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MANDALAY BAY / LAS VEGAS

Rogue7

Rogue Engineering Station Attacks on Simatic S7 PLCs

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Who Are We?

Dr. Sara Bitan

- Senior researcher at the Technion Hiroshi Fujiwara Cyber Security Research Center

- Founder and CEO of CyCloak - Secure System Design and Audit

Uriel Malin

- MSC Student at Tel Aviv University, advised by Prof. Avishai Wool
- Security Researcher at Medigate – Healthcare IoT Security

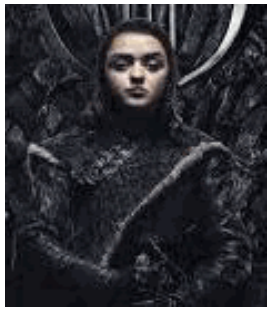
Talk Topics

- Uncovered design vulnerabilities in the S7 protocol
- An exploit that performs remote stealth programming of an S7-1500 PLC

The Operator

The Engineer

The Attacker



Industrial Control System

- A distributed computerized system
- Operates and monitors physical devices
- Controls critical infrastructure
  - Power plants
  - Water facilities
  - Transportation systems
  - Chemical plants

Programmable Logic Controller

- PLC - The core of the ICS
- Connected to sensors and active devices
- Runs a control program that periodically samples the sensors and triggers the devices accordingly
- A bridge between the virtual and the kinetic worlds
- The target of our attacks

PLC interfaces

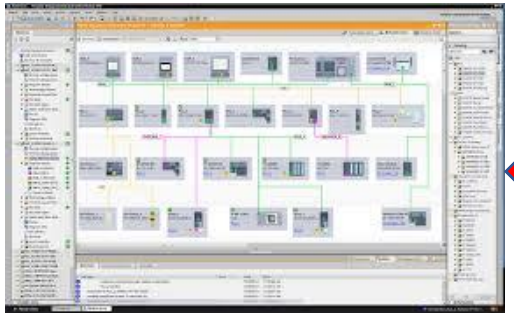
HMI - SCADA

WinCC

TIA

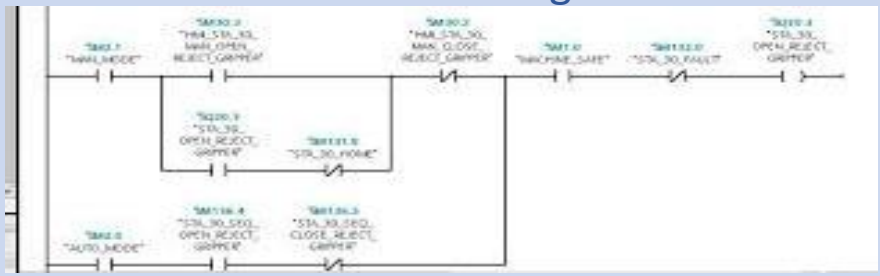
Engineering Workstation

STEP 7



The S7 Protocol

The Control Program



Web Server

SNMP Server

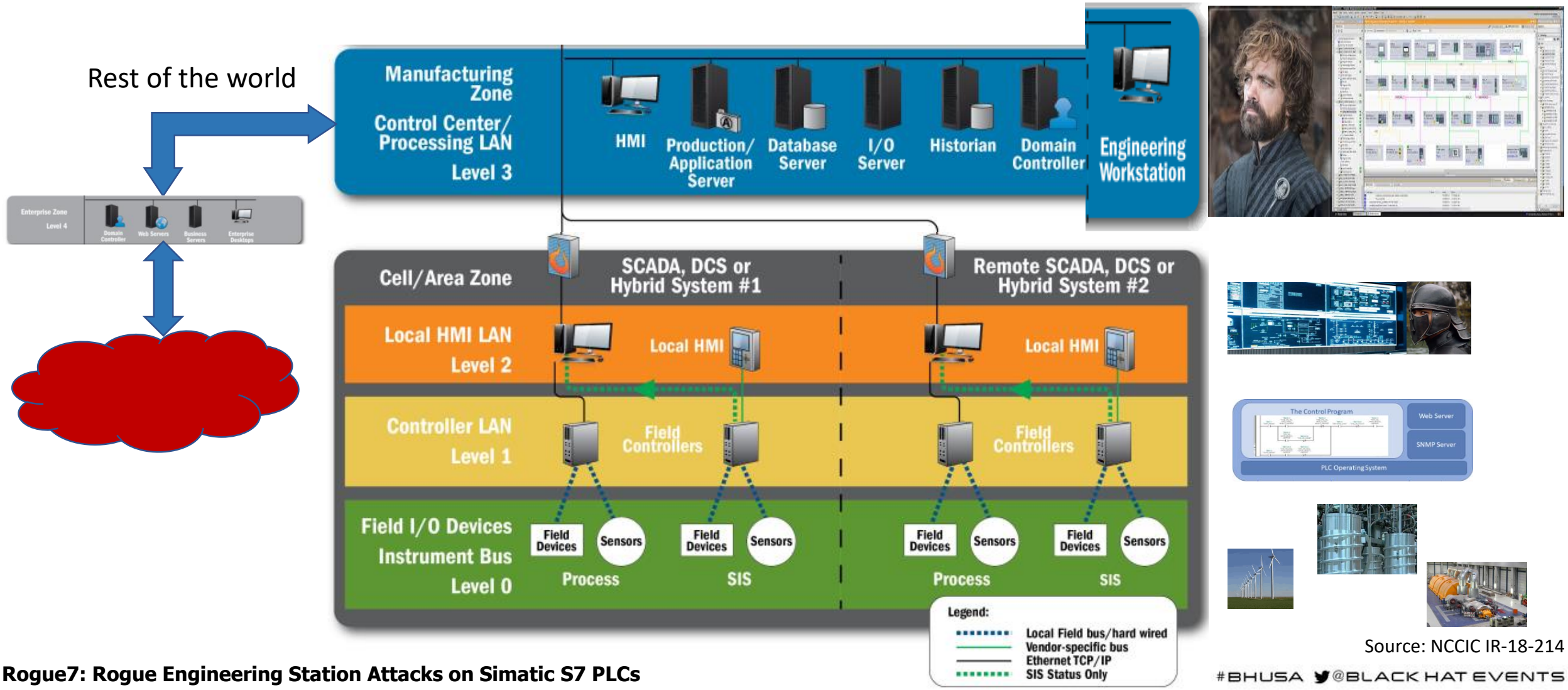
PLC Operating System

PLC

S7-1500

The S7 Protocol

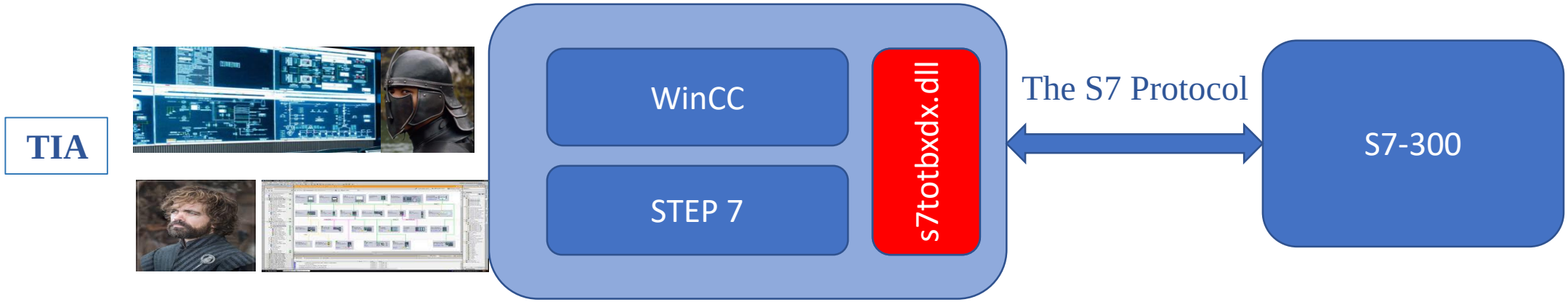
Secure ICS Topology



Source: NCCIC IR-18-214

Stuxnet Malware (9/2010)

- The most famous cyber-attack on ICS
- Targeted Siemens S7-300 PLC
- Infected both WinCC and Step 7 packages

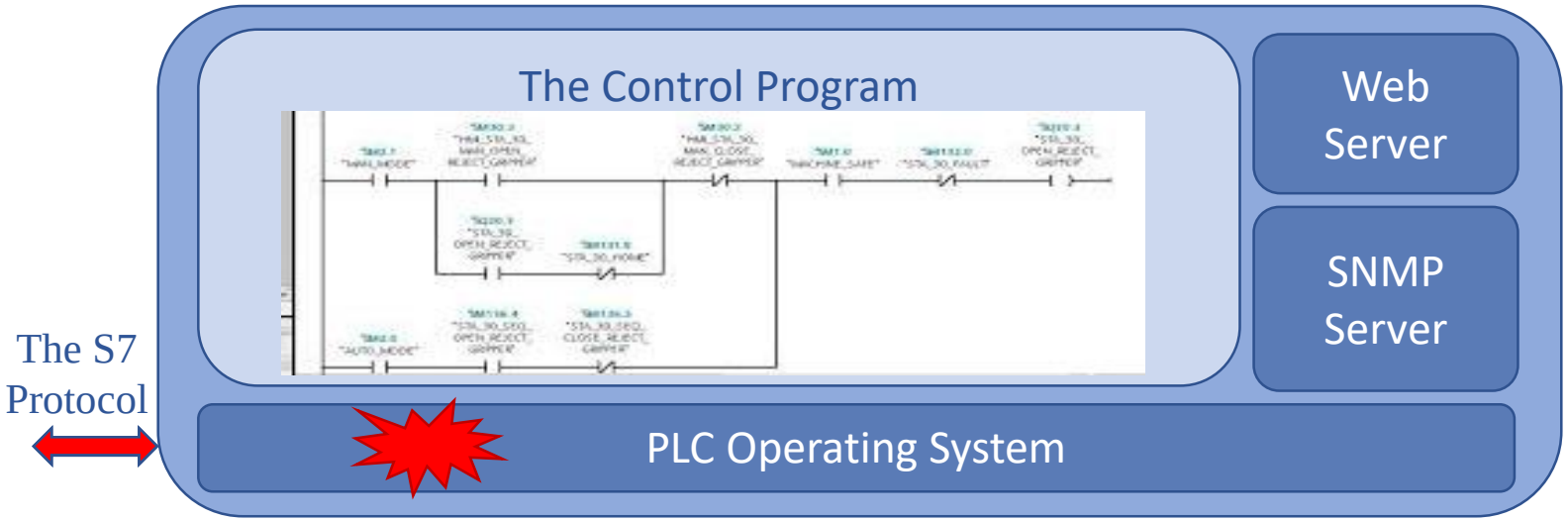


TIA as a Soft Belly

- Typically attacks are exploiting vulnerabilities the engineering station:
  - CVE-2012-3015 : untrusted search path vulnerability in Siemens SIMATIC STEP7 v5.5– July-26-2012
  - CVE-2019-10915: authentication bypass in TIA v15.1 –July-11-19 by Tenable Security

Our Attack

- Exploits vulnerabilities in the PLC Operating System
  - S7 protocol
- Any vulnerable station/ device in the network can serve as an attack machine



The S7-1500 PLC

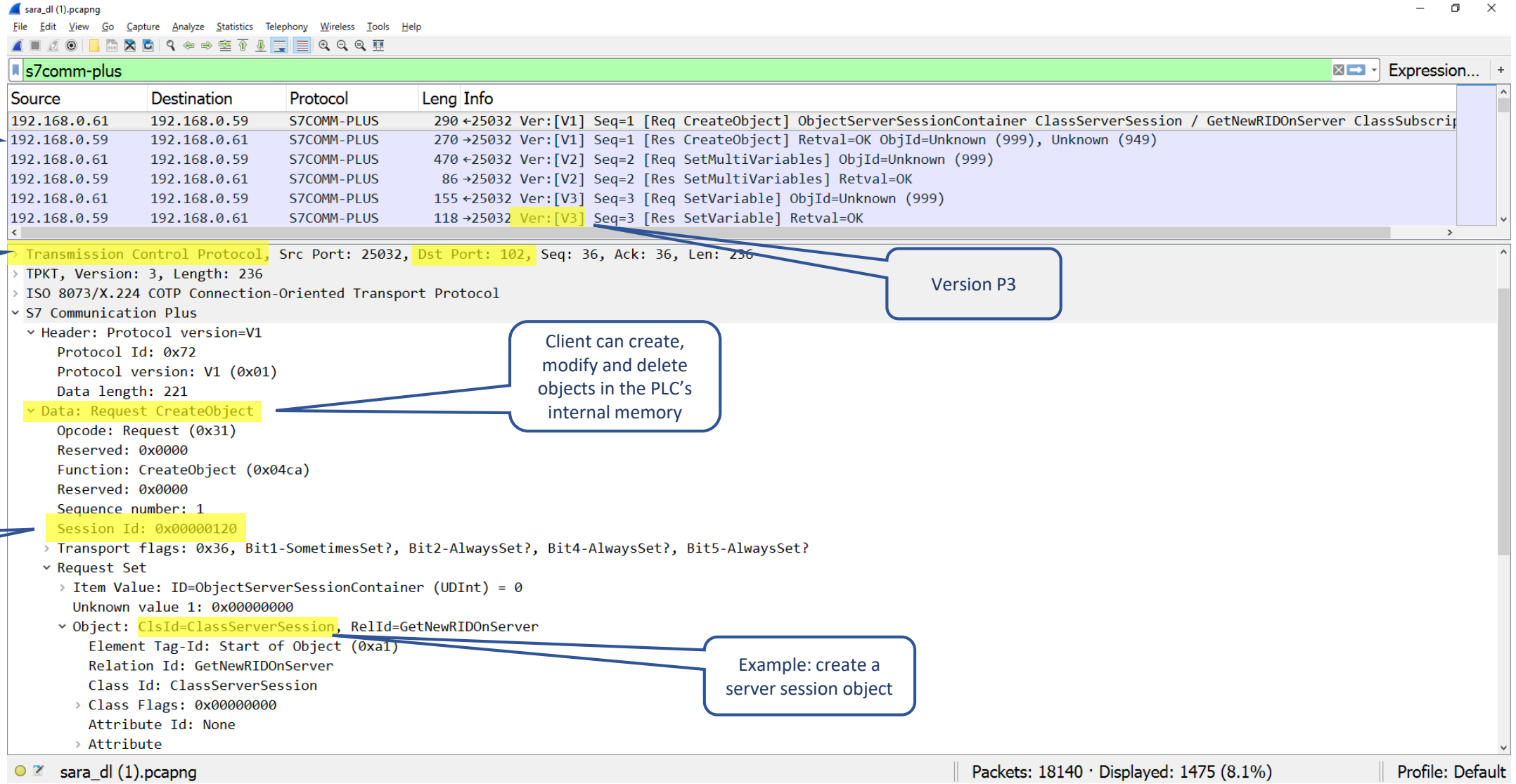
- One of two new members in the SIMATIC PLCs product line
  - S7-1500 is the high-end PLC
  - The other is S7-1200

S7-1500 Security Enhancements

- New version of the S7 protocol
  - Integrity protection of the messages
- Know-how and copy protection
- PLC access control
  - Using passwords
  - Mitigates the program download attacks
  - Not used by customers in practice

Protection level	Access			Access permission	
Protection	HMI	Read	Write	Password	Confirmation
Full access (no protection)	✓	✓	✓		
Read access	✓	✓			
HMI access	✓				
No access (complete protection)					

The S7 Protocol



Session oriented. Session begin with a 4-ways handshake

ISO transport over TCP

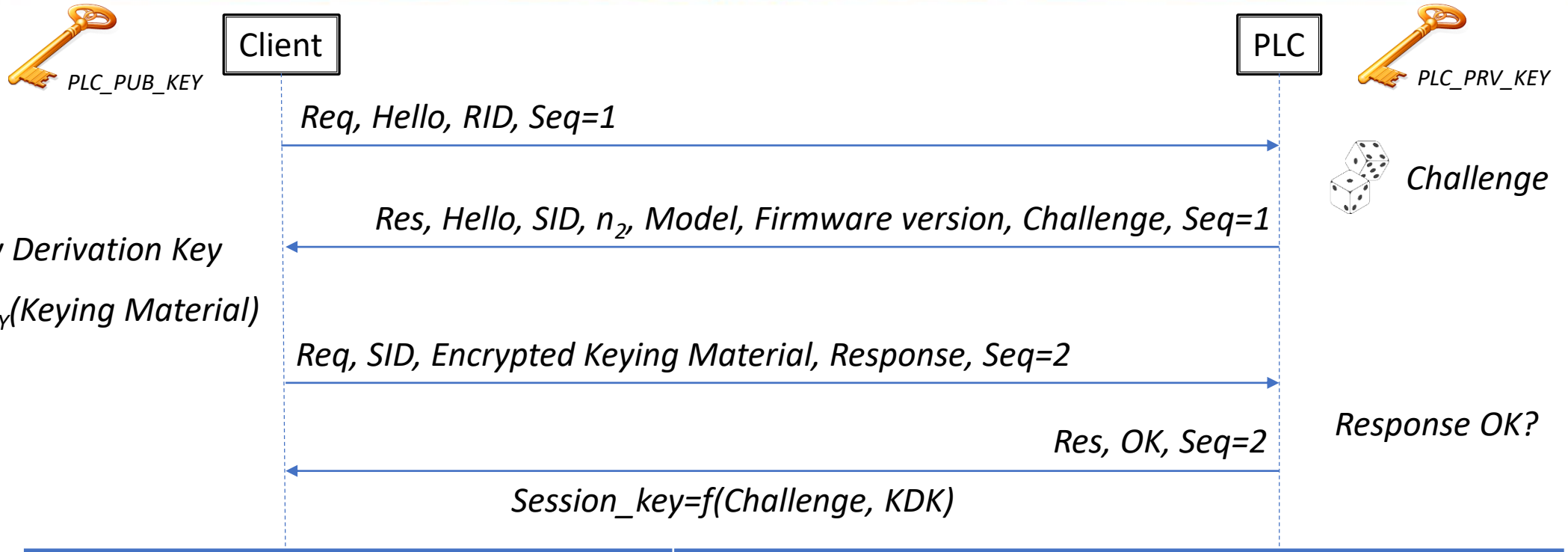
Version P3

Client can create, modify and delete objects in the PLC's internal memory

Session ID

Example: create a server session object

The P3 Handshake Protocol



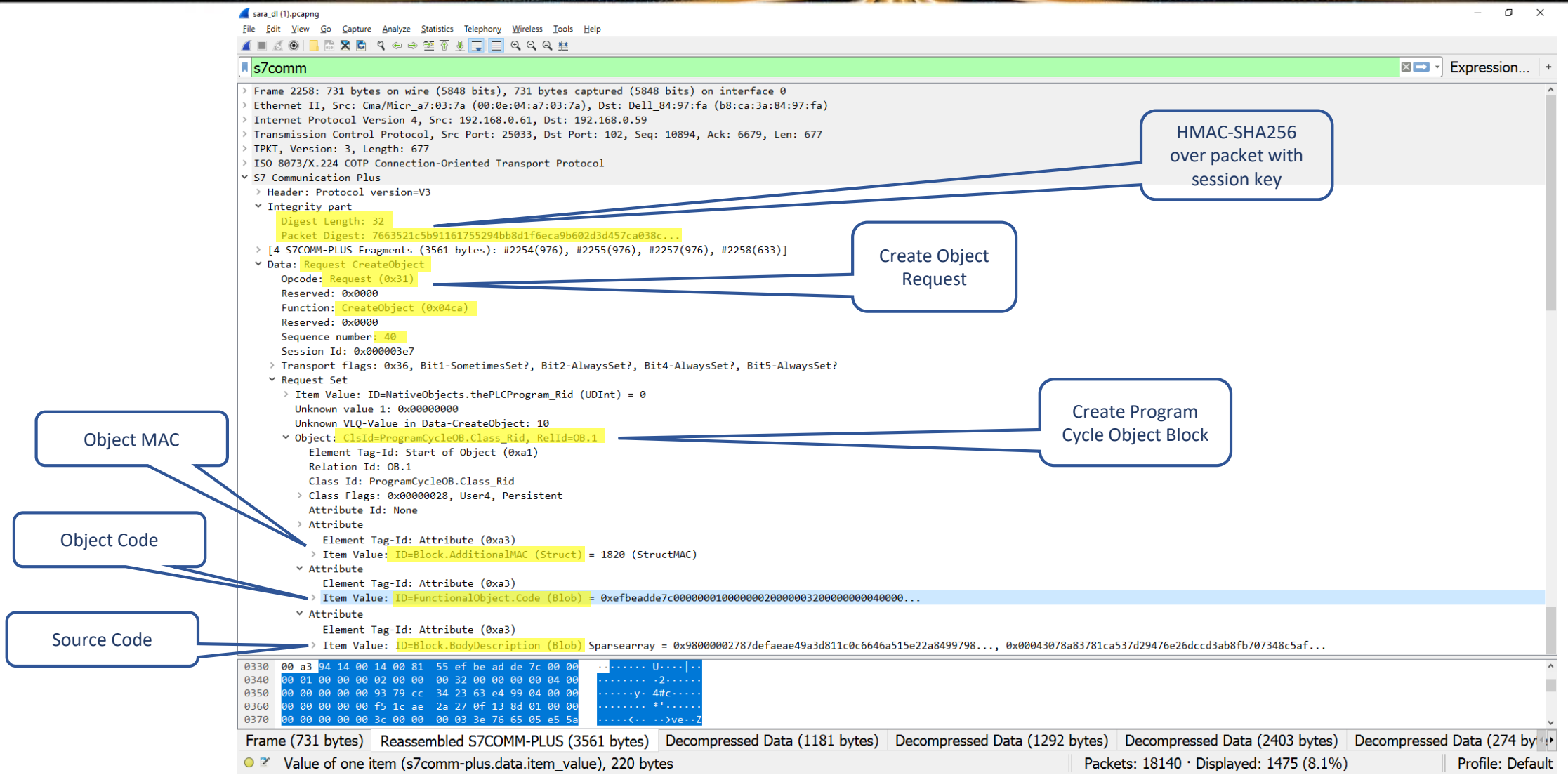
SSL	S7 P3 Handshake
Server only authentication	Server (PLC) only authentication
Client generates keying material. Encrypts with server public key.	Client generates keying material. Encrypts with server public key.
Different servers use different public keys.	All PLCs from the same model and version use a single key.

P3 Handshake Design Vulnerabilities

With Many Working Forged Copies

Attacking the P3 program download exchange

Control Program Create Message



HMAC-SHA256 over packet with session key

Create Object Request

Create Program Cycle Object Block

Object MAC

Object Code

Source Code

Control Program Representation

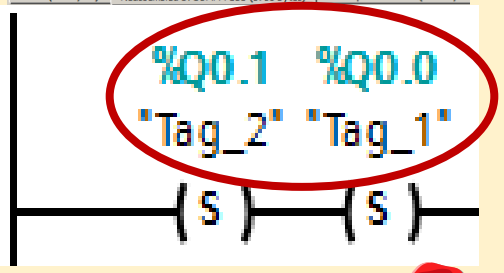
Object MAC

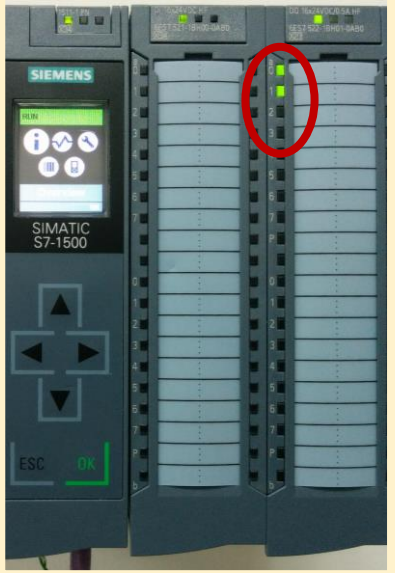
Object Code

```
0210  e8 ef be ad de 02 00 00  00 00 00 00 00 a3 9c 23
0220  00 08 00 a3 a3 62 00 14  00 15 01 00 08 00 00 00
0230  01 00 02 00 05 00 01 03  00 08 00 0f 00 00 00 a3
0240  bb 25 00 0c 00 00 00 00  a3 bd 17 00 17 00 00 07
0250  1c 8e 1d 00 04 00 8e 1e  00 17 00 00 07 08 8e 09
0260  00 04 00 8e 0a 00 02 00  8e 0b 00 17 00 00 07 21
0270  8e 22 00 05 00 8e 23 00  04 00 8e 24 00 04 00 00
0280  8e 0c 00 17 00 00 07 21  8e 22 00 05 00 8e 23 00
0290  04 00 8e 24 00 04 00 00  8e 0d 00 14 00 00 00 8e
02a0  1f 00 14 00 81 0c ea 1d  ad ab 8c 00 00 00 01 00
02b0  00 00 00 00 00 00 a5 f2  7b 76 43 5d 0c 12 01 00
02c0  00 00 00 00 00 00 93 79  cc 34 23 63 e4 99 04 00
02d0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
02e0  00 00 00 00 00 00 86 92  5f df 76 c7 17 b4 7e 7d
02f0  5e 7f 39 34 06 f2 3a 5b  59 fe 65 8d 68 d4 77 d8
0300  60 01 7e 94 f5 41 97 d5  9f 60 27 83 64 41 2c eb
0310  d9 f5 c5 42 2e 37 d8 fa  1a 13 31 0f 74 44 ac cc
0320  b0 2e 12 bd ef 37 74 2d  e0 d6 55 e1 25 72 32 06
0330  dc 52 00 a3 94 14 00 14  00 81 58 ef be ad de 7c
0340  00 00 00 01 00 00 00 02  00 00 00 32 00 00 00 00
0350  04 00 00 00 00 00 00 93  79 cc 34 23 63 e4 99 04
0360  00 00 00 00 00 00 00 a5  f2 7b 76 43 5d 0c 12 01
0370  00 00 00 00 00 00 00 3c  00 00 00 d7 3a d1 7a 6f
0380  5d a7 d3 3b 7f 7d e3 3f  b0 32 83 6d 93 b2 61 cd
0390  e3 cf c9 e1 45 57 7c c0  83 6c f7 c9 3f eb a0 3f
03a0  54 43 cb cd 65 27 fe b2  b2 f6 4e a2 e9 30 31 3e
03b0  00 a9 90 6f 75 56 2f ef  be ad de 00 00 00 00 20
03c0  00 00 00 d6 a6 62 46 72  d0 fc 43 ce 23 17 c9 be
03d0  ff 1d f1 33 26 92 8f 34  92 67 a1 83 74 b2 c9 61
03e0  39 c4 eb ef be ad de 01  00 00 00 18 00 00 00 4a
03f0  23 04 b3 0a e6 5d 3e 52  f9 f9 d1 31 b7 74 2b d6
0400  48 75 4a 0f 5a 81 fa ef  be ad de 02 00 00 00 00
0410  00 00 00 a3 94 15 00 05  8a e2 8c b8 c6 ba 97 a5
0420  08 a3 94 1a 00 14 00 04  00 00 00 00 a3 94 1b 00
```

Frame (906 bytes) | Reassembled S7COMM-PLUS (3733 bytes) | Decompressed Data (1180 bytes)

Source Code





Yellow Program

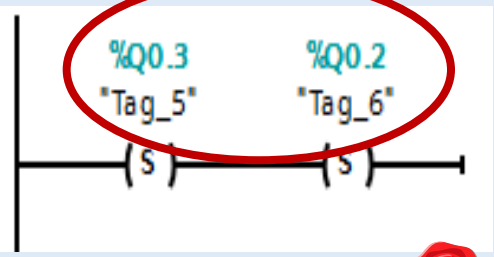
Object MAC

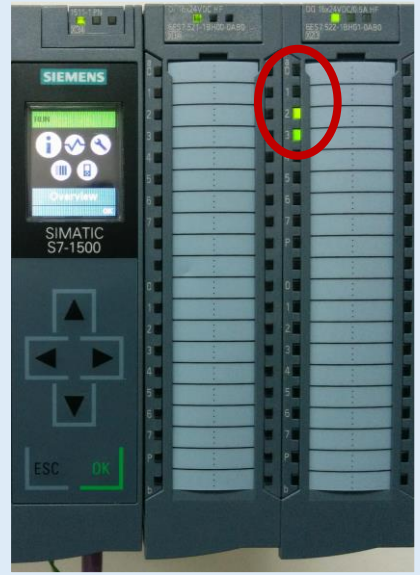
Object Code

```
0210  aa ef be ad de 02 00 00  00 00 00 00 00 a3 9c 23
0220  00 08 00 a3 a3 62 00 14  00 15 01 00 08 00 00 00
0230  01 00 02 00 05 00 01 03  00 08 00 0f 00 00 00 a3
0240  bb 25 00 0c 00 00 00 00  a3 bd 17 00 17 00 00 07
0250  1c 8e 1d 00 04 00 8e 1e  00 17 00 00 07 08 8e 09
0260  00 04 00 8e 0a 00 02 00  8e 0b 00 17 00 00 07 21
0270  8e 22 00 05 00 8e 23 00  04 00 8e 24 00 04 00 00
0280  8e 0c 00 17 00 00 07 21  8e 22 00 05 00 8e 23 00
0290  04 00 8e 24 00 04 00 00  8e 0d 00 14 00 00 00 8e
02a0  1f 00 14 00 81 0c ea 1d  ad ab 8c 00 00 00 01 00
02b0  00 00 00 00 00 00 a5 f2  7b 76 43 5d 0c 12 01 00
02c0  00 00 00 00 00 00 93 79  cc 34 23 63 e4 99 04 00
02d0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
02e0  00 00 00 00 00 00 86 92  5f df 76 c7 17 b4 7e 7d
02f0  5e 7f 39 34 06 f2 3a 5b  59 fe 65 8d 68 d4 77 d8
0300  60 01 7e 94 f5 41 97 d5  9f 60 27 83 64 41 2c eb
0310  d9 f5 c5 42 2e 37 d8 fa  1a 13 31 0f 74 44 ac cc
0320  b0 2e b2 2b 07 94 cd 1d  1d eb 2d 74 ac 22 85 4e
0330  c1 79 00 a3 94 14 00 14  00 81 58 ef be ad de 7c
0340  00 00 00 01 00 00 00 02  00 00 00 32 00 00 00 00
0350  04 00 00 00 00 00 00 93  79 cc 34 23 63 e4 99 04
0360  00 00 00 00 00 00 00 a5  f2 7b 76 43 5d 0c 12 01
0370  00 00 00 00 00 00 00 3c  00 00 00 d7 3a d1 7a 6f
0380  5d a7 d3 3b 7f 7d e3 3f  b0 32 83 6d 93 b2 61 cd
0390  e3 cf c9 e1 45 57 7c c0  83 6c f7 c9 3f eb a0 3f
03a0  54 43 cb cd 65 27 fe b2  b2 f6 4e a2 e9 30 31 3e
03b0  00 a9 90 6f 75 56 2f ef  be ad de 00 00 00 00 20
03c0  00 00 00 d6 a6 62 46 72  d0 fc 43 ce 23 17 c9 be
03d0  ff 1d f1 2d a5 c5 91 8c  af b6 fa 75 d5 1c 01 9b
03e0  03 69 9f ef be ad de 01  00 00 00 18 00 00 00 4a
03f0  23 06 b3 0a e4 5d 3e 87  c9 5b e7 51 7f 78 55 f9
0400  34 07 0b 69 b0 11 39 ef  be ad de 02 00 00 00 00
0410  00 00 00 a3 94 15 00 05  8a e2 8c b8 c6 ba 97 a5
0420  08 a3 94 1a 00 14 00 04  00 00 00 00 a3 94 1b 00
```

Frame (906 bytes) | Reassembled S7COMM-PLUS (3734 bytes) | Decompressed Data (1180 bytes)

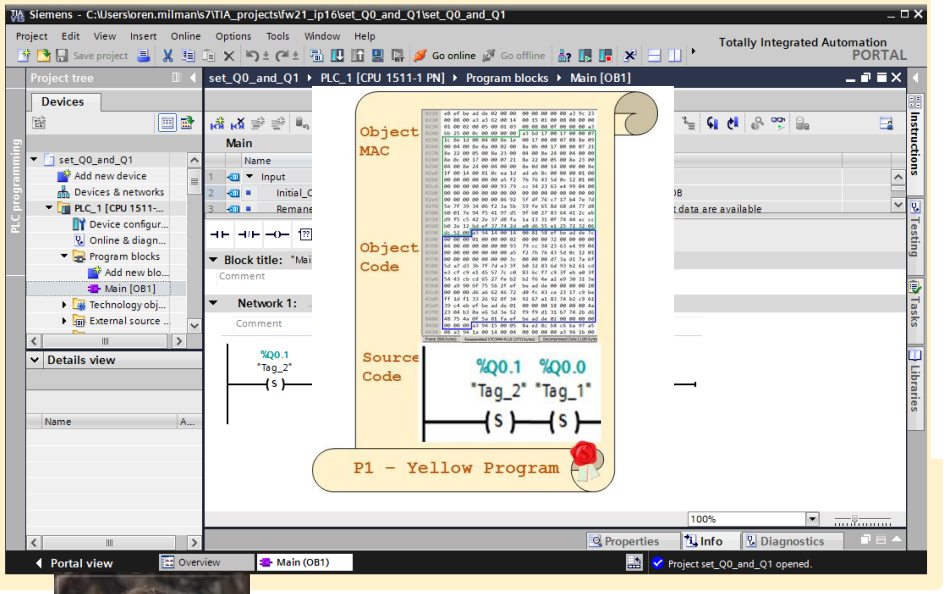
Source Code

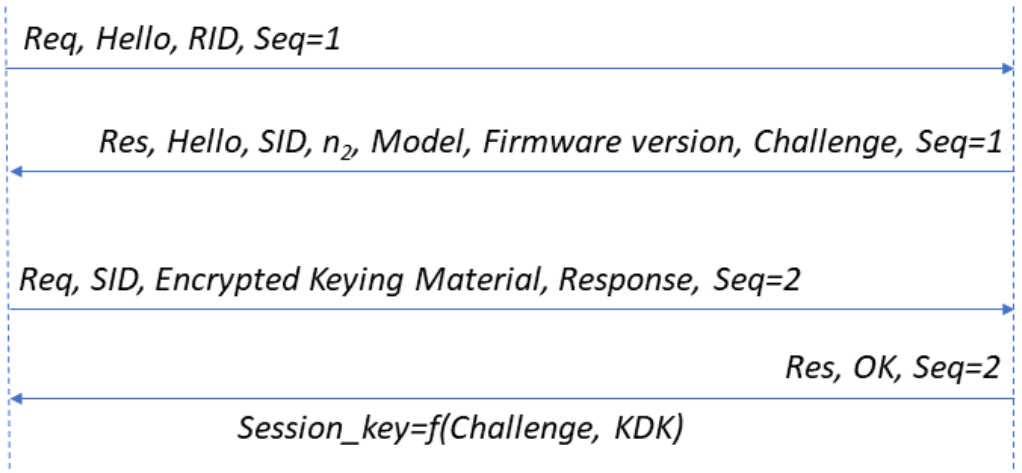




Blue Program

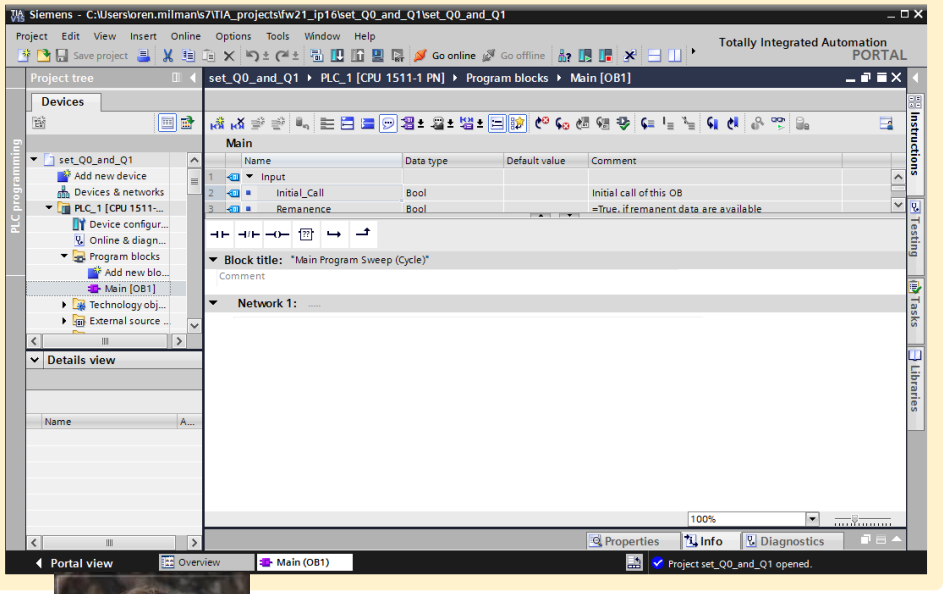
Program Download



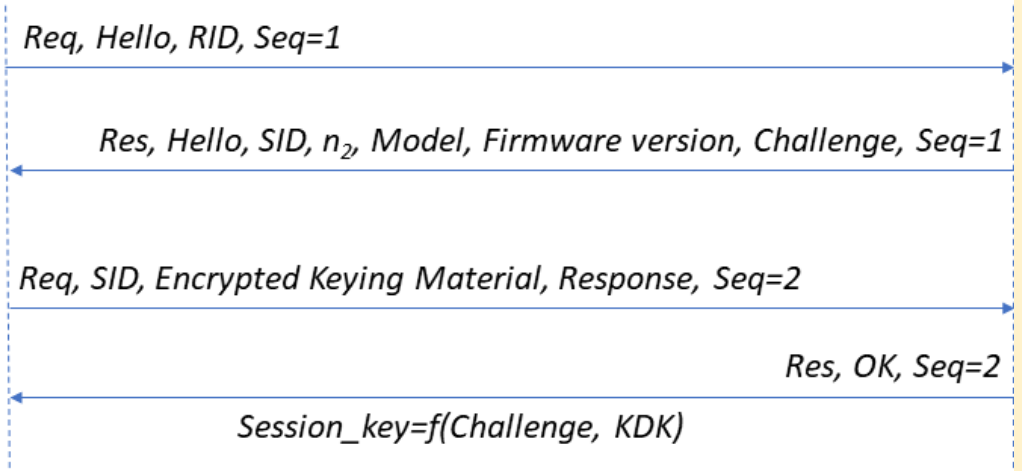


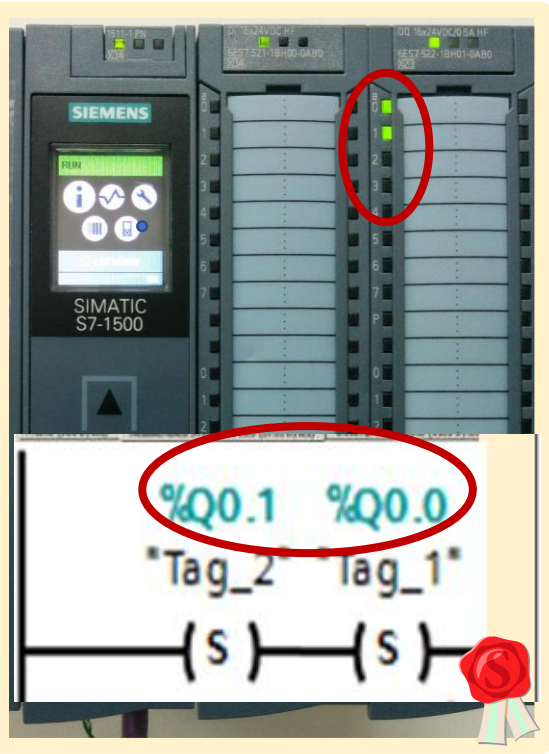
Download

Program Upload



Upload



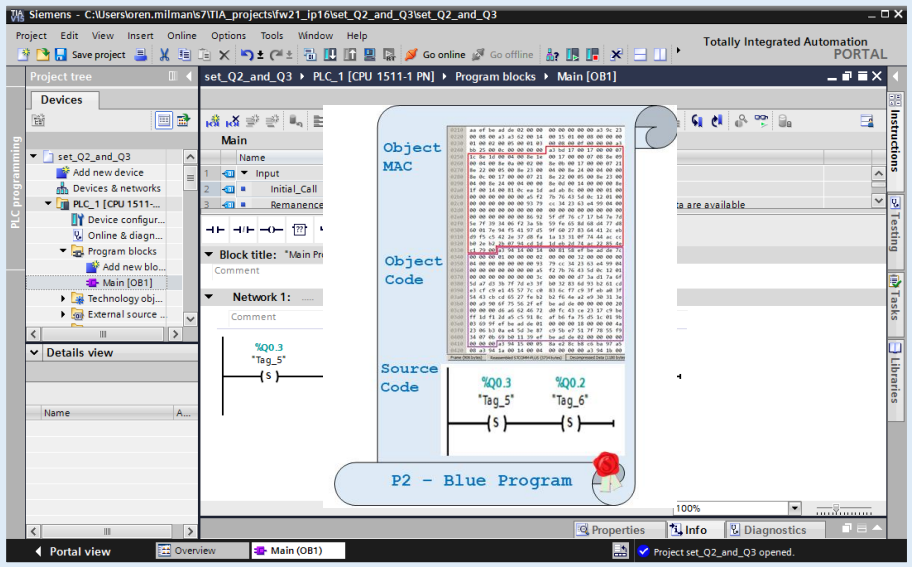


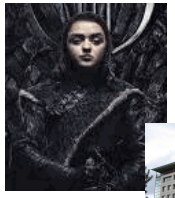
The Rogue TIA

- No engineering station in the production network.
- The attacker brings it with him.
- Rogue TIA: The attack system consists of a modified legitimate TIA and a malicious proxy.

Rogue TIA

Rogue TIA Stealth Program Injection Setup Phase





Download

Req, Hello, RID, Seq=1

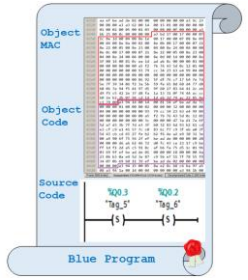
Res, Hello, SID, n_2, Model, Firmware version, Challenge, Seq=1

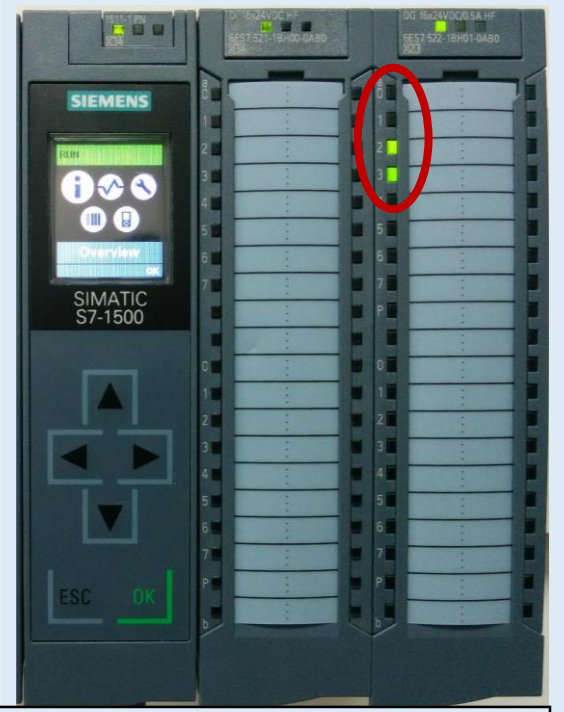
Req, SID, Encrypted Keying Material, Response, Seq=2

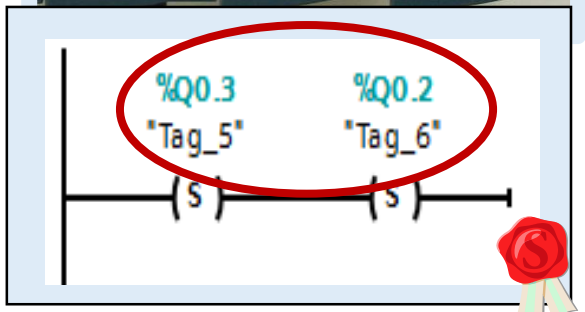
Res, OK, Seq=2

Session_key=f(Challenge, KDK)

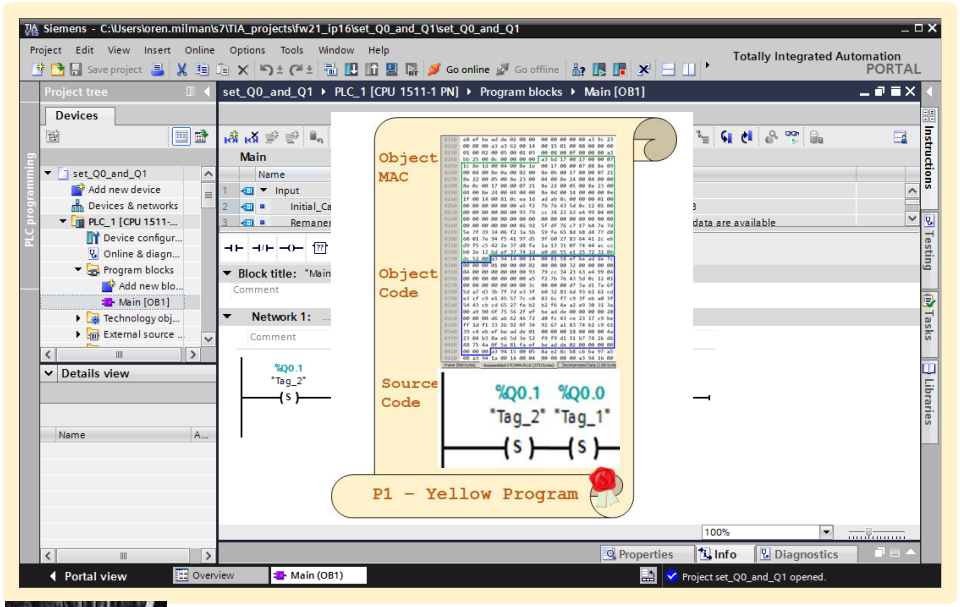
Record

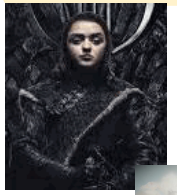






Rogue TIA Stealth Program Injection Attack Phase





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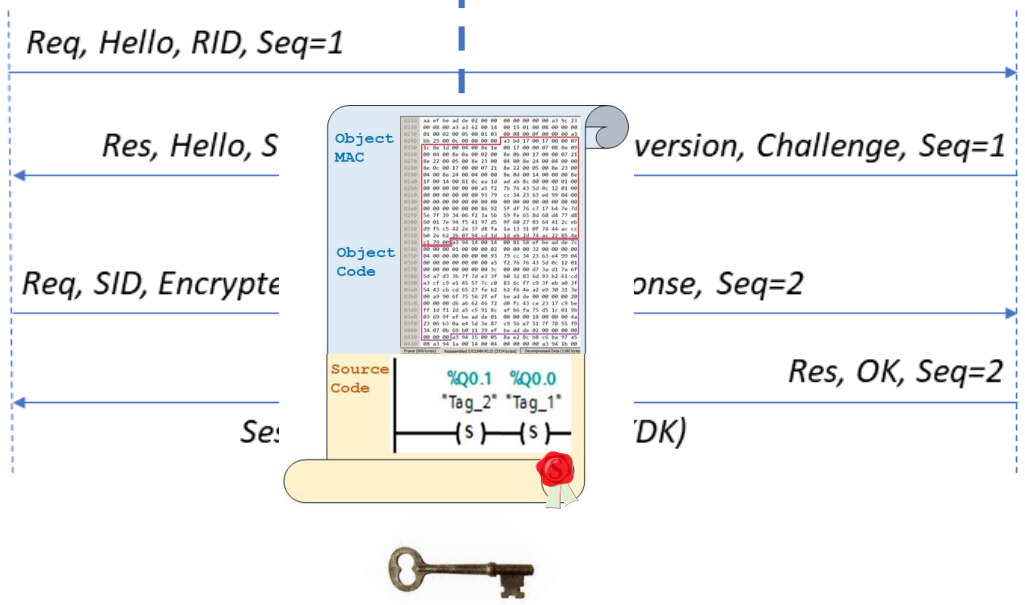
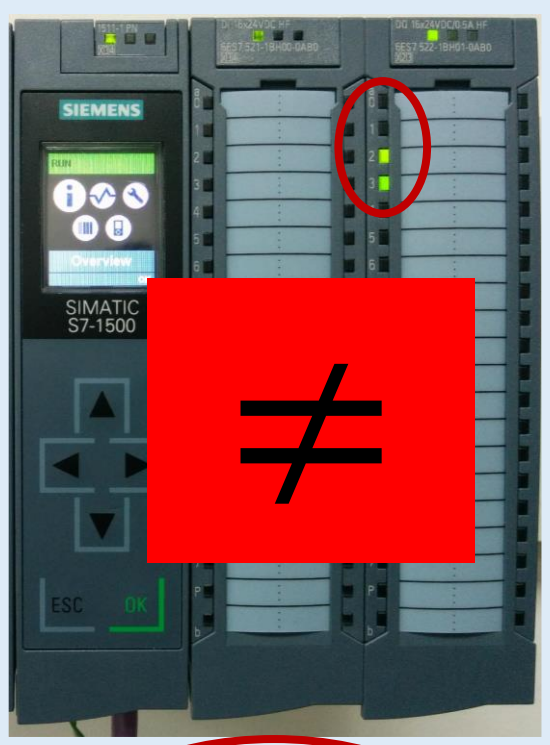
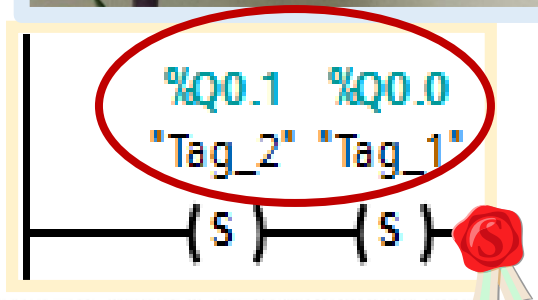


Re-calc integrity



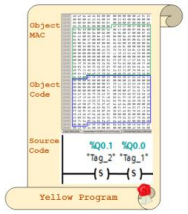


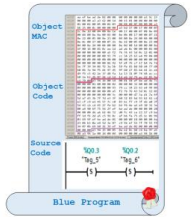
But we cannot always bring our own TIA with us….

Introducing

The Rogue Engineering Station

Rogue Engineering Station



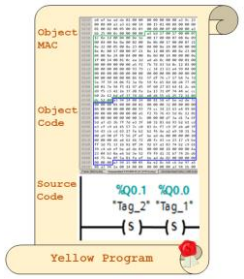


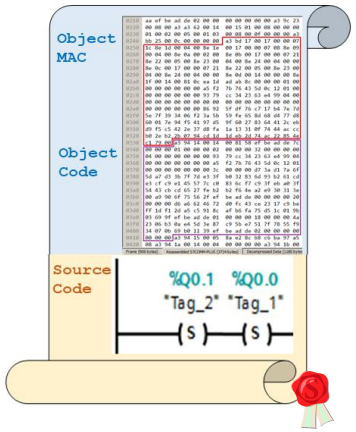
Rogue
Engineering Station

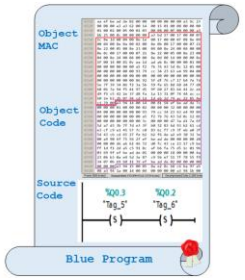
- A Python attack script that impersonates a TIA
- Inputs: PLC's IP address; Yellow and blue programs download pcap files

- Runs a live download session with the PLC
  - Four-way hand-shake
  - All S7 message fields are taken from the yellow pcap file
  - Except, the object code and MAC that are taken from blue pcap file
  - Fixes message SID, integrity protection and additional cookies

Rogue Engineering Workstation Stealth Program Injection

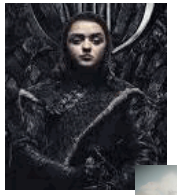






Fix SID
Fix other cookies
Re-calc integrity

Download



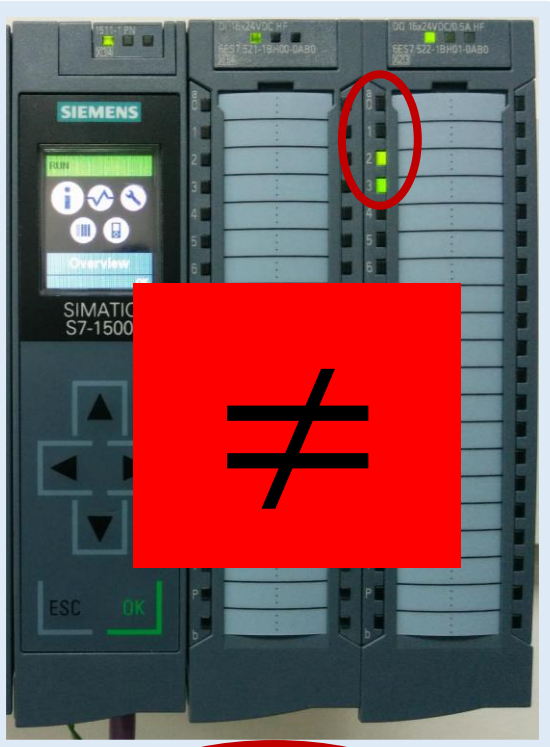
Req, Hello, RID, Seq=1

Res, Hello, SID, n_2, Model, Firmware version, Challenge, Seq=1

Req, SID, Encrypted Keying material, Response, Seq=2

Res, OK, Seq=2

Session_key=f(Challenge, Keying material)



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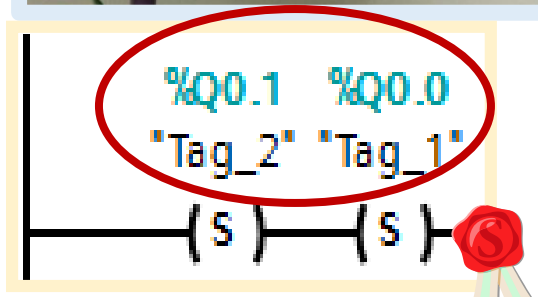
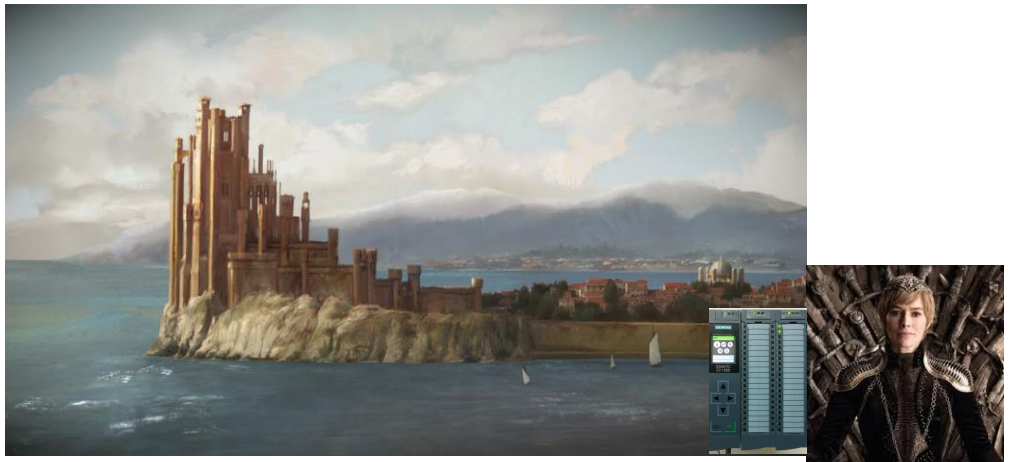


Step7 Impersonation

My Lab

The Wall

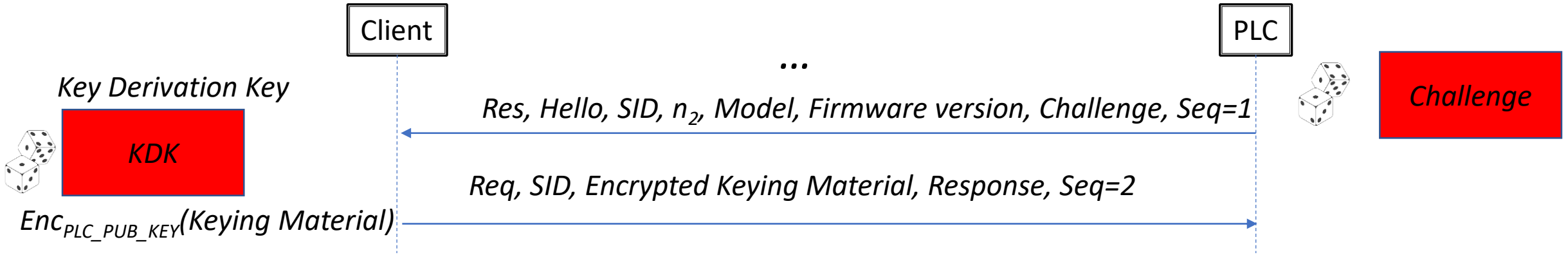


King's Landing

P3 Handshake Details

Deep technical details not for the faint-hearted

P3 Session Key Establishment



- Recall that:

  Session_key = f(Challenge, KDK)

- What is this *EncryptedKeyingMaterial* Structure?

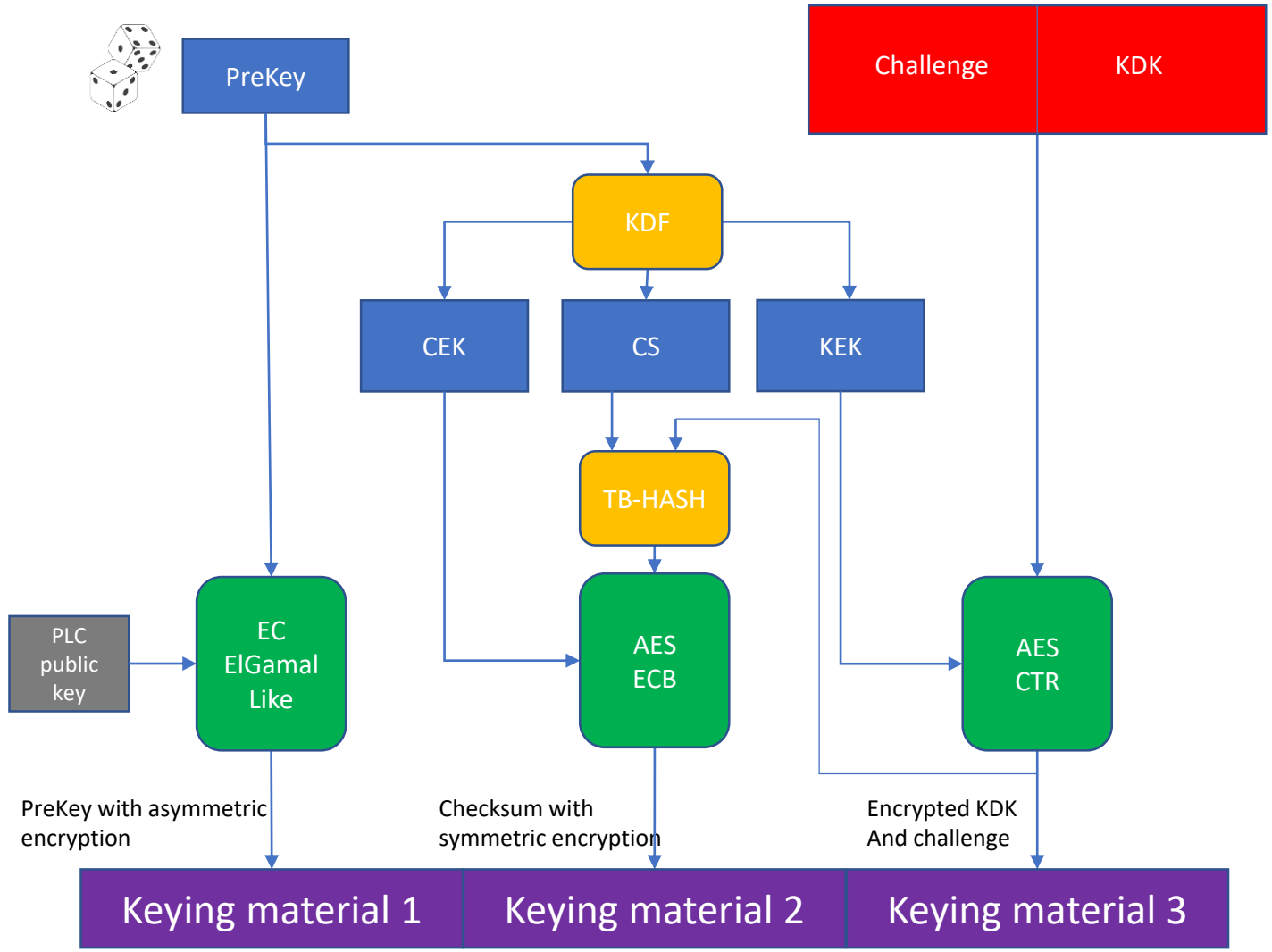
P3 Handshake
Cryptographic Primitives in Use

- Public-private key based asymmetric encryption
  - Elliptic curve: EC-ElGamal
- Symmetric encryption
  - AES
    - Electronic Code Book – ECB Mode
    - Counter mode
- Key Derivation Function: KDF

- Non-cryptographic checksum: Tabulation hash

P3 – KDK Sharing

1. Generate 20 bytes PreKey
   1. Encrypt it using EC-ElGamal–like encryption with the plc public key and add it to Keying material
2. Calculate KDF on PreKey and get
   1. Checksum Encryption Key (CEK)
   2. Checksum Seed (CS)
   3. Key Encryption Key (KEK)
3. Concatenate the KDK to the challenge, encrypt them using AES-CTR with the KEK, and add to Keying material
4. Initiate the Tabulation Hash with CS and calculate checksum over (3)
5. Encrypt (4) using AES-ECB with CEK and add to Keying material



P3 – Asymmetric Keys

- The public keys are stored in compressed .key files at
  [TIA INSTALLATION]\Data\Hwcn\Custom

- Each key file contains
  - Metadata (version, key type, key family, etc.)
  - **Key data – PLC public key for the EC-ElGamal-like encryption**

P3 – An Example .key File

version: 1

orderNumber: s71500-connection

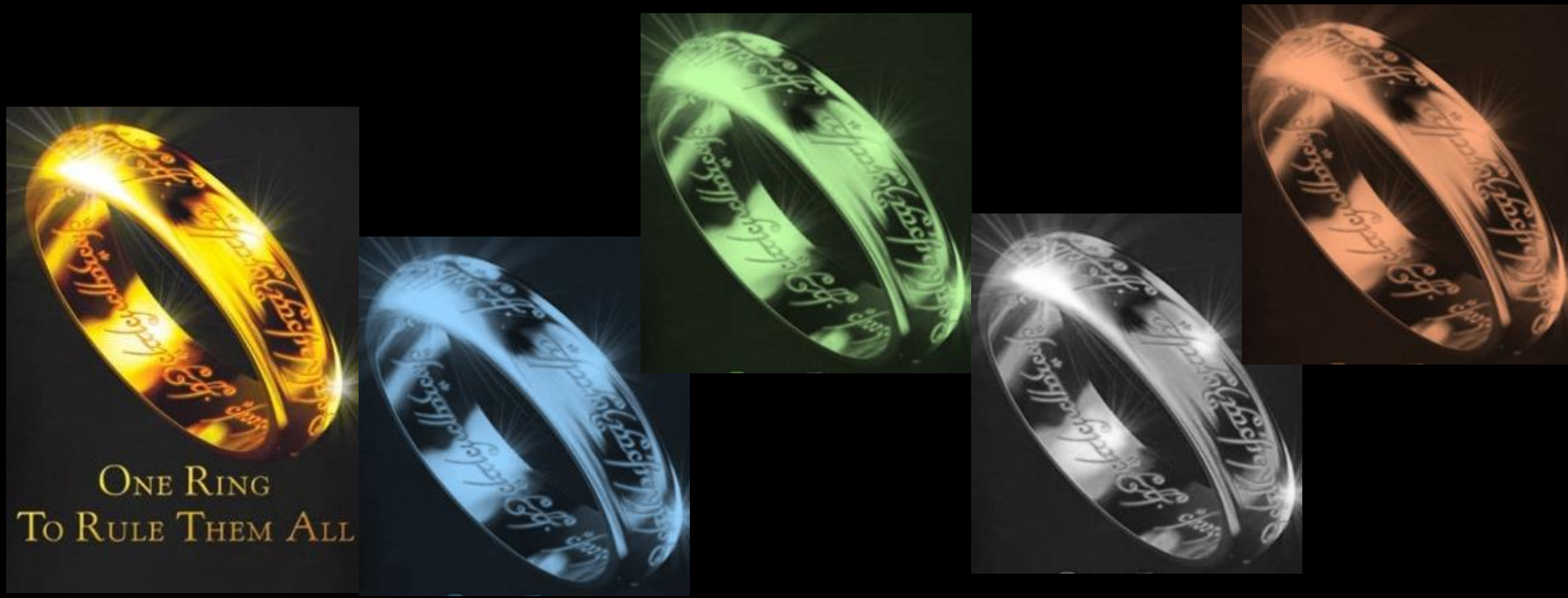
firmwareVersion:

keyType: connection

familyType: S7-1500

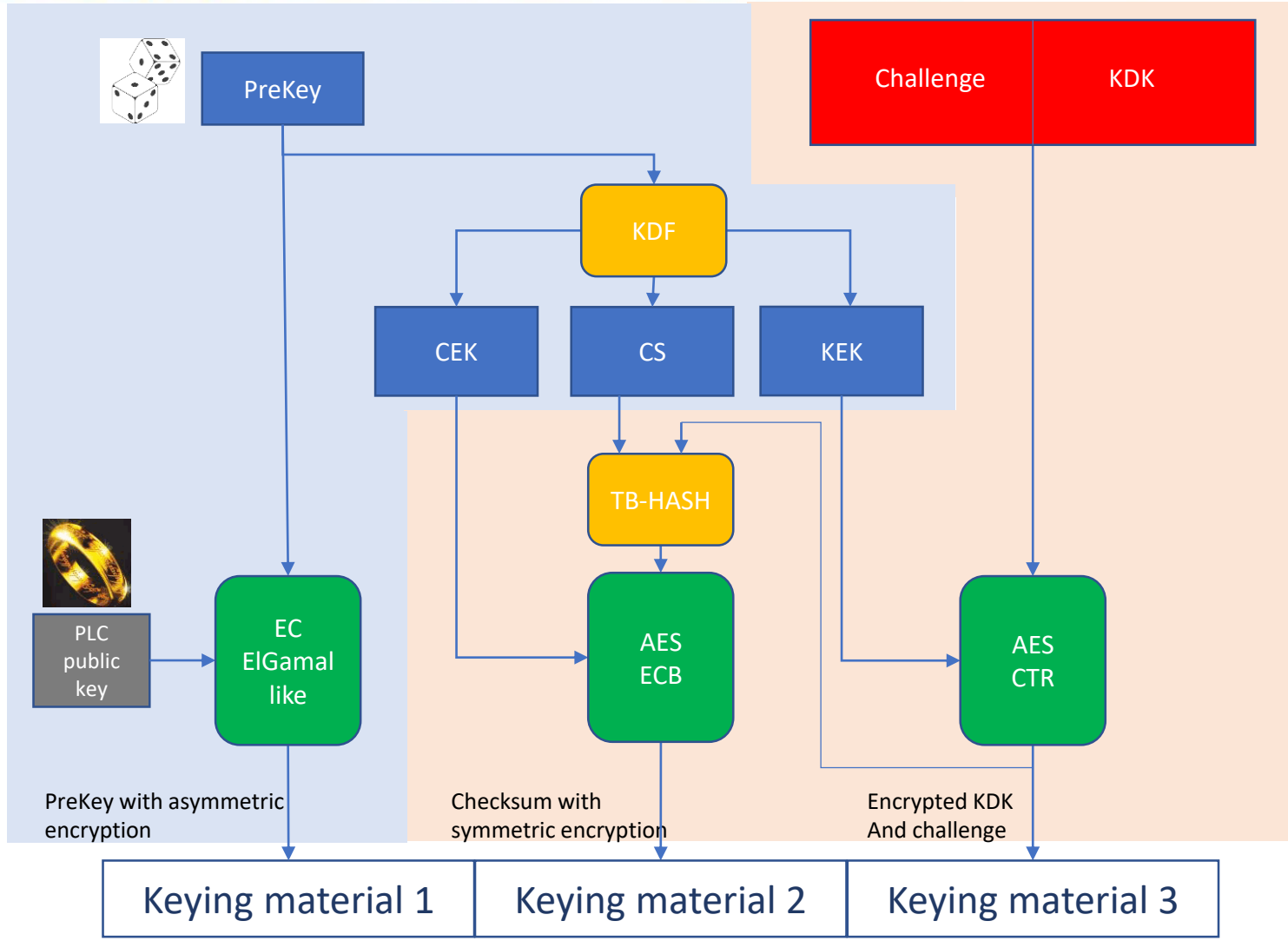
key data: 8456…

P3 Handshake Design Vulnerabilities



Rogue Engineering Station Session Key Establishment

1. Pre-calculate PreKey encryption and CEK, CS, KEK
2. Let Python do the symmetric encryptions and the checksum calculation to build keying material 2 & 3
3. The Python script wraps the session key derivation function from the relevant dll
   - We didn't reverse the session key derivation function *f*, due to lack of time



REing the TIA Handshake

- TIA is huge – find your target files
  - OMSp_core_managed.dll – main S7 communication DLL
  - Mixed mode DLL
    - Managed CIL bytecode – C#
    - Native (unmanaged) x86/x64 opcodes – C++
- Choose your tools
  - Managed code (.NET) - Reflector/dnSpy
  - Native C++ code - IDA Pro

- Improve your reverse engineering starting point

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- Improve your reverse engineering starting point

Tip #1 – Identify Native Code Entry Points

- omsp_core_managed.dll managed part opened in dnSpy

```
1669        public unsafe static Error SetServerPublicKeyGlobal(uint keyType, byte[] key)
1670        {
1671            if (key != null && key.Length != 0)
1672            {
1673                ref byte byte& = ref key[0];
1674                byte* ptr = ref byte&;
1675                uint num = (uint)key.Length;
1676                Blob blob;
1677                <Module>.OMS.Blob.{ctor}(ref blob);
1678                Error result;
1679                try
1680                {
1681                    long num2 = <Module>.OMS.StructValue.copy_data(ref blob, (void*)ptr, num, 0u, false);
1682                    if ((((num2 & -9223372036854775808L) != 0L) ? 1 : 0) != 0)
1683                    {
1684                        Error error = new Error(ref num2);
1685                        result = error;
1686                    }
1687                    else
1688                    {
1689                        num2 = <Module>.OMS.ClientSession.s_set_server_public_key(keyType, ref blob);
1690                        Error error2 = new Error(ref num2);
1691                        result = error2;
1692                    }
```

- Let's click on *s_set_server_public_key*

Tip #1 – Identify Native Code Entry Points

```
13524    // Token: 0x0600037A RID: 890 RVA: 0x00109780 File Offset: 0x00108B80
13525    [SuppressUnmanagedCodeSecurity]
13526    [MethodImpl(MethodImplOptions.Unmanaged | MethodImplOptions.PreserveSig)]
13527    internal unsafe static extern long s_set_server_public_key(uint, OMS.Blob*);
```

- Wait…Where is the function body???
- Looks like it's an unmanaged function…
- How can we find its implementation?

Tip #1 – Identify Native Code Entry Points

- RVA for the native part

```
13524    // Token: 0x0600037A RID: 890 RVA: 0x00109780 File Offset: 0x00108B80
13525    [SuppressUnmanagedCodeSecurity]
13526    [MethodImpl(MethodImplOptions.Unmanaged | MethodImplOptions.PreserveSig)]
13527    internal unsafe static extern long s_set_server_public_key(uint, OMS.Blob*);
```

```
.text:0000000180109780 OMS__ClientSession__s_set_server_public_key proc near
.text:0000000180109780
.text:0000000180109780 var_38          = dword ptr -38h
.text:0000000180109780 var_28          = xmmword ptr -28h
.text:0000000180109780 arg_0           = qword ptr  8
.text:0000000180109780 arg_8           = qword ptr  10h
.text:0000000180109780 arg_10          = qword ptr  18h
.text:0000000180109780 arg_18          = qword ptr  20h
.text:0000000180109780
.text:0000000180109780 ; __unwind { // j___CxxFrameHandler3
.text:0000000180109780                 mov     rax, rsp
.text:0000000180109783                 push    rdi
.text:0000000180109784                 push    r14
.text:0000000180109786                 push    r15
.text:0000000180109788                 sub     rsp, 50h
.text:000000018010978C                 mov     qword ptr [rax-48h], 0FFFFFFFFFFFFFFFEh
.text:0000000180109794                 mov     [rax+8], rbx
.text:0000000180109798                 mov     [rax+10h], rbp
.text:000000018010979C                 mov     [rax+20h], rsi
.text:00000001801097A0                 mov     r15, rdx
.text:00000001801097A3                 mov     ebp, ecx
.text:00000001801097A5                 and     ebp, 0FF00h
.text:00000001801097AB                 or      ebp, 10h
.text:00000001801097AE                 mov     r14, cs:18096D0B0h
.text:00000001801097B5                 add     r14, 2C8h
.text:00000001801097BC                 mov     [rax-40h], r14
.text:00000001801097C0                 mov     rax, [r14]
.text:00000001801097C3                 mov     r8, [rax+8]
.text:00000001801097C7                 lea     rcx, OMS_Recursive_Thread_Mutex_vtable
```

Image Base (0x180000000) + RVA (0x109780)

= 0x180109780

Tip #2: C++ and RTTI

- Run-Time Type Information
- Allow C++ programmers to examine object types dynamically
- The information must be inside the binary
- We could use it

Tip #2: C++ and RTTI – Virtual Tables

1. Find RTTI Objects
2. Locate the relevant virtual tables

```
; const OMS::Parser::`RTTI Complete Object Locator'
??_R4Parser@OMS@@6B@_5 dd 1             ; DATA XREF: .rdata:00000001806C69C0↑o
                                        ; .rdata:00000001807AAFE4↓o
                                        ; signature
                                        ; signature
                dd 0                    ; offset of this vtable in complete class (from top)
                                        ; offset of this vtable in complete class (from top)
                dd 0                    ; offset of constructor displacement
                                        ; offset of constructor displacement
                dd rva ??_R0?AVParser@OMS@@@8 ; reference to type description
                                        ; reference to type description
                dd rva ??_R3Parser@OMS@@8 ; reference to hierarchy description
                                        ; reference to hierarchy description
                dd rva ??_R4Parser@OMS@@6B@_5 ; reference to object's base
                                        ; reference to object's base
                db    0
                db    0
```

Tip #2: C++ and RTTI – Virtual Tables

1. Find RTTI Objects
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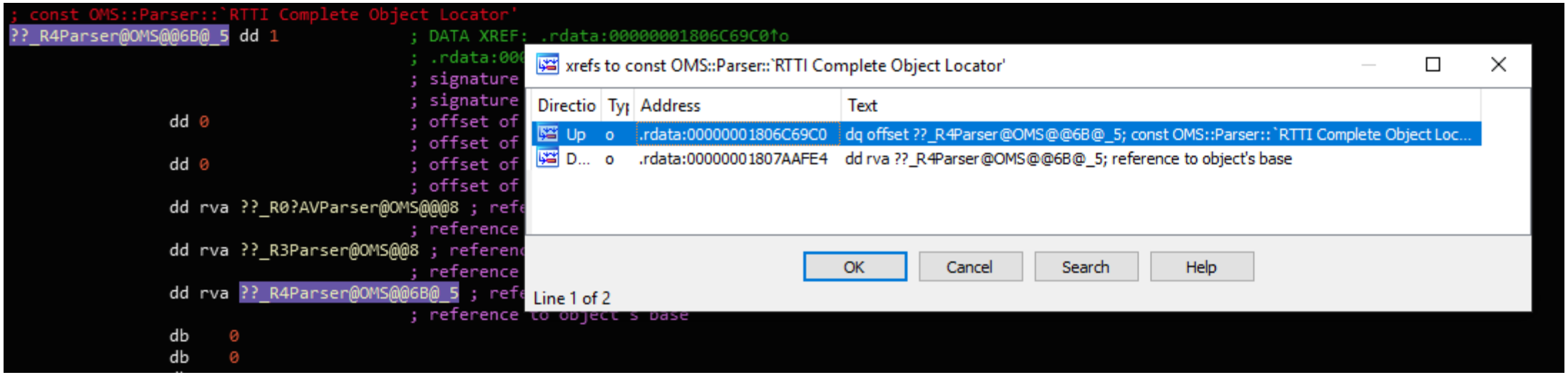


Tip #2: C++ and RTTI = Virtual Tables

1. Find RTTI Objects
2. Locate the relevant virtual tables
3. Rebuild them

```
.rdata:00000001806C69C0                 dq offset ??_R4Parser@OMS@@6B@_5 ; const OMS::Parser::`RTTI Complete Object Locator'
.rdata:00000001806C69C8 off_1806C69C8   dq offset sub_1800ACA20 ; DATA XREF: sub_1800AC380+131↑o
.rdata:00000001806C69C8                                         ; sub_1800ACAB0+1C↑o ...
.rdata:00000001806C69D0                 dq offset sub_1800AD020
.rdata:00000001806C69D8                 dq offset sub_1800CC970
.rdata:00000001806C69E0                 dq offset sub_1800ABC40
.rdata:00000001806C69E8                 dq offset sub_1800AB8C0
.rdata:00000001806C69F0                 dq offset sub_1800AB8D0
.rdata:00000001806C69F8                 dq offset sub_1800ACD10
.rdata:00000001806C6A00                 dq offset sub_1800CC820
```

Tip #2: C++ and RTTI = Virtual Tables

1. Find RTTI Objects
2. Locate the relevant virtual tables
3. Rebuild them

```
.rdata:00000001806C69C0                 dq offset ??_R4Parser@OMS@@6B@_5 ; const OMS::Parser::`RTTI Complete Object Locator'
.rdata:00000001806C69C8 ParserOOMS_vtable ParserOOMS::vtable <offset ParserOOMS__sub_1800ACA20, \
.rdata:00000001806C69C8                                       ; DATA XREF: ParserOOMS__ParserOOMS+131↑o
.rdata:00000001806C69C8                                       ; sub_1800ACAB0+1C↑o ...
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800AD020, \
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800CC970, \
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800ABC40, \
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800AB8C0, \
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800AB8D0, \
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800ACD10, \
.rdata:00000001806C69C8                                     offset ParserOOMS__sub_1800CC820>
```

Combine Them All

- Scan the .NET metadata and grab the native entry points
- Scan your .idb and grab the relevant RTTI data
- Use IDAPython to add this information to your .idb

Combine Them All - Example

```
1  signed __int64 __fastcall sub_1800ABC80(DWORD *a2, char a1)
2  {
3    DWORD *v2; // rdi
4    char v3; // si
5    __int64 v4; // rcx
6    __int64 v5; // rcx
7    DWORD *v6; // rbx
8    DWORD *v7; // rax
9
10   v2 = a2;
11   v3 = a1;
12   v4 = *((_QWORD *)a2 + 385);
13   if ( !v4 || (*(unsigned __int8 (**)(void))(*(_QWORD *)v4 + 8i64))() != a1 )
14   {
15     v5 = *((_QWORD *)v2 + 385);
16     v6 = 0i64;
17     if ( v5 )
18     {
19       v6 = *(DWORD **)(v5 + 32);
20       (**(void (__fastcall ***)(__int64, signed __int64))v5)(v5, 1i64);
21     }
22     v7 = (DWORD *)sub_18017DBE0(v3, v2);
23     *((_QWORD *)v2 + 385) = v7;
24     if ( !v7 )
25       return -6701032989083762692i64;
26     if ( v6 )
27       *((_QWORD *)v7 + 4) = v6;
28   }
29   return 0i64;
30 }
```

Combine Them All - Example

```
1  signed __int64 __fastcall ParserOOMS::createScanner(ParserOOMS *this, char scanner_type)
2  {
3    PackedScannerOOMS *v4; // rcx
4    PackedScannerOOMS *old_scanner; // rcx
5    ACE_Message_Block *v6; // rbx
6    PackedScannerOOMS *v7; // rax
7
8    v4 = this->packedScanner;
9    if ( !v4 || (unsigned __int8)v4->vtable->PackedScannerOOMS::get_default_scanner_type() != scanner_type )
10   {
11     old_scanner = this->packedScanner;
12     v6 = 0i64;
13     if ( old_scanner )
14     {
15       v6 = old_scanner->base.message_block;
16       old_scanner->vtable->PackedScannerOOMS::destructor(old_scanner, 1);
17     }
18     v7 = f_create_scanner(scanner_type, this);
19     this->packedScanner = v7;
20     if ( !v7 )
21       return -6701032989083762692i64;
22     if ( v6 )
23       v7->base.message_block = v6;
24   }
25   return 0i64;
26 }
```

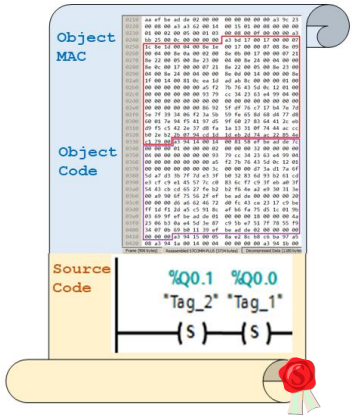
- Much better, isn't it?

Rogue Engineering Station Stealth Program Injection

Attack Demo

Summary

- Vulnerabilities in the S7 protocol – P3
  - TIA is not authenticated
  - “One Ring to Rule them All”
- A Python attack tool that impersonates TIA
  - Download a recorded program to any S7-1500 PLC
  - Stealth program injection attack



Thank You!