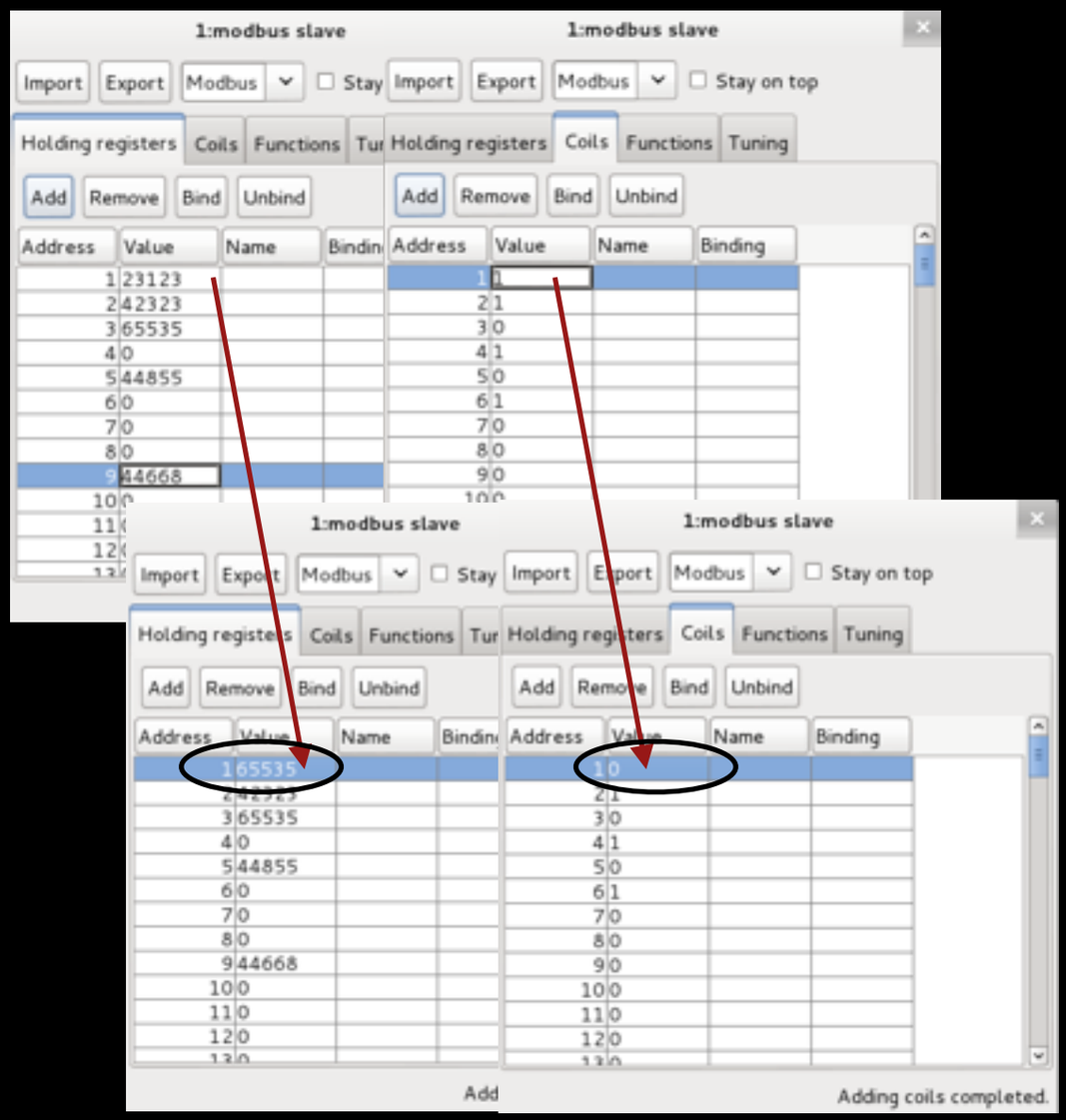
[mbtget]

Perl脚本Modbus协议工具

https://github.com/sourceperl/mbtget

```
root@kali:~/ICS/mbtget# mbtget -r1 -a 0 -n 8 127.0.0.1
values:
  1 (ad 00000):     0
  2 (ad 00001):     1
  3 (ad 00002):     0
  4 (ad 00003):     1
  5 (ad 00004):     0
  6 (ad 00005):     1
  7 (ad 00006):     0
  8 (ad 00007):     0
root@kali:~/ICS/mbtget# mbtget -r3 -a 0 -n 8 127.0.0.1
values:
  1 (ad 00000): 23123
  2 (ad 00001): 42323
  3 (ad 00002): 65535
  4 (ad 00003):     0
  5 (ad 00004): 44855
  6 (ad 00005):     0
  7 (ad 00006):     0
  8 (ad 00007):     0
```

```
root@kali:~/ICS/mbtget# mbtget -w5 0 -a 0 -d 127.0.0.1
Tx
[97 0B 00 00 00 06 01] 05 00 00 00 00

Rx
[97 0B 00 00 00 06 01] 05 00 00 00 00

bit write ok
root@kali:~/ICS/mbtget# mbtget -w6 65535 -a 0 -d 127.0.0.1
Tx
[40 14 00 00 00 06 01] 06 00 00 FF FF

Rx
[40 14 00 00 00 06 01] 06 00 00 FF FF

word write ok
```

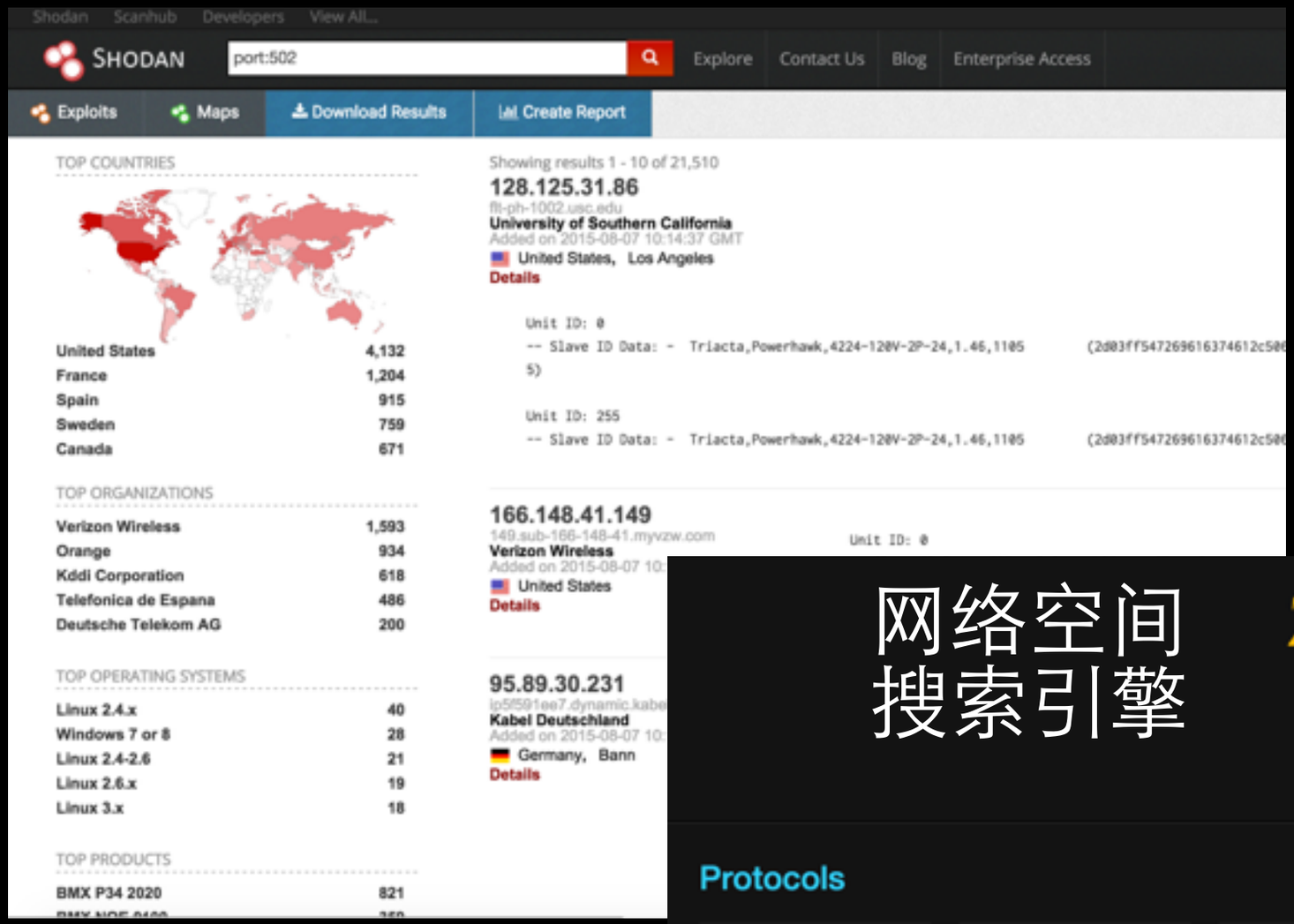


本地模拟攻防

[Metasploit Framework]
auxiliary/scanner/scada/modbus_findunitid
auxiliary/scanner/scada/modbusclient
auxiliary/scanner/scada/modbusdetected

```
msf auxiliary(modbusclient) > info

       Name: Modbus Client Utility
     Module: auxiliary/scanner/scada/modbusclient
    License: Metasploit Framework License (BSD)
       Rank: Normal

Provided by:
  EsMnemon <esm@mnemonic.no>
  Arnaud SOULLIE <arnaud.soullie@solucom.fr>

Available actions:
  Name           Description
  ----           -----------
  READ_COIL      Read one bit from a coil
  READ_REGISTER  Read one word from a register
  WRITE_COIL     Write one bit to a coil
  WRITE_REGISTER  Write one word to a register

Basic options:
  Name          Current Setting  Required  Description
  ----          ---------------  --------  -----------
  DATA          1                no        Data to write (WRITE_COIL and WRITE_REGISTER modes only)
  DATA_ADDRESS  0                yes       Modbus data address
  RHOST         127.0.0.1        yes       The target address
  RPORT         502              yes       The target port
  UNIT_NUMBER   1                no        Modbus unit number

Description:
  This module allows reading and writing data to a PLC using the
  Modbus protocol. This module is based on the 'modiconstop.rb'
  Basecamp module from DigitalBond, as well as the mbtget perl script.
```

探索发现目标



PLC、RTU..工控设备
无一幸免

黑暗“Google”

网络空间
搜索引擎

探索发现目标

[Nmap]

modbus-discover.nse

modbus-enum.nse

```
root@kali:/usr/share/nmap/scripts# nmap --scan-delay=1 -p502 --script modbus-discover.nse

Starting Nmap 6.47 ( http://nmap.org ) at 2015-08-07 18:17 CST
Nmap scan report for 90-25-187-213.wifi4all.it (213.187.25.90)
Host is up (0.76s latency).
PORT    STATE SERVICE
502/tcp open  modbus
| modbus-discover:
|   Positive error response for sid = 0x1 (ILLEGAL FUNCTION)
|_    DEVICE IDENTIFICATION: Schneider Electric TM258LF42DT4L V02.00.31.15

Nmap done: 1 IP address (1 host up) scanned in 9.85 seconds
```

注意

《NIST SP800-82》

1.降低扫描速度—scan-delay=1

2.TCP替代UDP

3.避免使用nmap指纹识别 -sC

4.不推荐nmap

5.不要尝试对运行中的设备进行测试

探索发现目标

[plcscan]

TCP/502 TCP/102端口PLC识别工具

code.google.com/p/plcscan

```
root@kali:~/ICS/plcscan# python plcscan.py -h
Usage: plcscan.py [options] [ip range]...

Scan IP range for PLC devices. Support MODBUS and S7COMM protocols

Options:
  -h, --help            show this help message and exit
  --hosts-list=FILE     Scan hosts from FILE
  --ports=PORTS         Scan ports from PORTS
  --timeout=TIMEOUT     Connection timeout (seconds)

Modbus scanner:
  --brute-uid           Brute units ID
  --modbus-uid=UID      Use uids from list
  --modbus-function=NOM
                        Use modbus function NOM for discover units
  --modbus-data=DATA    Use data for for modbus function
  --modbus-timeout=TIMEOUT
                        Timeout for modbus protocol (seconds)

S7 scanner options:
  --src-tsap=LIST       Try this src-tsap (list) (default: 0x100,0x
  --dst-tsap=LIST       Try this dst-tsap (list) (default: 0x102,0x
```

```
root@kali:~/ICS/plcscan# python plcscan.py 127.0.0.1 --brute-uid
Scan start...
127.0.0.1:502 Modbus/TCP
  Unit ID: 0
    Device: Schneider Electric   BMX P34 2020 v2.2
  Unit ID: 255
    Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 1
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 2
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 3
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 4
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 5
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 6
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 7
  Device: Schneider Electric   BMX P34 2020 v2.2
Unit ID: 8
  Device: Schneider Electric   BMX P34 2020 v2.2
```

探索发现目标

[ModTest]

针对Modbus分析协议、扫描、指纹识别、Fuzzing、甄别蜜罐

https://github.com/ameng929/ModTest

```
Usage: ModTest.py [options] [ip]...

Scan IP range for PLC devices, Support MODBUS and...

Options:
  -h, --help            show this help message and exit
  --host-list=FILE      Scan hosts from file
  --ports=PORTS         Scan ports
  --timeout=TIMEOUT     Connection timeout (seconds)

  Modbus Tester:
    --brute-uid         Brute units ID
    --modbus-uid=UID    Use uids from list
    --modbus-function=NOM
                        Use modbus function NOM for discover units
    --modbus-data=DATA  Use data for for modbus function
    --modbus-timeout=TIMEOUT
                        Timeout for modbus protocol (seconds)
    -f, --func-fuzzing  Modbus FunctionCode Fuzzing
    -d, --debug         Debug-verbose mode
    -i, --device-info-scan
                        Scan Schneider PLC for more device information
```

探索发现目标

[ModTest]

Modbus分析协议

https://github.com/ameng929/ModTest

```
qmwang@MacBook-Pro:~/Documents/workspace/ModTest% python ModTest.py 192.168.213.135 -d
Scan start...
192.168.213.135:502...
------------------send package:
0000   00 00 00 00 00 05 00 2B  0E 01 00                        .......+...
None

------------------recv package:
0000   00 00 00 00 00 32 00 2B  0E 01 81 00 00 03 00 14   .....2.+........
0010   53 63 68 6E 65 69 64 65  72 20 45 6C 65 63 74 72   Schneider Electr
0020   69 63 20 20 01 0C 42 4D  58 20 50 33 34 20 32 30   ic  ..BMX P34 20
0030   32 30 02 04 76 32 2E 32                           20..v2.2
None
192.168.213.135:502 Modbus/TCP
```

探索发现目标

[ModTest]

Modbus Fuzzing

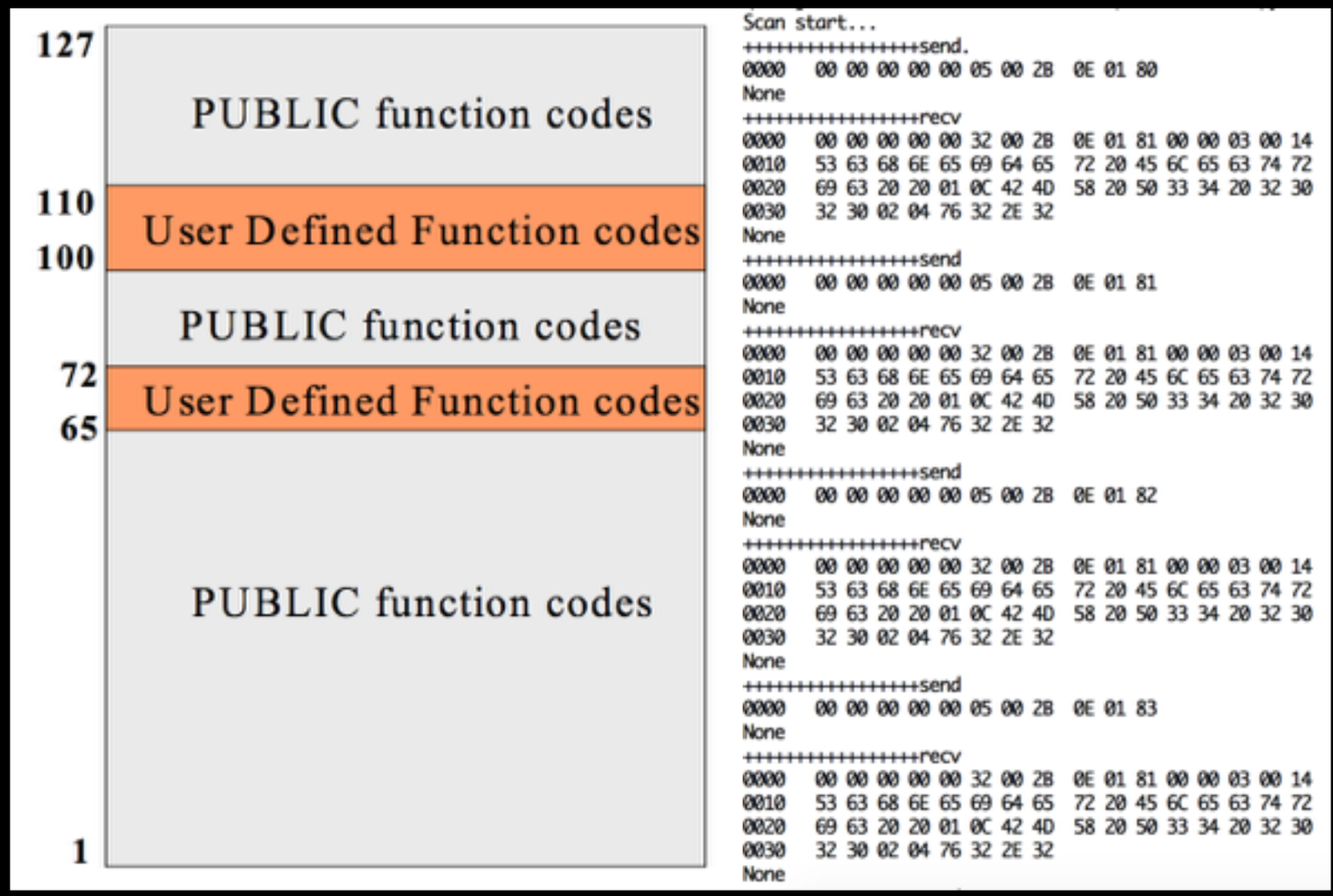
https://github.com/ameng929/ModTest

方式:

- 针对Function Code
- 针对Diagnostics Code

发现:

- 90/91/99功能码
- 识别工控蜜罐的方式
- 拒绝服务



探索发现目标

[ModTest]

Modbus 指纹识别

https://github.com/ameng929/ModTest

识别更多的plc设备信息

更邪恶的入侵方式

...

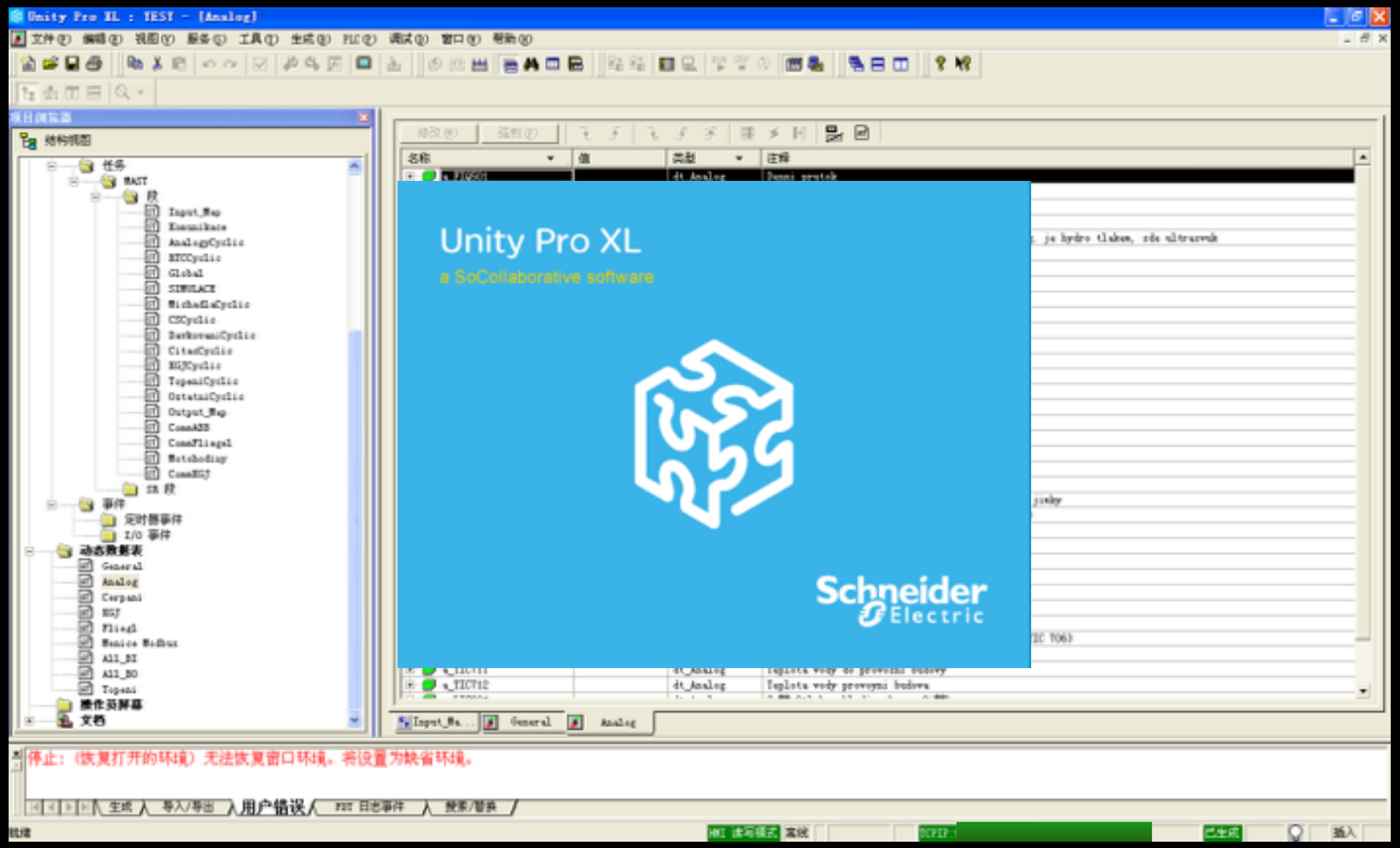
```
qmwang@MacBook-Pro:~/Documents/workspace/ModTest% python ModTest.py -i 80.20.122.191
Scan start...
------------send2...
0000   00 0F 00 00 00 0D 00 5A  00 20 00 14 00 64 00 00   .......Z. ...d..
0010   00 F6 00                                          ...
None
------------recv
0000   00 0F 00 00 00 FD 00 5A  00 FE 00 F6 00 00 00 00   .......Z........
0010   00 00 00 00 00 00 00 00  00 00 00 00 00 01 00 46   ...............F
0020   A5 61 B5 3A 97 D8 48 8A  1B 09 3D 54 A1 AE EB B2   .a.:..H...=T....
0030   BC B7 DD E5 94 D3 40 B0  92 DE 7A 83 5C 35 62 00   ......@...z.\5b.
0040   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
0050   0A 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
0060   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
0070   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
0080   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
0090   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
00a0   00 00 00 00 00 00 00 00  00 50 72 6F 67 65 74 74   .........Progett
00b0   6F 00 00 00 00 00 00 00  00 00 56 38 2E 30 00 00   o.........V8.0..
00c0   00 49 56 41 4E 2D 50 43  00 00 00 00 00 00 00 00   .IVAN-PC........
00d0   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
00e0   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
00f0   00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ................
0100   00 00 00                                          ...
None
```

入侵方式

[Unity Pro XL]

施耐德PLC编程软件

http://www.schneider-electric.com/



入侵方式

[Unity Pro XL]

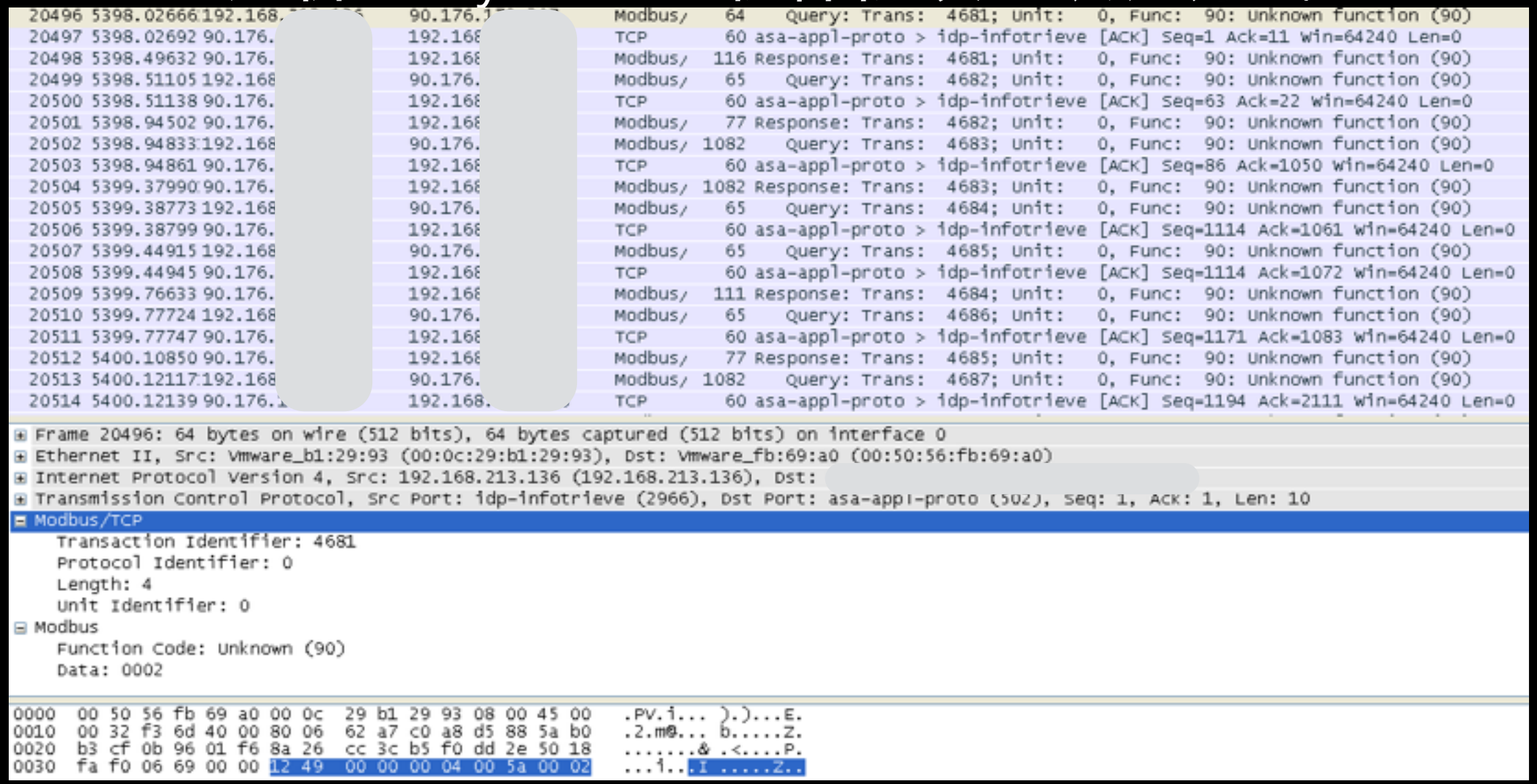
施耐德PLC编程软件

http://www.schneider-electric.com/

发现：
可远程接入设备
但远程传输项目失败
原因：
Unity Pro XL版本多样
兼容性差

入侵方式

分析Unity Pro XL软件协议、认证方式



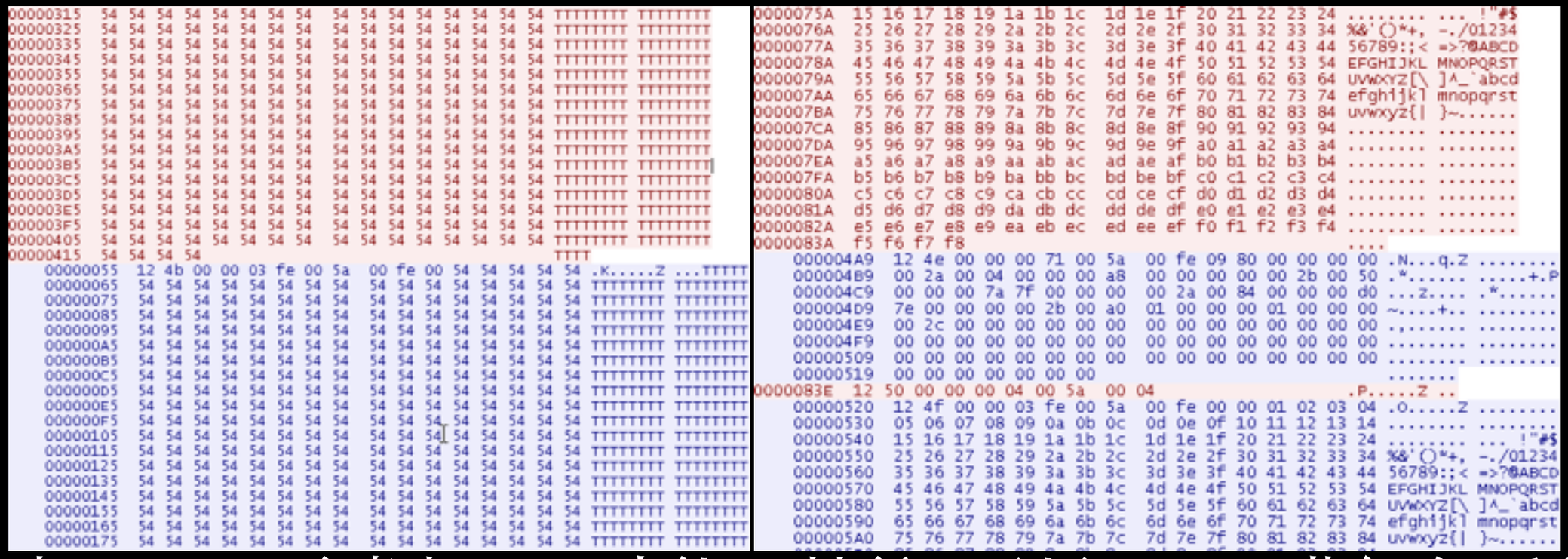
软件使用Modbus功能码90进行通信
协议内容无加密！

入侵方式

分析Unity Pro XL软件协议、认证方式

```
00000000  12 49 00 00 00 04 00 5a  00 02                     .I.....Z ..
    00000000  12 49 00 00 00 38 00 5a  00 fe 06 30 01 03 00 00 .I...8.Z ...0....
    00000010  00 00 50 02 00 00 08 00  06 01 03 01 00 00 00 00 ..P..... ........
    00000020  0c 42 4d 58 20 50 33 34  20 32 30 32 30 02 01 01 .BMX P34  2020...
    00000030  00 00 00 00 40 00 04 01  00 00 00 00 0a 03       ....@... ......
0000000A  12 4a 00 00 00 05 00 5a  00 01 00                  .J.....Z ...
    0000003E  12 4a 00 00 00 11 00 5a  00 fe fd 03 00 06 00 00 .J.....Z ........
    0000004E  32 00 00 00 00 00 00                           2......
```

通过90功能码进行身份识别与握手请求、消息同步



通过ModTest测试，90功能码协议无认证，可进行包重放

入侵方式

分析Unity Pro XL软件协议、认证方式

```
00000895  12 56 00 00 00 0d 00 5a  00 20 00 14 00 64 00 00 .V.....Z . ...d..
000008A5  00 f6 03                                        ...
    00000B93  12 56 00 00 03 fd 00 5a  00 fe 00 f6 03 00 00 00 .V.....Z ........
    00000BA3  00 00 00 00 00 00 00 00  00 00 00 00 00 02 00 0f ........ ........
    00000BB3  43 fb f0 f4 b9 e9 43 88  24 1e 98 aa 8a 0c 60 68 C.....C. $.....`h
    00000BC3  38 2b 7f 27 00 a4 46 9d  f9 c7 5e ce 9d 98 a6 00 8+.'..F. ..^.....
    00000BD3  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
    00000BE3  0a 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
    00000BF3  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
    00000C03  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
    00000C13  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
    00000C23  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 ........ ........
    00000C33  00 00 00 00 00 00 00 00  00 53 74 61 74 69 6f 6e ........ .Station
    00000C43  00 00 00 00 00 00 00 00  00 56 35 2e 30 00 00 00 ........ .V5.0...
    00000C53  4b 55 4e 41 52 54 2d 4e  42 32 00 43 3a 5c 56 4f KUNART-N B2.C:\VO
    00000C63  44 41 52 4e 41 5c 53 63  68 6e 65 69 64 65 72 5c DARNA\Sc hneider\
    00000C73  55 6e 69 74 79 5c 42 50  53 20 42 72 6c 6f 68 5c Unity\BP S Brloh\
    00000C83  62 70 73 5f 62 72 6c 6f  68 5f 76 37 30 2e 73 74 bps_brlo h_v70.st
    00000C93  75 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00 u....... ........
```

协议中发现读取PLC设备信息通信数据

0x00, 0x0f, 0x00, 0x00, 0x00, 0x0d, 0x00, 0x5a, 0x00, 0x20, 0x00, 0x14, 0x00, 0x64, 0x00, 0x00, 0x00, 0xf6, 0x03

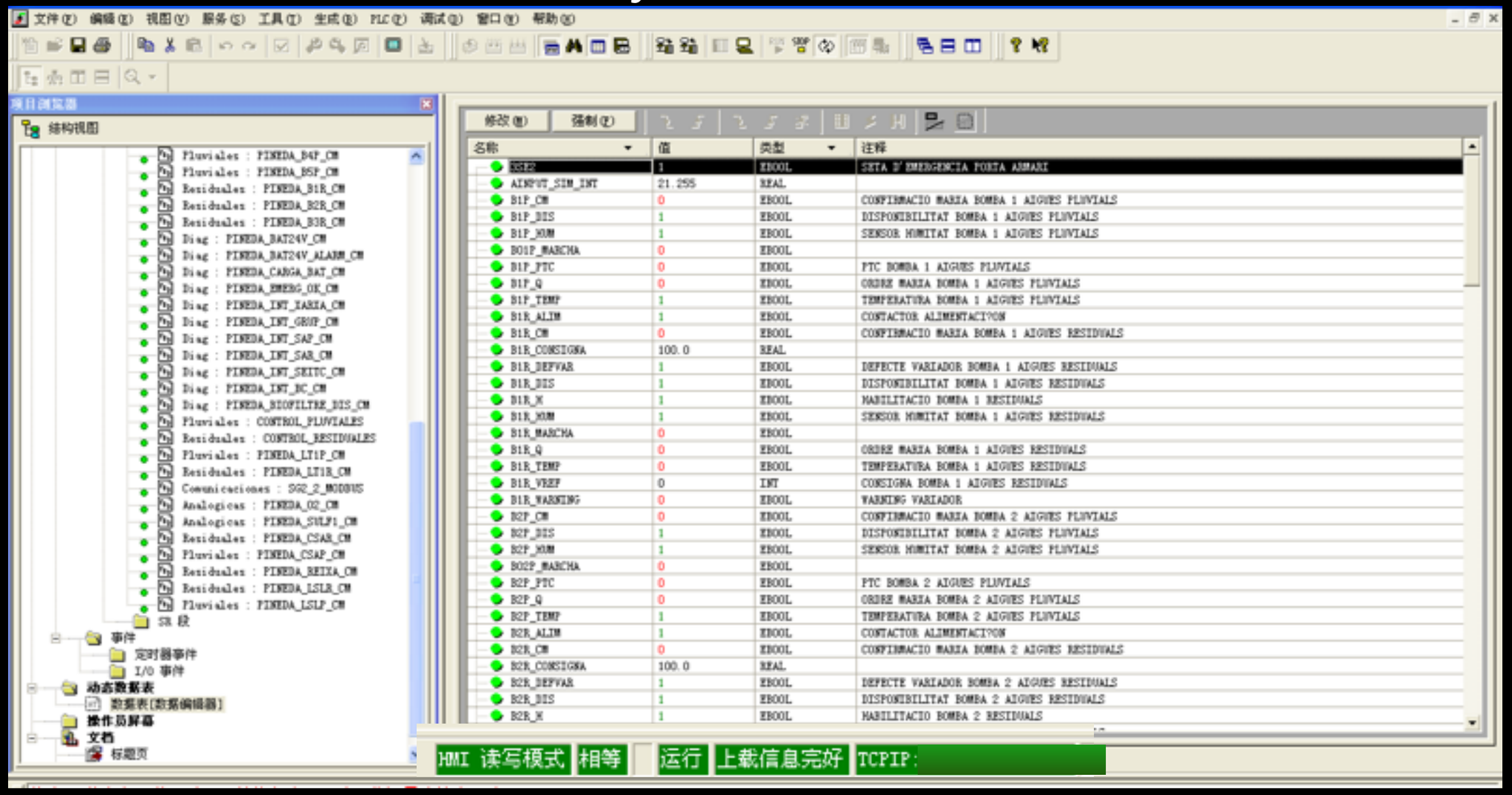
重放请求，获得PLC设备项目信息

针对应答数据选择针对的Unity Pro XL软件

V5.0 → Unity Pro XL 5.0

入侵方式

通过针对版本的Unity Pro XL软件获取到PLC权限



可查看实时数据表、修改上传PLC程序、停止PLC执行!!!

入侵方式

通过Shodan进行设备探索与入侵

针对施耐德PLC编程软件的Dork

port:502 V5.0 .stu

V5.0——编程软件版本号

.stu——施耐德PLC程序后缀

应对探索

[工控蜜罐]

协议仿真scapy、pymodbus

https://github.com/tecpal/PyModbus

- 对读写PLC Coil、Register值的响应
- 对43功能码读取PLC设备信息的响应
- 对17功能码请求从节点信息的响应
- 对90功能码读取Modicon PLC信息的响应

应对探索

[工控蜜罐]

Web管理登陆界面

应对探索

[工控蜜罐]
其他选择组件

- FTP
- SNMP
- TELNET
- 其他工控协议

应对探索

[工控蜜罐]

conpot

https://github.com/mushorg/conpot

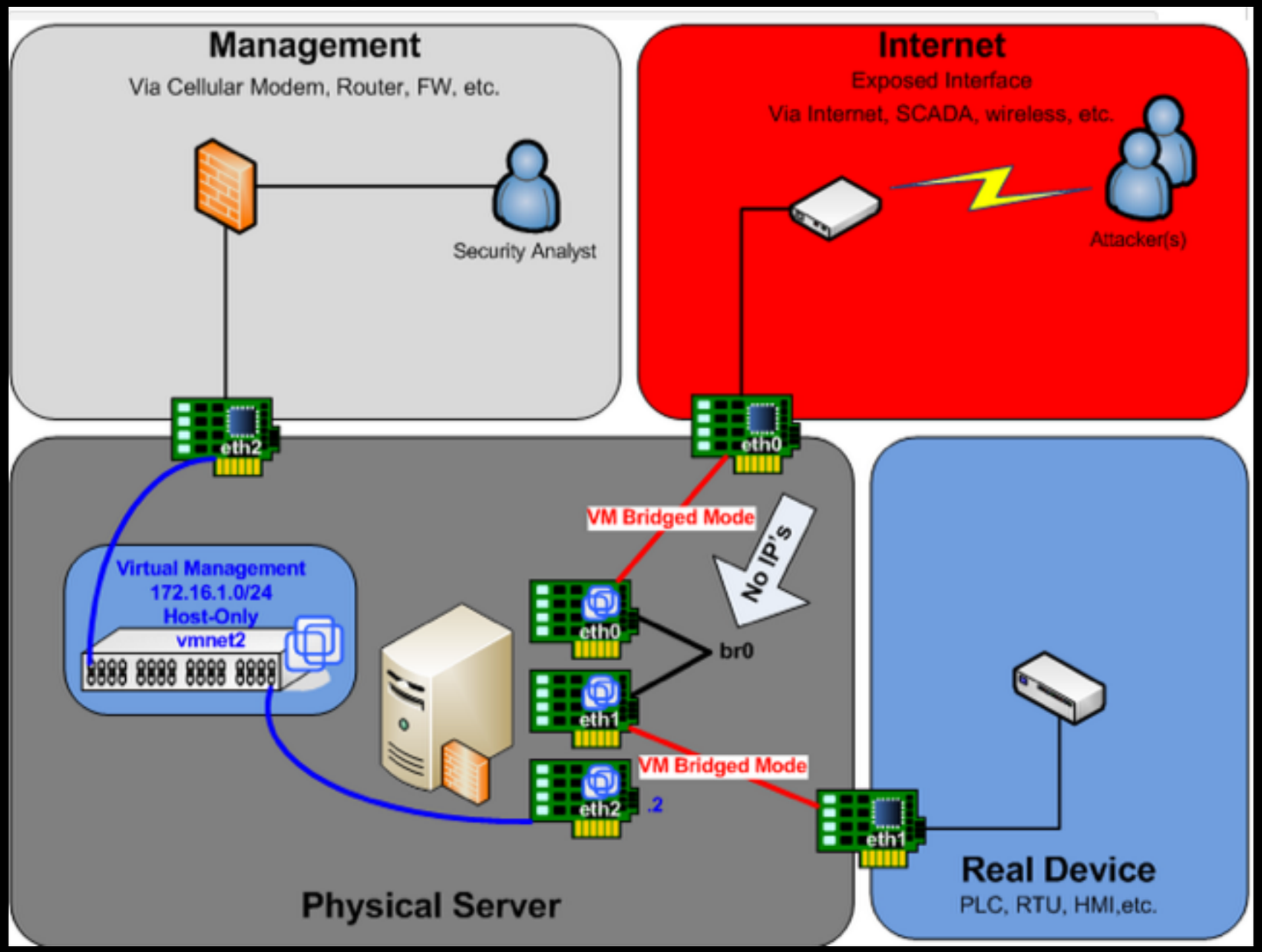
```
# conpot --template default

                  _
 ___ ___ ___ ___ |_| |_
|  _| . |   | . | . |  _|
|___|___|_|_|_  |___|_|
            |_|

 Version 0.4.0
 Glastopf Project

2015-05-27 16:05:08,355 Starting Conpot using template: /usr/local/lib/python2.7/dist-packages/Conpot-0.4.0-py2.7.egg/conp
2015-05-27 16:05:08,366 Starting Conpot using configuration found in: /usr/local/lib/python2.7/dist-packages/Conpot-0.4.0-
2015-05-27 16:05:08,428 Starting new HTTP connection (1): www.telize.com
2015-05-27 16:05:08,861 Fetched xxx.xxx.xxx.xxx as external ip.
2015-05-27 16:05:08,891 Conpot modbus initialized
2015-05-27 16:05:08,893 Found and enabled ('modbus', <class conpot.protocols.modbus.modbus_server.ModbusServer at 0xb4f1e3
2015-05-27 16:05:08,898 Conpot S7Comm initialized
2015-05-27 16:05:08,899 Found and enabled ('s7comm', <class 'conpot.protocols.s7comm.s7_server.S7Server'>) protocol.
2015-05-27 16:05:08,902 Found and enabled ('http', <class 'conpot.protocols.http.web_server.HTTPServer'>) protocol.
2015-05-27 16:05:08,905 Found and enabled ('snmp', <class 'conpot.protocols.snmp.snmp_server.SNMPServer'>) protocol.
2015-05-27 16:05:08,915 Conpot Bacnet initialized using the /usr/local/lib/python2.7/dist-packages/Conpot-0.4.0-py2.7.egg/
2015-05-27 16:05:08,916 Found and enabled ('bacnet', <class 'conpot.protocols.bacnet.bacnet_server.BacnetServer'>) protoco
2015-05-27 16:05:08,922 IPMI BMC initialized.
2015-05-27 16:05:08,923 Conpot IPMI initialized using /usr/local/lib/python2.7/dist-packages/Conpot-0.4.0-py2.7.egg/conpot
2015-05-27 16:05:08,923 Found and enabled ('ipmi', <class 'conpot.protocols.ipmi.ipmi_server.IpmiServer'>) protocol.
2015-05-27 16:05:09,003 No proxy template found. Service will remain unconfigured/stopped.
2015-05-27 16:05:09,015 Modbus server started on: ('0.0.0.0', 502)
2015-05-27 16:05:09,017 S7Comm server started on: ('0.0.0.0', 102)
2015-05-27 16:05:09,018 HTTP server started on: ('0.0.0.0', 80)
2015-05-27 16:05:09,285 SNMP server started on: ('0.0.0.0', 161)
2015-05-27 16:05:09,286 Bacnet server started on: ('0.0.0.0', 47808)
2015-05-27 16:05:09,286 IPMI server started on: ('0.0.0.0', 623)
2015-05-27 16:05:09,287 connecting to hpfriends.honeycloud.net:20000
2015-05-27 16:05:14,006 Privileges dropped, running as nobody/nogroup.
```

应对探索

[工控蜜罐]

SCADA Honeynet

http://www.digitalbond.com/tools/scada-honeynet/



应对探索

[工控蜜罐]

Modhoney

在PyModbus与Z-one版本上进行了改进与优化

https://github.com/ameng929/Modhoney

```
Received =  array('B', [33, 0, 0, 0, 0, 6, 2, 4, 0, 1, 0, 0, 0])
ID= 2,  Fun.Code= 4,  Address= 1,  Length= 0
Received =  array('B', [33, 0, 0, 0, 0, 6, 2, 4, 0, 1, 0, 0, 0])
ID= 2,  Fun.Code= 4,  Address= 1,  Length= 0
Received =  array('B', [33, 0, 0, 0, 0, 6, 2, 4, 0, 1, 0, 0, 0])
ID= 2,  Fun.Code= 4,  Address= 1,  Length= 0
Received =  array('B', [33, 0, 0, 0, 0, 6, 2, 4, 0, 1, 0, 0, 0])
ID= 2,  Fun.Code= 4,  Address= 1,  Length= 0
```

```
Received =  array('B', [0, 0, 0, 0, 0, 2, 0, 17, 0, 0, 0, 0, 0])
ID= 0,  Fun.Code= 17
```

```
Received =  array('B', [0, 0, 0, 0, 0, 5, 0, 43, 14, 1, 0, 0, 0])
```

502

Modbus

BMX P34 20302 Version: v2.2

```
Unit ID: 0
-- Device Identification: Schneider Electric BMX P34 20302 v2.2
-- CPU module: BMX P34 20302
-- Memory card: BMXRMS008MP
-- Project information: Progetto - V5.0   MASSIMOURBA9562 \\psf\Dropbox\PLC\HOFMANN\POV
O\PLCPOVO V3 2.STU
-- Project revision: 0.0.217
-- Project last modified: 2015-05-21 14:32:04

Unit ID: 255
-- Device Identification: Schneider Electric BMX P34 20302 v2.2
```

增加了对于TransactionID的识别与应答

增加了对于功能码90的识别与应答

配合conpot更容易被网络搜索引擎发现

应对探索

[工控蜜罐]

Modhoney

在PyModbus与Z-one版本上进行了改进与优化

https://github.com/ameng929/Modhoney

```
GET request from ('103.233.194.106', 60811): ('/phpMyAdmin/scripts/setup.php', ['Host: 103.56.112.82\r\n'], None).
response to ('103.233.194.106', 60811): 404. 95710883-e1b9-4ba8-a2d8-9f381b57161d
GET request from ('103.233.194.106', 61029): ('/pma/scripts/setup.php', ['Host: 103.56.112.82\r\n'], None). 9571088
response to ('103.233.194.106', 61029): 404. 95710883-e1b9-4ba8-a2d8-9f381b57161d
GET request from ('103.233.194.106', 61257): ('/myadmin/scripts/setup.php', ['Host: 103.56.112.82\r\n'], None). 957
response to ('103.233.194.106', 61257): 404. 95710883-e1b9-4ba8-a2d8-9f381b57161d
```

```
HEAD request from ('60.177.39.7', 55035): ('/2.php', ['User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/535.19 (KHTML, like Gecko) Chrome/18.0.1025
103.56.112.82\r\n'], None). 3f679959-b61d-42fb-8fb9-8752f11a546a
response to ('60.177.39.7', 55035): 404. 3f679959-b61d-42fb-8fb9-8752f11a546a
HEAD request from ('60.177.39.7', 55035): ('/admin.php', ['User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/535.19 (KHTML, like Gecko) Chrome/18.0.
ost: 103.56.112.82\r\n'], None). 3f679959-b61d-42fb-8fb9-8752f11a546a
response to ('60.177.39.7', 55035): 404. 3f679959-b61d-42fb-8fb9-8752f11a546a
HEAD request from ('60.177.39.7', 55035): ('/login.php', ['User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/535.19 (KHTML, like Gecko) Chrome/18.0.
ost: 103.56.112.82\r\n'], None). 3f679959-b61d-42fb-8fb9-8752f11a546a
response to ('60.177.39.7', 55035): 404. 3f679959-b61d-42fb-8fb9-8752f11a546a
HEAD request from ('60.177.39.7', 55035): ('/02nfdiy.php', ['User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/535.19 (KHTML, like Gecko) Chrome/18.
'Host: 103.56.112.82\r\n'], None). 3f679959-b61d-42fb-8fb9-8752f11a546a
response to ('60.177.39.7', 55035): 404. 3f679959-b61d-42fb-8fb9-8752f11a546a
```

增加了对于TransactionID的识别与应答

增加了对于功能码90的识别与应答

配合conpot更容易被网络搜索引擎发现

应对探索

[工控蜜罐]

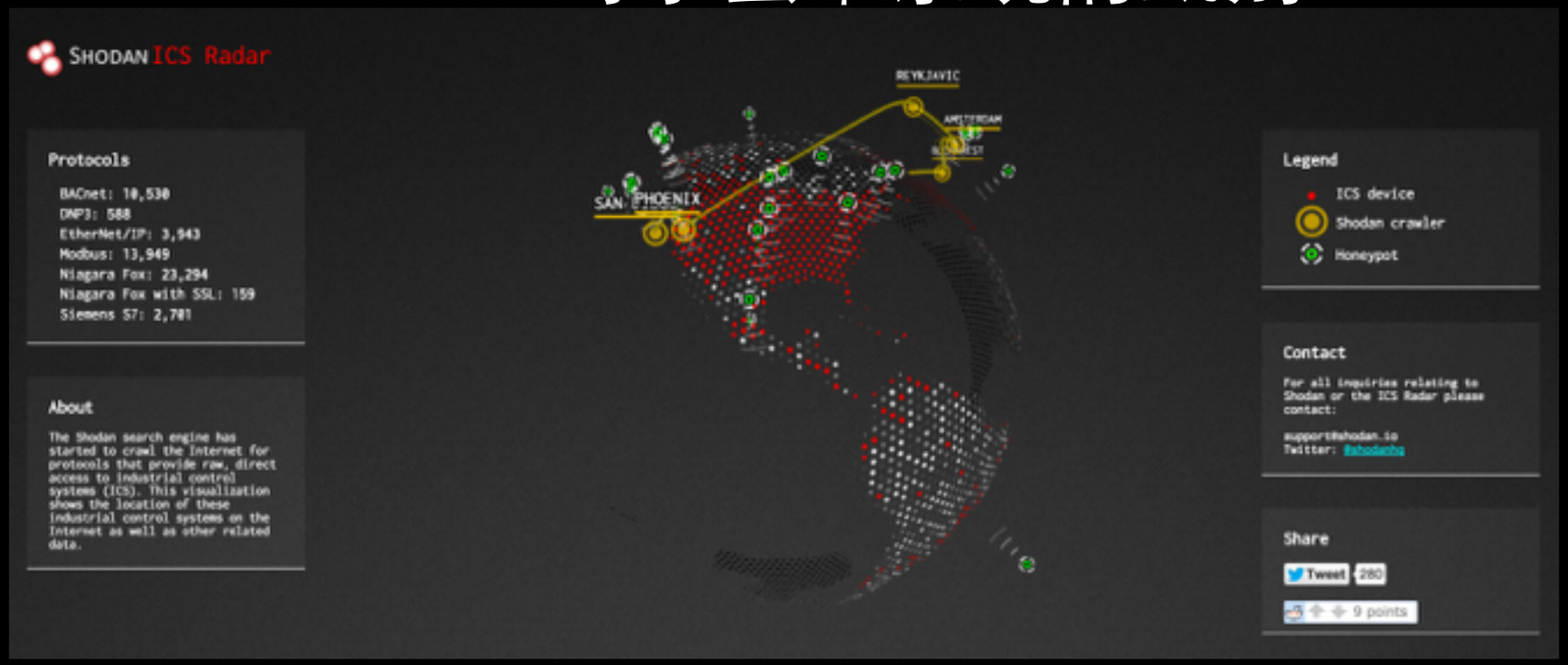
发现

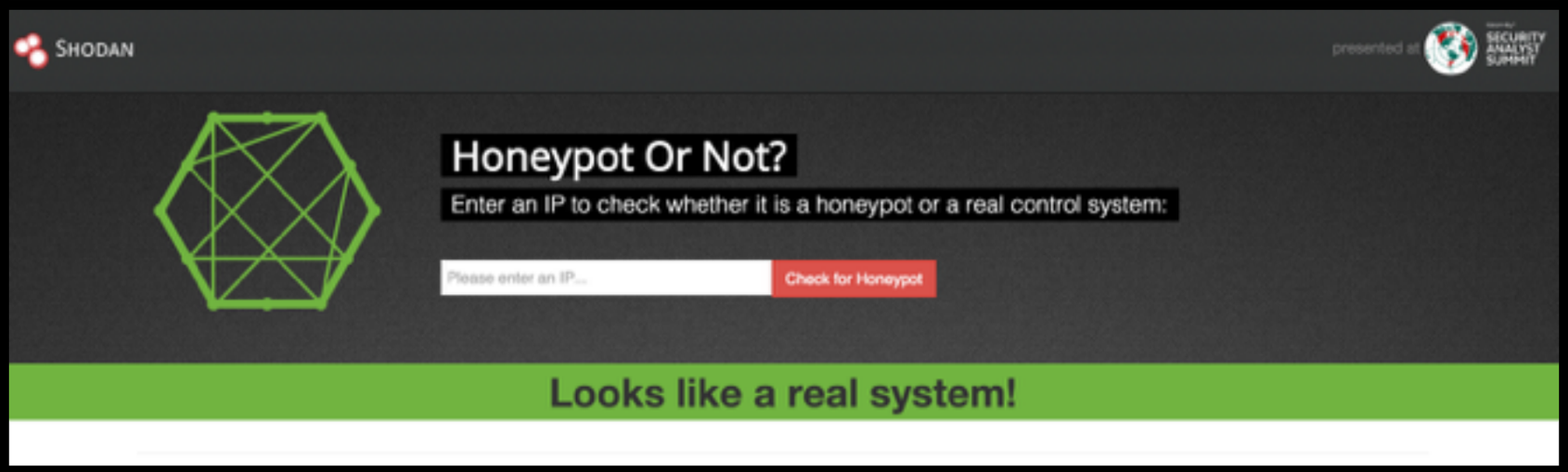
198. 20. 70.114	Shodan
71. 6.216. 34	Rapid7
169. 54.233.119	Credit Suisse Group / CANA
185. 35. 62. 11	Switzerland Group
85. 25.185.112	BSB-Service GmbH Germany
62. 75.207.109	Intergenia AG Germany
178. 19.104.138	Livenet sp. z o.o.
141.212.122. xxx	University of Michigan College of Engineering

蜜罐捕获数据主要为协议扫描
其中严重的威胁为对地址数据的改写

应对探索

Shodan对于蜜罐系统的甄别





应对探索

蜜罐甄别方法

Function code	1 Byte	**0x2B**
MEI Type*	1 Byte	0x0E
Read Device ID code	1 Byte	01 / 02 / 03 / 04
Object Id	1 Byte	0x00 to 0xFF

Real

```
Scan start...
++++++++++++++++++send
0000   00 00 00 00 00 05 00 2B 0E 04 80                  .......+...
None
++++++++++++++++++recv
0000   00 00 00 00 00 03 00 AB 02                        .........
None
recv.functionId != 43
Read Device Identification Error, error code:'\x02'
```

Honey

```
Scan start...
++++++++++++++++++send.
0000   00 00 00 00 00 05 00 2B 0E 04 80                  .......+...
None
++++++++++++++++++recv
0000   00 00 00 00 00 32 00 2B 0E 01 81 00 00 03 00 14   .....2.+........
0010   53 63 68 6E 65 69 64 65 72 20 45 6C 65 63 74 72   Schneider Electr
0020   69 63 20 20 01 0C 42 4D 58 20 50 33 34 20 32 30   ic  ..BMX P34 20
0030   32 30 02 04 76 32 2E 32                          20..v2.2
None
```

对于43(0x2B)功能码中的异常数据的应答

应对探索

蜜罐甄别方法

Function code	1 Byte	**0x01**
Starting Address	2 Bytes	0x0000 to 0xFFFF
Quantity of coils	2 Bytes	1 to 2000 (0x7D0)

```
qmwang@MacBook-Pro:~/Documents/workspace/ModTest% python ModTest.py -f 1 -d '\x00\x13\x00\x13\x00'   24.159.192.236 -v
Scan start...
24.159.192.236:502...
------------------send package:
0000   00 00 00 00 00 07 00 01  00 13 00 13 00
None

------------------recv package:
0000   00 00 00 00 00 03 00 81  03                        .........
None
```

Real

```
qmwang@MacBook-Pro:~/Documents/workspace/ModTest% python ModTest.py -f 1 -d '\x00\x13\x00\x13\x00'   192.168.213.135 -v
Scan start...
192.168.213.135:502...
------------------send package:
0000   00 00 00 00 00 07 00 01  00 13 00 13 00
None

------------------recv package:
0000   00 00 00 00 00 06 00 01  03 55 56 57              .........UVW
None
```

Honey

对于01(0x01)功能码中的异常数据的应答

应对探索

工控蜜罐的必要性

- 发现网络空间扫面引擎IP地址，拦截扫描
- 了解扫描引擎的指纹识别方法，收集信息
- 掌握黑客的进一步攻击行为
- 收集异常数据中可能的0-Day
- 健壮蜜罐系统，使其更难被甄别，更好的伪装

应对探索

[Snort for ICS]

开源入侵检测

https://www.snort.org

http://www.digitalbond.com/tools/quickdraw/

SID	Message
1111001	Modbus TCP – Force Listen Only Mode
1111002	Modbus TCP – Restart Communications Option
1111003	Modbus TCP – Clear Counters and Diagnostic Registers
1111004	Modbus TCP – Read Device Identification
1111005	Modbus TCP – Report Slave ID
1111006	Modbus TCP – Unauthorized Read Request to a PLC
1111007	Modbus TCP – Unauthorized Write Request to a PLC
1111008	Modbus TCP – Illegal Packet Size, Possible DOS Attack
1111009	Modbus TCP – Non-Modbus Communication on TCP Port 502
1111010	Modbus TCP – Slave Device Busy Exception Code Delay
1111011	Modbus TCP – Acknowledge Exception Code Delay
1111012	Modbus TCP – Incorrect Packet Length, Possible DOS Attack
1111013	Modbus TCP – Points List Scan
1111014	Modbus TCP – Function Code Scan

Rule: 1111015

SID	1111015
Message	Schneider Modicon Function Code 90 – Download Ladder Logic Started
Rule	alert tcp any any -> any 502 (flow: established,to_server; content: "|00 5a 01 34 00 01|"; msg: "Schneider Modicon Function Code 90 – Download Ladder Logic Started";sid:1111015;priority:2; threshold:type limit, track by_src, count 1 , seconds 60;)
Summary	UnityPro will download the Ladder Logic from the PLC upon connection to the PLC. This can also be done by a Metasploit Module. This would allow an attacker to gather information about the PLC and then change it to upload new logic to the PLC later.
Impact	Recon
Detailed Information	Modicon is a PLC brand that is released by Schneider Electric. The PLCs utilize the Modbus protocol with a proprietary function code (FC 90).
Affected Systems	Modicon PLCs
Attack Scenarios	An attacker with IP connectivity sends a requests to download the ladder logic from the PLC.
Ease of Attack	Simple. There are multiple tools that can be used to perform this task.
False Positives	None known
False Negatives	None known
Corrective Action	Identify if this host is allowed download the Ladder Logic.
Contributors	Stephen Hilt

应对探索

[ModbusSec]
协议传输身份认证
http://www.digitalbond.com/tools/basecamp/

{Ethernet | TCP | Modbus}

{Ethernet | TCP | Tunnel | Modbus}

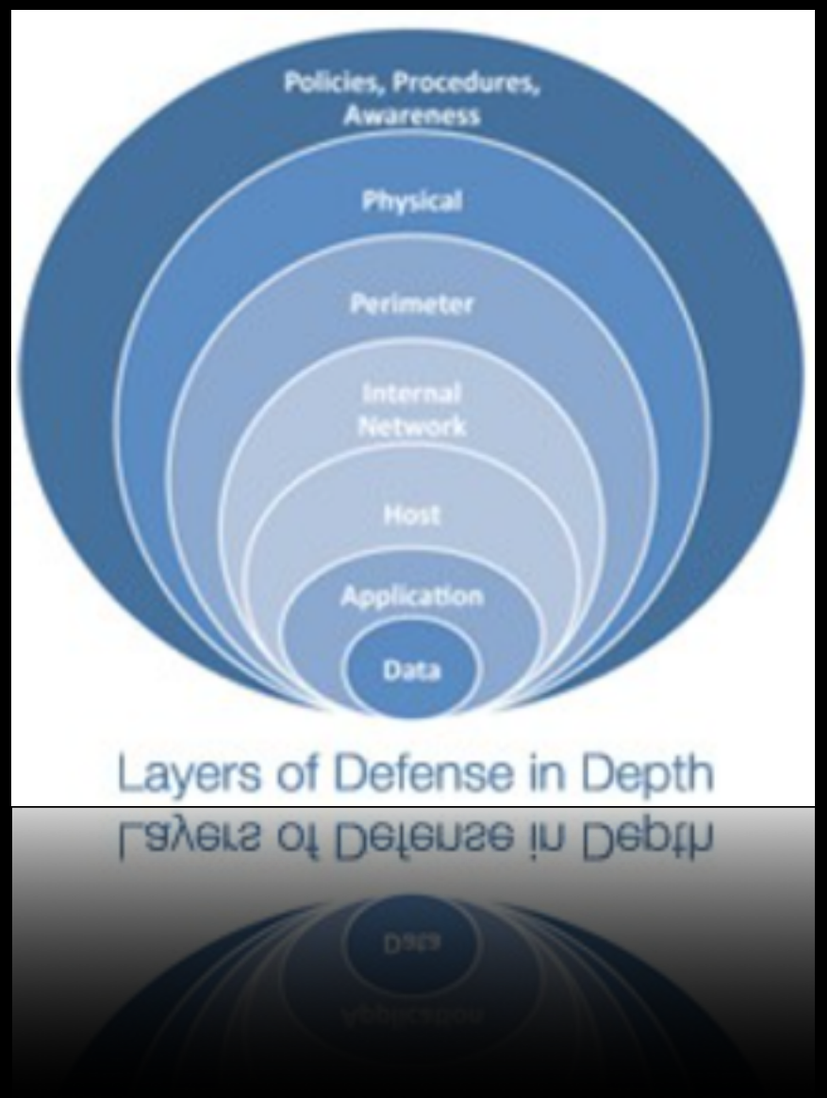
{Ethernet | TCP | Modbus | Tunnel | Modbus}

应对探索

[安全模块解决方案]

- 工业防火墙
- 网络隔离设备
- VPN接入
- 认证管理
- …

纵深防御



工控安全联盟

感谢聆听