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Question **1**

Not answered

Marked out of 10.00

a) Given a mixed strategy game $\Gamma = \langle N, (\Delta(S_i)), (u_i)\rangle$, then, for any $i \in N$,

Prove that

$$u_i(\sigma_i, \sigma_{-i}) = \sum_{s_{-i}\in S_{-i}} \left(\prod_{j\neq i} \sigma_j(s_j)\right) u_i(\sigma_i, \sigma_{-i})$$

b) State the Necessary and Sufficient Condition (NASC) for a Mixed Strategy Nash Equilibrium.

c) For the game with payoff matrix

$$\begin{array}{cc} & \text{Player B} \\ \text{Player A} & \left\Vert \begin{array}{ccc} -2 & 3 & -4 \\ 7 & 5 & -5 \end{array} \right\Vert \end{array}$$

Determine the best strategies for players A and B. Also, determine the value of the game. Is this game (i) fair? (ii) strictly determinable?

[3+3+4=10]

Question **2**

Not answered

Marked out of 10.00

a)Design the non-cooperative game model to the uplink power allocated problem in multi-cells. Clearly mention the game, players, strategy, utility function, and cost function

b) The strategy space *Pm* of participator m is a non-empty compact convex subset of a Euclidian space, and the net utility function is continuous and quasi-concave on *Pm* . Prove that in this game model *Nash Equilibrium* exists.

c) Prove that if P is denoted by the Nash equilibrium of the non-cooperative game model and its response function can be written as $I(P) = (I_1(P), I_2(P), I_3(P) \ldots\ldots\ldots I_n(P))$

[4+3+3=10]

Question **3**

Not answered

Marked out of 10.00

a) Consider there are Base Transceivers (BS) are deployed for cellular service. BSs in a certain geographical area are assumed to cooperate together by forming a coalition. Considering there are N_{BS} BSs in the coalition, each having its own payoff function or utility, such that the utility of BS l is denoted by U_l

Given,

1. The transmit power cannot exceed the maximum power for the UL and DL, respectively.
2. In each cell, a subcarrier can be allocated at most to a unique user at a given scheduling instant and applicable for both UL and DL.
3. The total outage rate in the network should not exceed a tolerated outage threshold $P_{out,th}$

Determine the objective function and constraints.

b) Write the Utility maximization algorithm. Use the following indicator variables

I_j^{ON} j indicates if a BS j is on or off, by setting its value to 1 or 0, respectively, whereas

I_j^{attempt} is a tracking parameter that indicates whether an attempt has been made to switch BS j off in the current iteration or not. It is set to 1 if the attempt was made and to 0 otherwise.

c)Define a utility that reflects the number of served users versus the power consumption in the network.

[2+3+4+1=10]

Question **4**

Not answered

Marked out of 10.00

Let there are N cloud service providers. We assume that each service provider has a set of $\mathcal{K} = \{1, 2, \cdots, K\}$ different types of resources such as communication, computation, and storage resources. The nth service provider represents its available resources as $C^n = \{C_1^{(n)}, \cdots, C_K^{(n)}\}$. $C_k^{(n)}$ is the number of resources of type *k* available at service provider n. The vector $\bar{C} = \{\sum_{n\in\mathcal{N}} C_1^{(n)}, \sum_{n\in\mathcal{N}} C_2^{(n)}, \cdots, \sum_{n\in\mathcal{N}} C_K^{(n)}\}$ represents all available resources at different service providers. Each service provider n has a set of native applications $\mathcal{M}_n = \{1, 2, \cdots, M_n\}$ that ask for resources. The set of all applications that ask for resources from the set of service providers (a coalition of service providers) is given by

$\mathcal{M} = \mathcal{M}_1 \cup \mathcal{M}_2 \cdots \cup \mathcal{M}_N, \text{ where } \mathcal{M}_i \cap \mathcal{M}_j = \emptyset, \ \forall i \neq j,$ i.e.,

each application originally asks only one service provider for resources.

a) Determine the allocation decision matrix for the multiple service provider $X_{SO}^{(n)}$

b) Express the optimization problem mathematically and mention the constraints.

c) Prove that the Resource allocation and sharing problem (with multiple objectives) for the aforementioned system model can be modeled as a canonical cooperative game with NTU

d) Prove that this canonical game is convex.

Given: A coalition game is said to be convex if and only if for every player $n \in \mathcal{N}$, the marginal contribution of the player is non-decreasing with respect to (W.R.T.) set inclusion. Mathematically, for $S_1 \subseteq S_2 \subseteq \mathcal{N} \backslash \{n\}$, where two coalitions are S_1 and S_2

$$v(S_1 \cup \{n\}) - v(S_1) \leq v(S_2 \cup \{n\}) - v(S_2).$$

[1+3+2+4=10]

Question **5**

Not answered

Marked out of 10.00

Consider clusters of multi-operator cells. Each cluster is formed by one central cell surrounded by M peripheral cells, while each cell includes N BSs of different MNOs. Therefore, the term $BS_{n,m}$ is used
to denote the BS of the nth operator in the mth macro cell, with $n \in [1, N]$ and $m \in [0, M]$. Part of the BS infrastructure in the M surrounding cells may be switched off during low traffic conditions, motivating the MNOs to share the resources of the remaining active BSs in the same cell. In contrast,
the central cell BSs always remain active and increase their transmission power to form an umbrella cell, in the extreme case where all the BSs of a peripheral cell are switched off.

For the low-traffic night zone, a subset of each operator's BSs in the peripheral cells is switched off. Once this BS subset is determined (through the game-theoretic algorithm described in the next section), the proposed infrastructure sharing scheme is applied to determine how the traffic will be served by the remaining active infrastructure, taking into account the corresponding operation and roaming costs.

The infrastructure sharing scheme is applied in the network after the execution of the independent switching-off decisions. According to the outcome of the decision process, there are ***three possible outcomes in a peripheral cell m***

a)Given the three possible outcomes for the peripheral cell m, four different cases can be observed from the point of view of the nth operator (i.e., MNOn). Determine the total cost (Cn,m) for the MNOnin each of for cases.

b) Formulate the game Γ i.e. mention Game, Player, and Strategy.

c) Prove that the Dominant Strategy Equilibrium (DSE) of the game Γ is unique.

[4+3+3=10]