Solution of Exercisesheet 9

Exercise 9-1

Exercise 9-2

Exercise 9-3

(a) **To show:** Prove that regular CPA security implies λ-CPA security.
We do this by a reduction. We assume there is an efficient adversary $\mathcal{A}$ against the λ-CPA-security of Π which is successful with non-negligible probability. From this we construct our adversary $\mathcal{B}$ against the CPA-security of Π which invokes $\mathcal{A}$. $\mathcal{B}$ has to provide an encryption oracle for $\mathcal{A}$. To do this, he forwards any message m $\mathcal{A}$ sends to his oracle to his own oracle and recieves the ciphertext c. He then makes a vector $\vec{C}$, which contains λ-times the ciphertext c, and forwards it to $\mathcal{A}$.
$\mathcal{A}$ eventually outputs two messages $(\widetilde{m_0}, \widetilde{m_1})$, which $\mathcal{B}$ forwards to his challenger. Then he sends an vector $\vec{C_b}$ to $\mathcal{A}$, which contains λ-times the recieved ciphertext c_b. Then $\mathcal{B}$ outputs the same bit b like $\mathcal{A}$ does.
$\mathcal{B}$ invokes $\mathcal{A}$ and $\mathcal{A}$ is efficient. Because of that, the message length have to be poly. Furthermore forwarding messages is in poly time too. So $\mathcal{B}$ is efficient.
To analyse the success, we ascertain, that $\mathcal{B}$ simulates the λ-CPA-game perfectly to $\mathcal{A}$. So the success probability of $\mathcal{B}$ is the same as $\mathcal{A}$, which is non-negligible. This is a contradiction to the CPA security of $\mathcal{B}$, so such an adversary $\mathcal{A}$ cannot exit.
It follows that the scheme is λ-CPA secure, if it CPA secure. In other words, regular CPA security implies λ-CPA security.

So ok and possible?

(b) **To show:** Prove that λ-CPA security implies normal CPA security.
We do this by a reduction. We assume there is an efficient adversary $\mathcal{A}$ against the CPA-security of Π which is successful with non-negligible probability. From this we construct our adversary $\mathcal{B}$ against the λ-CPA-security of Π which invokes $\mathcal{A}$. $\mathcal{B}$ has to provide an encryption oracle for $\mathcal{A}$. To do this, he forwards any message m $\mathcal{A}$ sends to his oracle to his own oracle and recieves the ciphertextvector $\vec{C} = (c_1, ..., c_\lambda)$. He then forwards only the first ciphertext c_1 to $\mathcal{A}$.
$\mathcal{A}$ eventually outputs two messages $(\widetilde{m_0}, \widetilde{m_1})$, which $\mathcal{B}$ forwards to his challenger. From the recieved ciphertextvector $\vec{C_b}$ he again forwards only the first ciphertext to $\mathcal{A}$. Then $\mathcal{B}$ outputs the same bit b like $\mathcal{A}$ does.
$\mathcal{B}$ invokes $\mathcal{A}$ and $\mathcal{A}$ is efficient. Because of that, the message length have to be poly. Furthermore forwarding messages is in poly time too. So $\mathcal{B}$ is efficient.
To analyse the success, we ascertain, that $\mathcal{B}$ simulates the CPA-game perfectly to $\mathcal{A}$. So the success probability of $\mathcal{B}$ is the same as $\mathcal{A}$, which is non-negligible. This is a contradiction to the λ-CPA security of $\mathcal{B}$, so such an adversary $\mathcal{A}$ cannot exit.
It follows that the scheme is CPA secure, if it λ-CPA secure. In other words, λ-CPA security implies normal CPA security.

Exercise 9-4