Live Interaction #8:

25th November 2023

E-masters Communication Systems

Detection for Wireless

- **Spectrum Sensing:**
- **Determine presence or absence of primary user or licensed user.**

$$\mathcal{H}_1: \begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix} = \begin{bmatrix} s(1) \\ s(2) \\ \vdots \\ s(N) \end{bmatrix} + \begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}$$

$$\mathcal{H}_0: \begin{bmatrix} y(1) \\ y(2) \\ \vdots \\ y(N) \end{bmatrix} = \begin{bmatrix} v(1) \\ v(2) \\ \vdots \\ v(N) \end{bmatrix}$$

- The above signals are **complex Gaussian**.
- Detection rule: **Energy Detector**.
- Choose $\mathcal{H}_0$ if

$$\|\bar{\mathbf{y}}\|^2 \leq \gamma$$

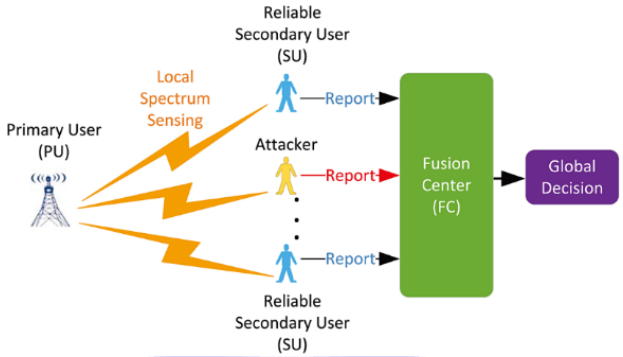
- **Probability of False Alarm:**

$$P_{FA} = Q_{\chi^2_{2N}}\left(\frac{2\gamma}{\sigma^2}\right)$$

- **Probability of detection:**

$$P_D = Q_{\chi^2_{2N}}\left(\frac{2\gamma}{\sigma^2 + \sigma_s^2}\right)$$

- **Cooperative Spectrum Sensing:**



- K secondary users:
- **Fusion rule: AND Rule**
- **AND of all decisions**.
- Decision if $\mathcal{H}_1$ only if all SUs report $\mathcal{H}_1$

$$P_D^{FC} = (P_D)^K$$
$$P_{FA}^{FC} = (P_{FA})^K$$

- **Fusion rule: OR Rule**
- **OR of all decisions**.
- Decision if $\mathcal{H}_0$ only if all SUs report $\mathcal{H}_0$

$$P_D^{FC} = 1 - (1 - P_D)^K$$
$$P_{FA}^{FC} = 1 - (1 - P_{FA})^K$$

- **L out of K rule:**
- Decision if $\mathcal{H}_1$ if at least L out of K SUs report $\mathcal{H}_1$

$$P_D^{FC} = \sum_{k=L}^{K} {}^K C_k (P_D)^k (1 - P_D)^{K-k}$$
$$P_{FA}^{FC} = \sum_{k=L}^{K} {}^K C_k (P_{FA})^k (1 - P_{FA})^{K-k}$$

- **MIMO Spectrum Sensing:**

$$\mathcal{H}_1 : \bar{\mathbf{y}} = \mathbf{H}\bar{\mathbf{x}} + \bar{\mathbf{v}}$$
$$\mathcal{H}_0 : \bar{\mathbf{v}}$$

- **Energy detector:**
- Choose $\mathcal{H}_0$ when

$$\|\bar{\mathbf{y}}\|^2 \leq \gamma$$

- x_i:BPSK symbols of power P.
- r is the number of receive antennas.
- t is the number of transmit antennas.
- **Probability of False Alarm:**

$$P_{FA} = Q_{\chi^2_{2r}}\left(\frac{\gamma}{\sigma^2/2}\right)$$

- **Probability of Detection:**

$$P_D = Q_{\chi^2_{2r}}\left(\frac{\gamma}{(\sigma^2 + tP)/2}\right)$$

- **Assignment #8 Deadline: 25th November 11:59 PM.**
- **Assignment #7, #8 Discussion: 26th November 4:30 – 5:30 PM.**
- **Quiz #4: 26th November Sunday 5:30 – 6:15 PM.**

Final Exam:

- **Total questions in Final: 40**
- **Multiple choice questions with four given options and only one correct option.**
- **NO negative marking**
- **Closed-book exam**
- **Duration is 3 hrs**
- **One mark per question**
- **Question Paper PATTERN**
- **8 questions: Recall type (Purely formula), one from each week**

- **16 questions: Seen, Directly from assignments/ quiz, two from each week**
- **16 questions: Unseen, Roughly 2 from every week based on assignment/ quiz questions**
- Weightage:

	Proposed Weightage
Assignments (Theory)	20%
Quizzes	30%
End-Sem	40%
Attendance Minimum 80% attendance	10%

- **Best 3 out of four quizzes**
- **Best 6 out of 8 assignments**