

Interference Temperature

Swrangsar Basumatary
swrangsar@iitb.ac.in

Indian Institute of Technology Bombay

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Introduction

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- Using this model, *Cognitive Radios* operating in licensed frequency bands would be able to measure their current interference environment and adjust their transmission characteristics so as not to raise the interference temperature over a regulatory limit.

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- Currently, they do a detailed analysis of the surroundings and rely on worst case analysis.
- But relying on worst case analysis leaves much of the spectrum unused.

Driving forces for interference metric

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- **Changing landscape**

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- **Increased density and mobility**

People are owning more cellular devices. Density of mobile devices has increased and interference management has become more complicated.

Definition of Interference Temperature

Interference temperature, T_I is defined as

$$T_I(f_c, B) = \frac{P_I(f_c, B)}{kB}$$

where

- $P_I(f_c, B)$ is the average interference power centered at frequency, f_c , and covering bandwidth B .
- k is the Boltzmann's constant $k = 1.38 \times 10^{-23} J/K$

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In SI system, the unit of interference temperature turns out to be *degrees Kelvin*.

Interference Temperature Models

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- ① Ideal model
- ② Generalized model

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Ideal model

In the ideal model we try to guarantee that

$$T_I(f_i, B_i) + \frac{M_i P}{k B_i} \leq T_L(f_i) \quad \forall \quad 1 \leq i \leq n \quad (1)$$

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where

- $T_I(f_i, B_i)$ is the interference temperature of the i 'th receiver with center frequency f_i and bandwidth B_i
- P is the power of the unlicensed transmitter
- M_i is a constant between 0 and 1 representing the attenuation of the transmitted power P at the i 'th receiver, and
- $T_L(f_i)$ is the interference temperature limit of the i 'th receiver at center frequency f_i .

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Usually, a unified factor M is used instead of M_i 's because we do not know the distance of every receiver. The factor M is fixed by the regulators.

Challenges in implementing the ideal model

- Hard to differentiate between licensed and unlicensed signals unless we already know the coexisting transmitters in the surrounding environment.
- Difficult to measure the interference temperature T_I in the presence of a licensed signal.
 - We can determine the noise floor only when there is no signal power. For that we have to know when the signal power is going to be zero if it does. If the signal periodically goes to zero then we can measure the T_I during the interval when it goes to zero.
 - The other way is to take an average of the noise floor just outside the licensed signal band, but we need to have information about the licensed signal's properties, like center frequency and bandwidth, to do that.

Generalized model

The generalized model assumes that we have no a priori knowledge about the signal environment. Thus the constraint in this model has to be written in terms of the unlicensed transmitter's parameters.

$$T_I(f_c, B) + \frac{MP}{kB} \leq T_L(f_c) \quad (2)$$

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where

- $T_L(f_c)$ is the interference temperature limit of the unlicensed transmitter,
- $T_I(f_c, B)$ is the interference temperature of the unlicensed transmitter,
- P is the power of the unlicensed transmitter, and
- M is a constant between 0 and 1 representing the factor by which the transmitted power gets attenuated.

Generalized model (continued)

- If we constrain the transmitted power P to be less than that in the ideal model, from the equations (1) and (2) we get the following constraint,

$$B(T_L - T_I(f_c, B)) \leq B_i(T_L - T_I(f_i, B_i)) \quad \forall \quad 1 \leq i \leq n$$

If every receiver receives a power P_i and if the noise floor is the thermal noise temperature T_N , then we can rewrite the above equation as,

$$kBT_L(f_c)(B - B_i) + kBT_N \sum_{j=1}^N B_j \leq \sum_{j=1}^N B_j P_j \quad \forall \quad 1 \leq i \leq n$$

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- Though $T_I(f_c, B)$ can be measured easily, inclusion of all signals in its measurement gives rise to a more complex interference environment.

Properties of Interference Temperature

The problem with Interference Temperature model is that it is too simple. It tries to quantify interference assuming that interference behaves like noise. But interference doesn't actually behave like noise because interference includes all signals other than the one from the licensed transmitter. We are defining interference that way. So, *Interference Temperature* can't really model interference well enough.

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- So, usually the incoming RF stimuli are sectioned into a continuous sequence of successive bursts, with each burst being short enough to justify pseudo-stationarity and yet long enough to produce an accurate spectral estimate.
- A nonparametric spectral estimation method is required for this purpose and *multi-taper spectral estimation* turns out to be the best choice.
- Multitaper spectral estimation has a nice property of allowing both reduced bias and reduced variance at the same time.

References