Fundamental Security Properties and Mechanisms

Issued: 5 September 2022

Total Marks Available 100.

Answer both questions.

Question 1. Substitution Permutation Network Cipher and Differential Cryptanalysis (60 Marks)

A simple 3-round substitution permutation network (SPN) cipher inspired by the Heys cipher is shown in **Figure 1**.

The cipher operates o e 8-bit plaintext block **P** is XOR-ed bitwise with t rs the two first round S-boxes. The remaining

A substitution box (S-box) is shown in Figure 2. The S- cipher shown in **Figure** 1, i.e. all 6 S-boxes are identical.

The permutation part of the first two rounds is as shown in **Figure** 1. The final (third) round does not implement any permutation; the outputs from the final round S-boxes are simply XOR-ed bitwise with the key $\mathbf{K_4}$ to produce ciphertext **C**.

256 plaintext-ciphertext (P-C) pairs have been generated using the 3-round cipher and four secret keys ($\mathbf{K_1}$, $\mathbf{K_2}$, $\mathbf{K_3}$, $\mathbf{K_4}$). The 256 P-C pairs are given in the file **TwoFiveSixPCs.txt** that accompanies this assessment. Plaintexts and ciphertexts are given as integers with the natural binary interpretation, e.g. the integer 5 represents the 8-bit block 00000101, 129 represents the 8-bit block 10000001, and so on.

You are required to carry out Differential Cryptanalysis on the P-C pairs provided.

You should:

a) Use **Differential Cryptanalysis** to recover the final round key $\mathbf{K_4}$. You should:

   i. **develop** one or more suitable **2-round** differential approximations involving bits of the plaintexts **P** and bits of intermediate ciphertexts **U3** (as shown in **Figure 1**). [**10 Marks**]

ii. **indicate** any active S-boxes in your approximations and their biases. Indicate any tables (or other sources) you have used to calculate the biases [**5 Marks**]

iii. **give** the absolute value of the bias of any 2-round approximation derived above and show how all such biases were calculated. [**5 Marks]**

iv. **Explain** your specific choice of approximation(s). [**5 Marks**]

The above allows for using two approximations: one that targets the first four bits of **K₄** and one that targets the second four bits of **K₄**. It also allows for the use of a single approximation that targets all 8 bits of the key **K₄**. You should justify your choice.

The above is the theoretical part of the question. You need to complete this part to inform the practical part of the question immediately below.

b) Use the results above to **recover** the key **K₄**. Show the results of your work. You will need to **implement code to:**

i. **read-in** the P-C pairs. [**5 Marks**]

ii. **identify and use** suitable (P,C), (P',C'), where P XOR P'=ΔP, i.e. the plaintext difference part of a differential approximation. [**5 Marks**]

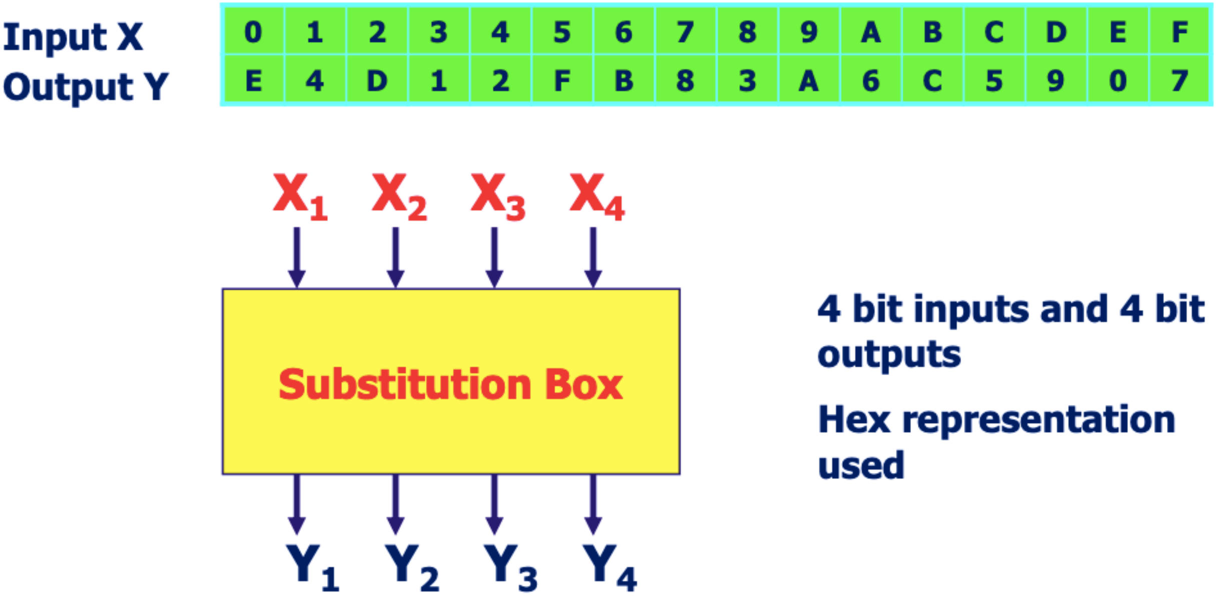
iii. **carry out** the (partial) decryption of pairs of relevant ciphertexts for a given (possibl **U₃** bits. [**10 Marks**]

iv. **carry o** n appropriate Δ**P** bits and Δ**U₃** bit

v. **identify** **4** our answer **why** identified candidate(s) are particularly

c) **Outline** how you would recover all remaining (You are **not** expected to actually recover them, just outline how you would do this.) [**5 Marks**]

Figure 1. Simple Very Small SPN Cipher



Input X	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Output Y	E	4	D	1	2	F	B	8	3	A	6	C	5	9	0	7

Figure 2. Specification of the Common S-Box

Q2 Podcast on

You are required to prod entication'. The intended listeners are the general al jargon. It should:

- indicate what user authentication is and why it is n
- identify major user authentication approaches and ;
- highlight some practical downsides/challenges with user authentication and how they can be addressed;
- highlight some controversial issues (or potentially controversial issues); and
- give an indication of how you see the future of user authentication in cybersecurity evolving.

Marks are awarded for:

- **Topic content.** Selection of content. Coverage of the above requirements. Is there a coherent and balanced narrative? [24 Marks]
- **Appropriate expression.** Will the **public** understand it? It is expressed in an accurate but accessible way? [8 Marks]
- **Oral delivery.** Is there a natural and engaging feel to your presentation? [8 Marks]

You should prepare a **script file** for your podcast (i.e., a file that has the textual version of your podcast content) and an audio file. [The script will allow the markers to determine what is being said if the audio is unclear.] The duration of the podcast **must** be between **2 minutes 55 seconds** and **3 minutes**. It **must** be submitted in a common audio format (mp3 preferred).

A **folder containing all necessary submission elements** should be **compressed** (using zip) and **submitted** via the MOLE site. A COM6014 blog will be maintained specifically for this assignment. Queries on this assignment should be made via that blog.