جامعة الملك فهد للبترول و المعادن
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CRP 514: Geographic Information Systems (GIS)

Mobile-Based Location Estimation For Emergency Call Situations

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Outline

- Introduction
- Objective
- The Approach and Methods
  - TOA
  - AOA
  - Single BS
- Simulation and Results
- Conclusion

Introduction

- **Where are you?**
- **You know whom you are calling but not where.**
- **U.S. Federal Communications Commission (FCC) with in an accuracy of 125 m in 67%**
- **Show the performance of selected methods**

Introduction

- **Even the most sophisticated positioning algorithms requires:**

✓ **At least three BSs to achieve satisfactory precision**

✓ **Algorithm that makes use of a single-BS**

Introduction

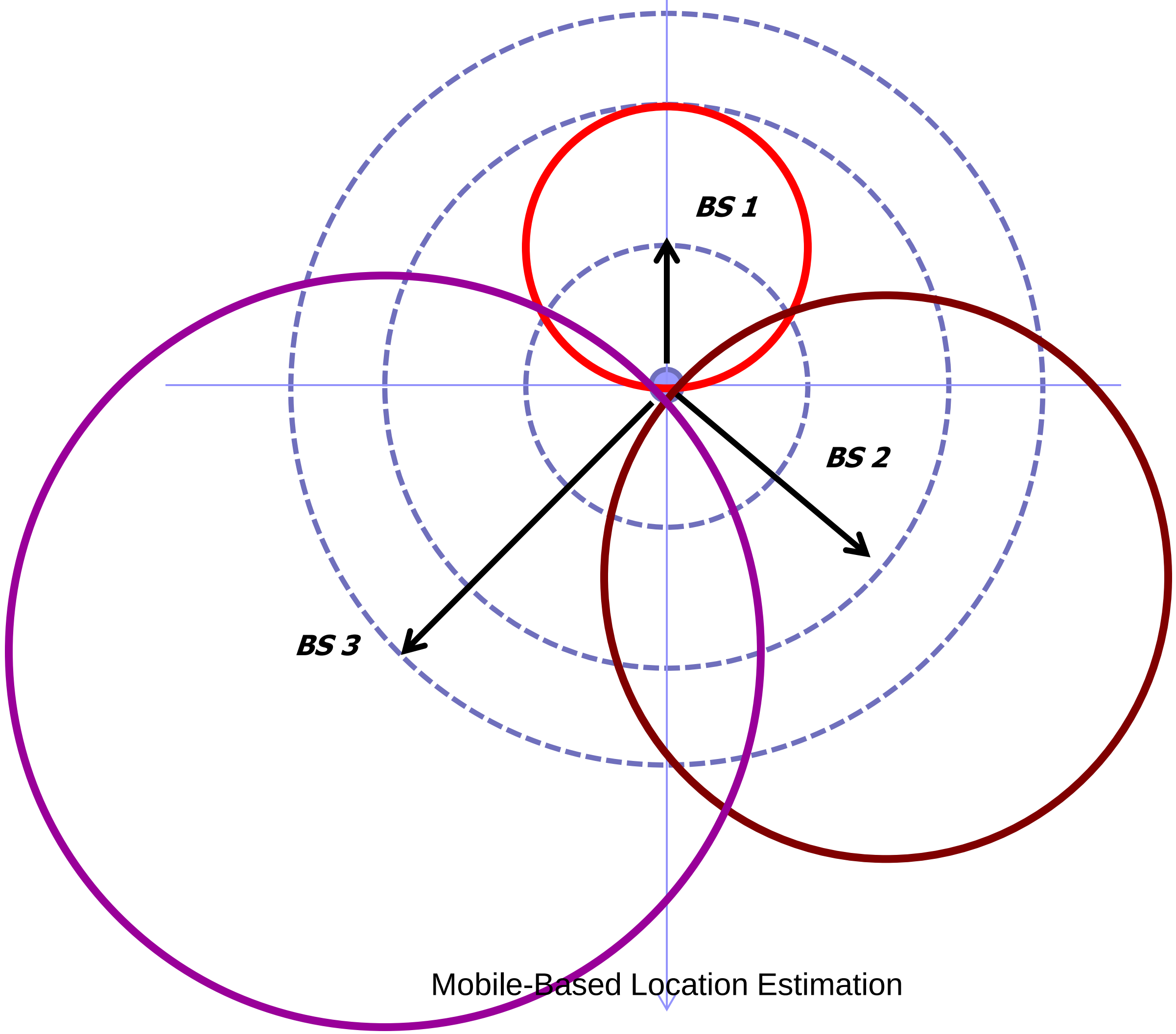
- The algorithm assumes that the signal sent by the MT, takes an absolute time τ_{BSi} .

- The signal will interact with buildings, trees, cars, and any other obstacles before reaching the BS.
- N_{BS} circles are determined; their intersection.
- Initial guess $(\hat{x}_{MT}^{(0)}, \hat{y}_{MT}^{(0)})$ for the MT location can be obtained

Objectives

- **To identify the subscribers locations using different techniques.**
- **To implement our selected approaches in some possible scenarios.**
- **Validate the acquired results with FCC standard.**

Time of Arrival (TOA)



Mobile-Based Location Estimation

Time of Arrival (TOA)

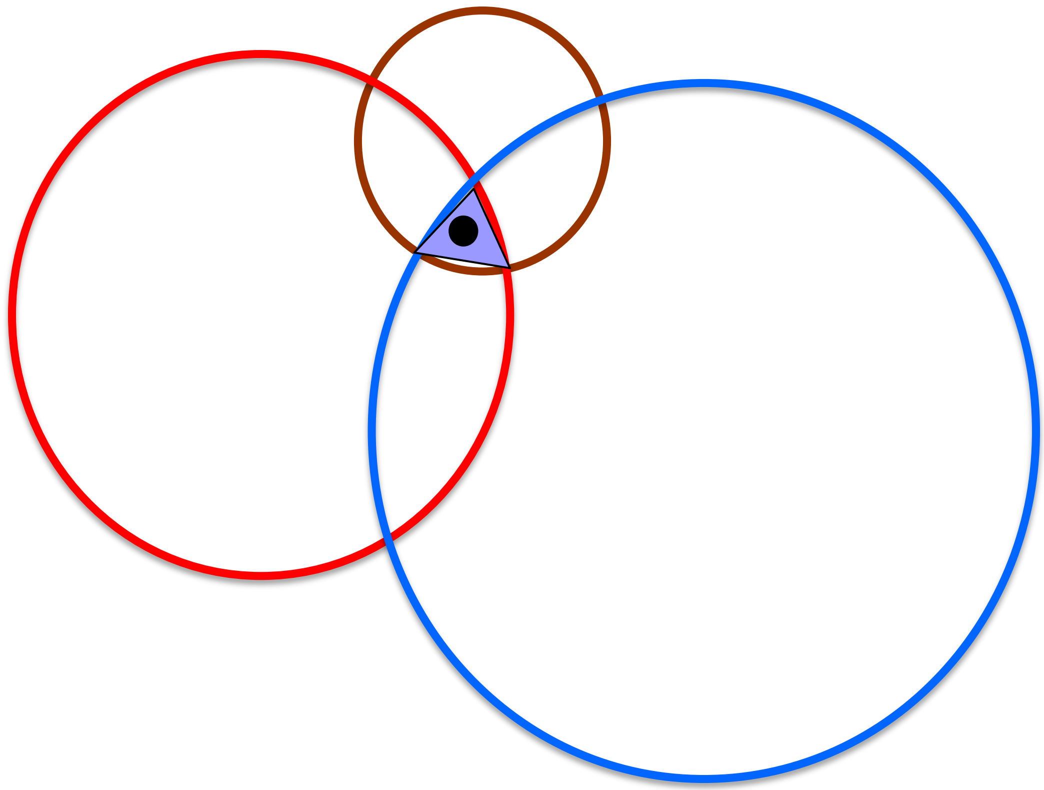
GIS

(x_1, y_1) (x_2, y_2) (x_3, y_3)

$$\hat{x}_{MT} = \frac{(x_1 + x_2 + x_3)}{3}$$

$$\hat{y}_{MT} = \frac{(y_1 + y_2 + y_3)}{3}$$

$$d_i \leq c\tau_{\mathrm{BSi}}$$



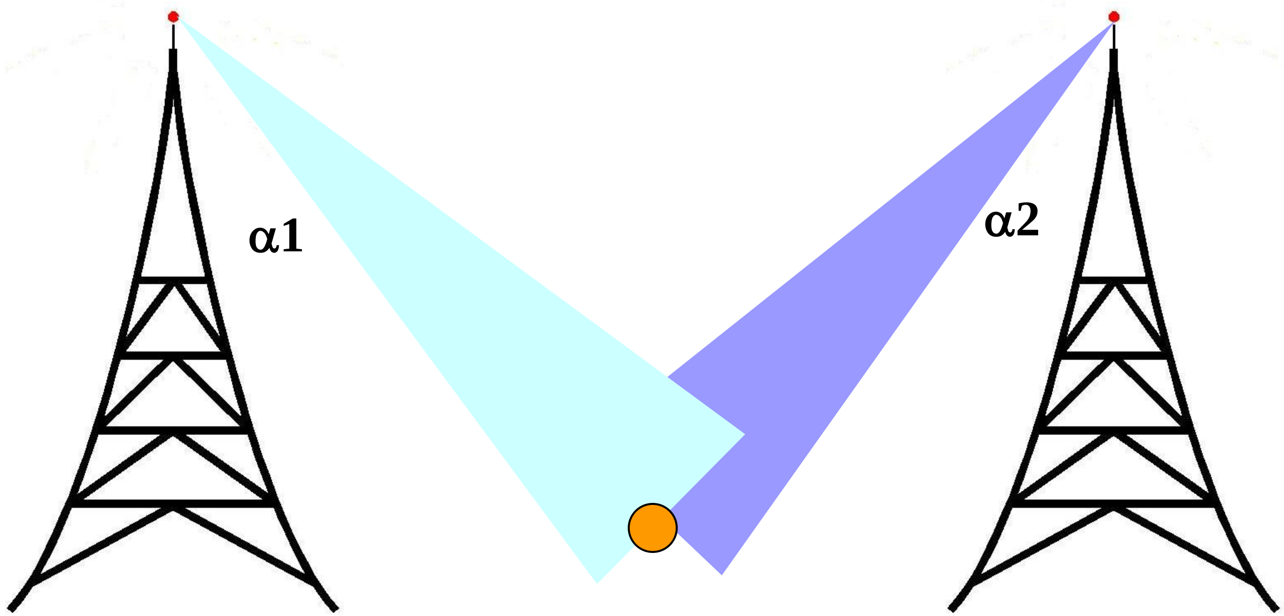
Time of Arrival (TOA)

$$g_i(x,y) = c\tau_{\mathrm{BSi}} - \sqrt{(x - x_{\mathrm{BSi}})^2 + (y - y_{\mathrm{BS}i})^2}$$
$$(i = 1, \ldots, N_{\mathrm{BS}})$$

$$G(x,y) = \sum_{i=1}^{N_{\mathrm{BS}}} \alpha_i^2 g_i^2(x,y)$$

$$(\hat{x}_{\mathrm{MT}}, \hat{y}_{\mathrm{MT}}) = \arg \min_{(x,y)\in E} \{G(x,y)\}.$$

Angle of Arrival (AOA)



Three Base Station

Single Base Station

- This method needs some minimal information about the environment.
- First, it is decided if the MT is in line of sight (LoS) of the BS. its location is determined directly .
- Second, if the MT is found to be in non-LoS (NLoS), its location is then determined by minimizing a given cost function.

Single Base Station cont.

This technique uses a single-BS to locate MT:

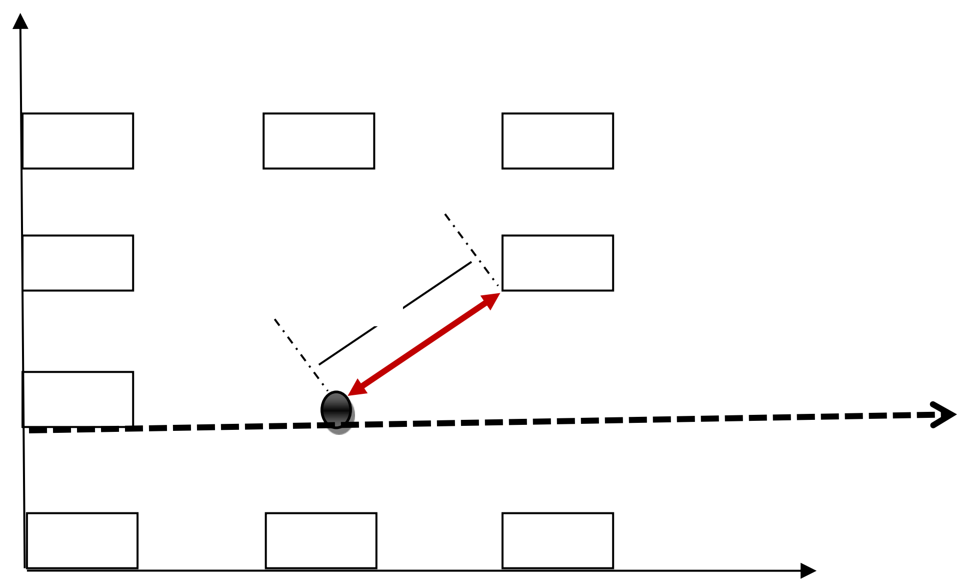
- the MT does not have to be synchronized with other BSs.
- The coverage by several BSs is no longer a problem.

The algorithm needs knowledge of the following:

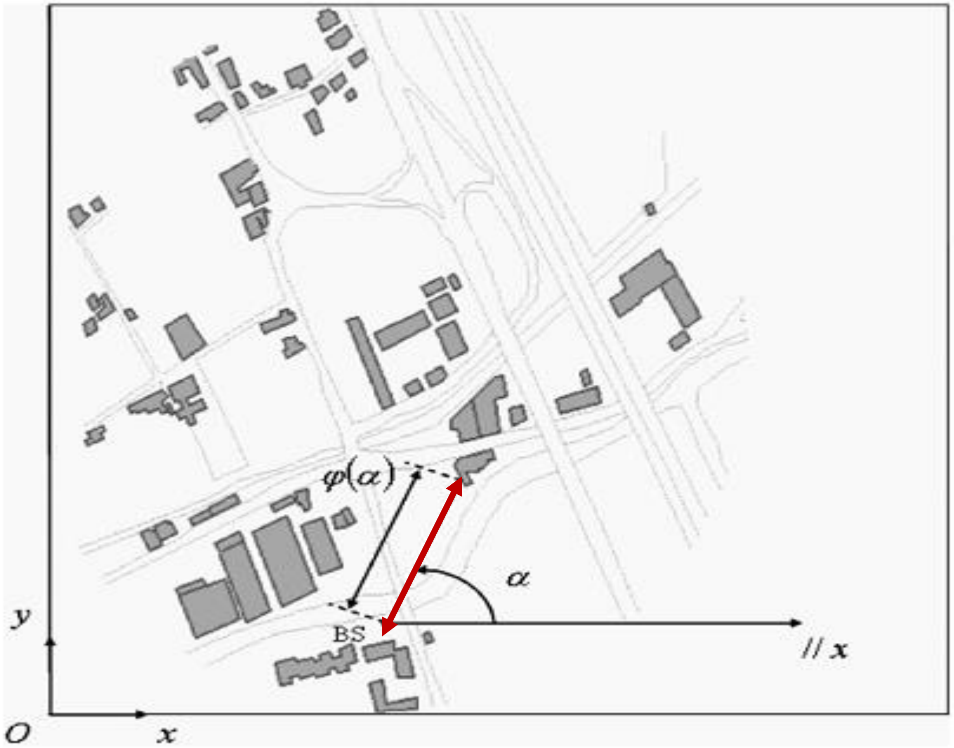
- AoAs
- ToAs

Single BS Location Technique

- The technique is depending on a sentinel function (SF), which is defined as the distance between the BS and the nearest obstacle found along the azimuth direction

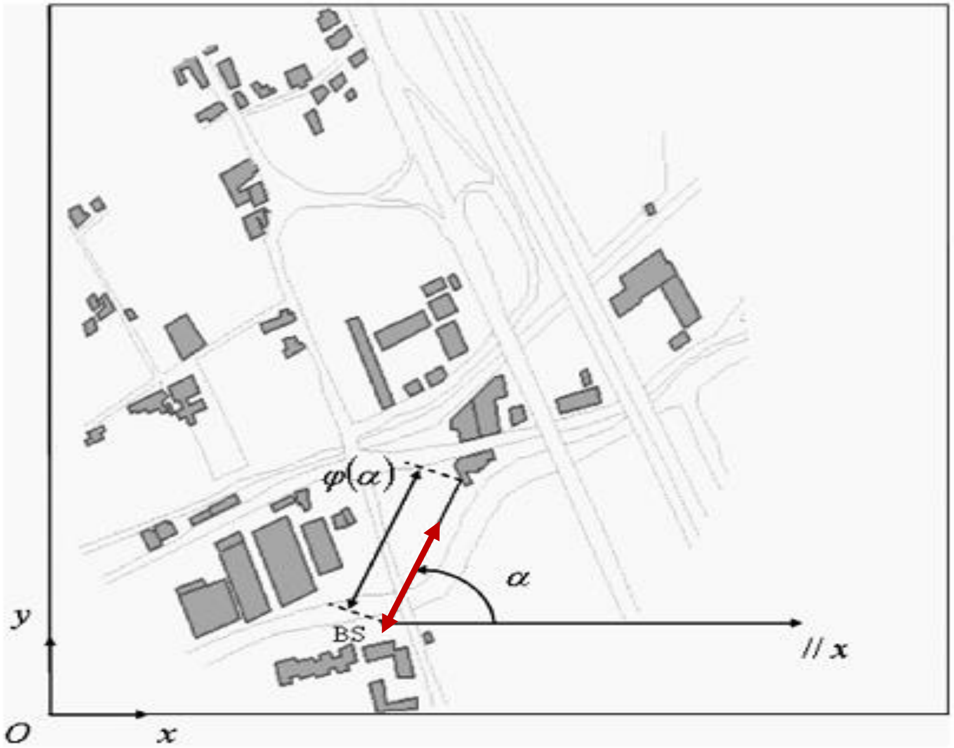


Single BS Location Technique

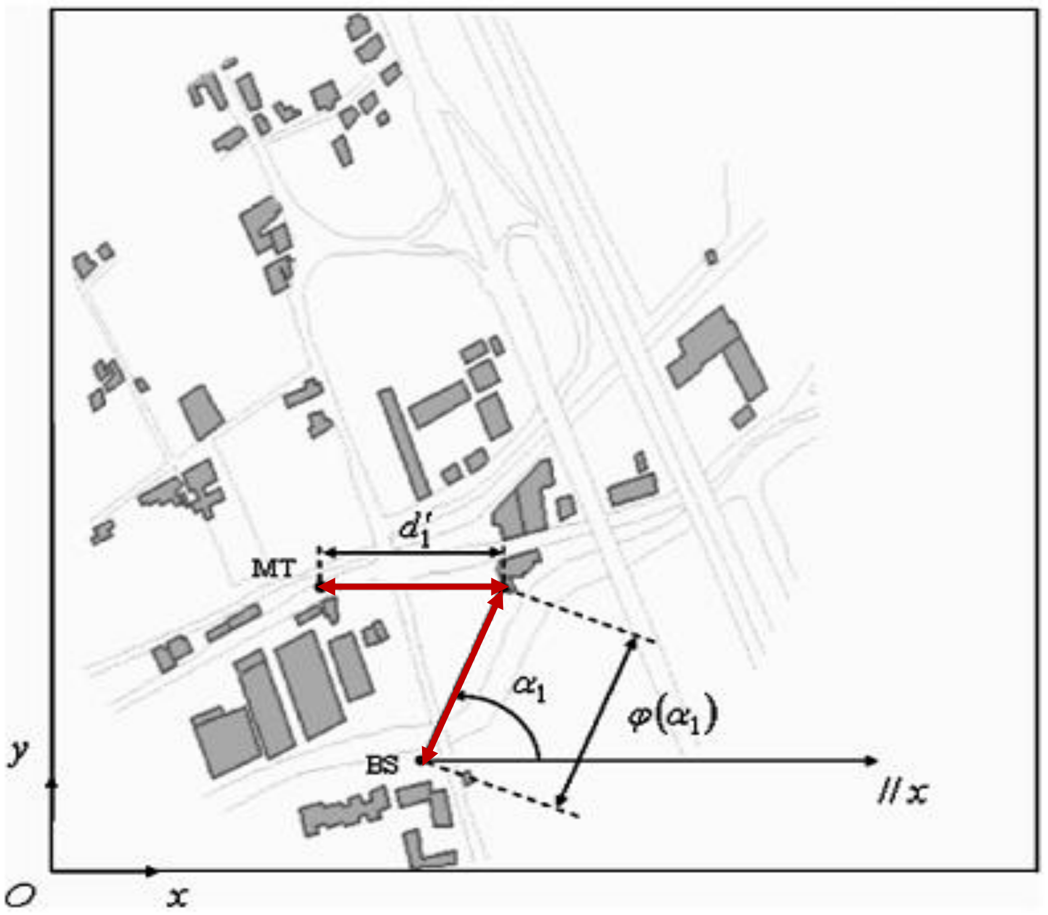


Single BS Location Technique

GIS



Single BS Location Technique



Estimation in LOS Conditions

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The absolute distance traveled by the first MPC received at the BS can be calculated as

$$d_1 = \sqrt{(c\tau_1)^2 - (h_{BS} - h_{MT})^2}$$

If

$$\varphi(\alpha_1) \geq d_1$$

Then LoS

$$\begin{cases} \hat{x}_{MT} = x_{BS} + d_1 . \cos(\alpha_1) \\ \hat{y}_{MT} = y_{BS} + d_1 . \sin(\alpha_1) \end{cases}$$

Single BS Location Technique

GIS

- **The MT position is determined by minimizing a given cost function.**

$$\begin{cases} x_{Si} = x_{\mathrm{BS}} + \varphi(\alpha_i) \cdot \cos(\alpha_i) \\ y_{Si} = y_{\mathrm{BS}} + \varphi(\alpha_i) \cdot \sin(\alpha_i) \end{cases} \quad (i = 1, \ldots, N).$$

- **Then, the following cost function is introduced:**

$$F(x, y) = \sum_{i=1}^{N} f_i^2(x, y)$$

$$f_i(x, y) = c\tau_{Ri} - \sqrt{(x - x_{Si})^2 + (y - y_{Si})^2}.$$

Simulation and Results

- **The location techniques have been evaluated in terms of the location error:**

$$\varepsilon_d = \sqrt{(x_{\mathrm{MT}} - \hat{x}_{\mathrm{MT}})^2 + (y_{\mathrm{MT}} - \hat{y}_{\mathrm{MT}})^2}$$

Experimental Measures

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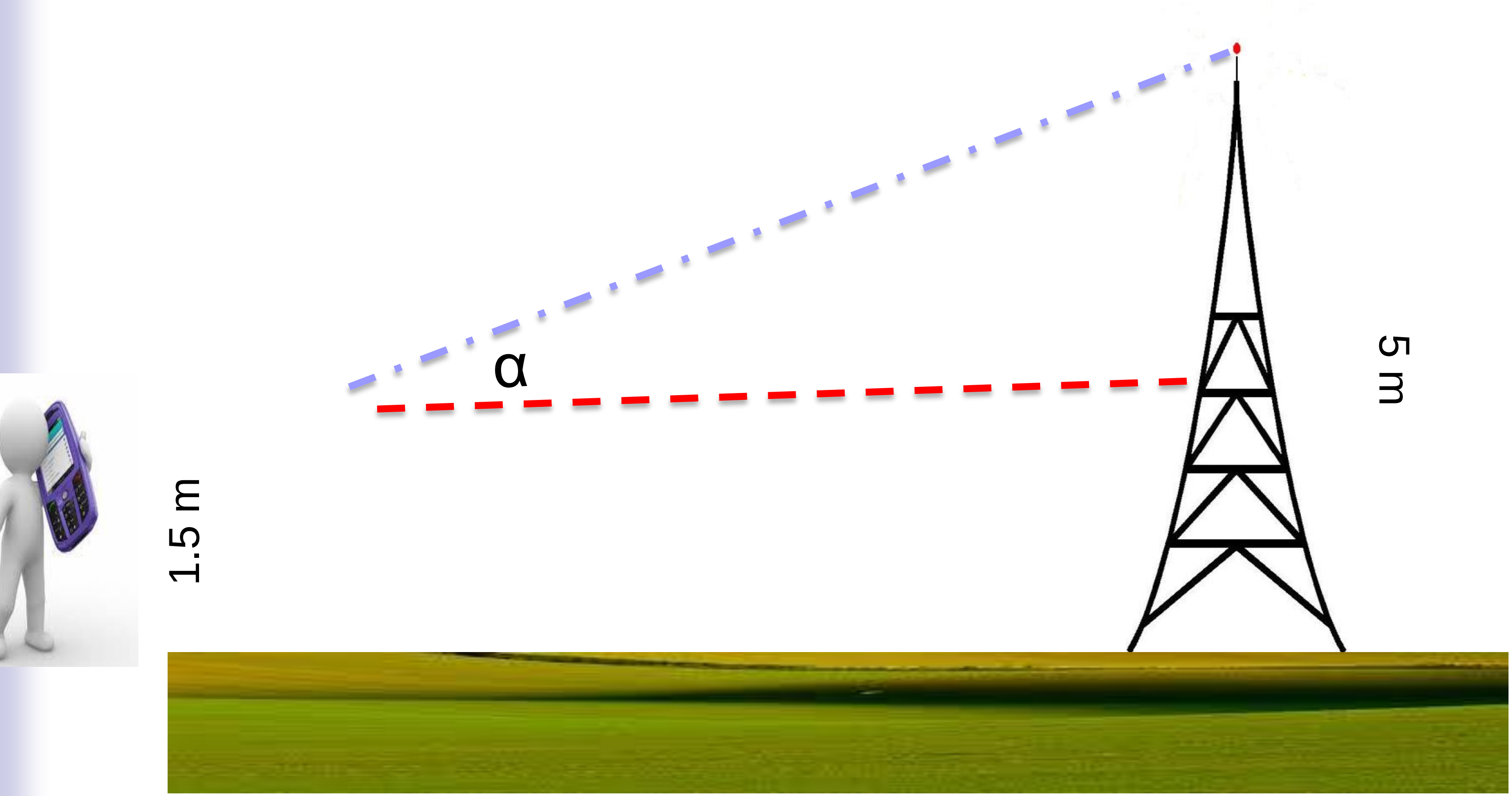
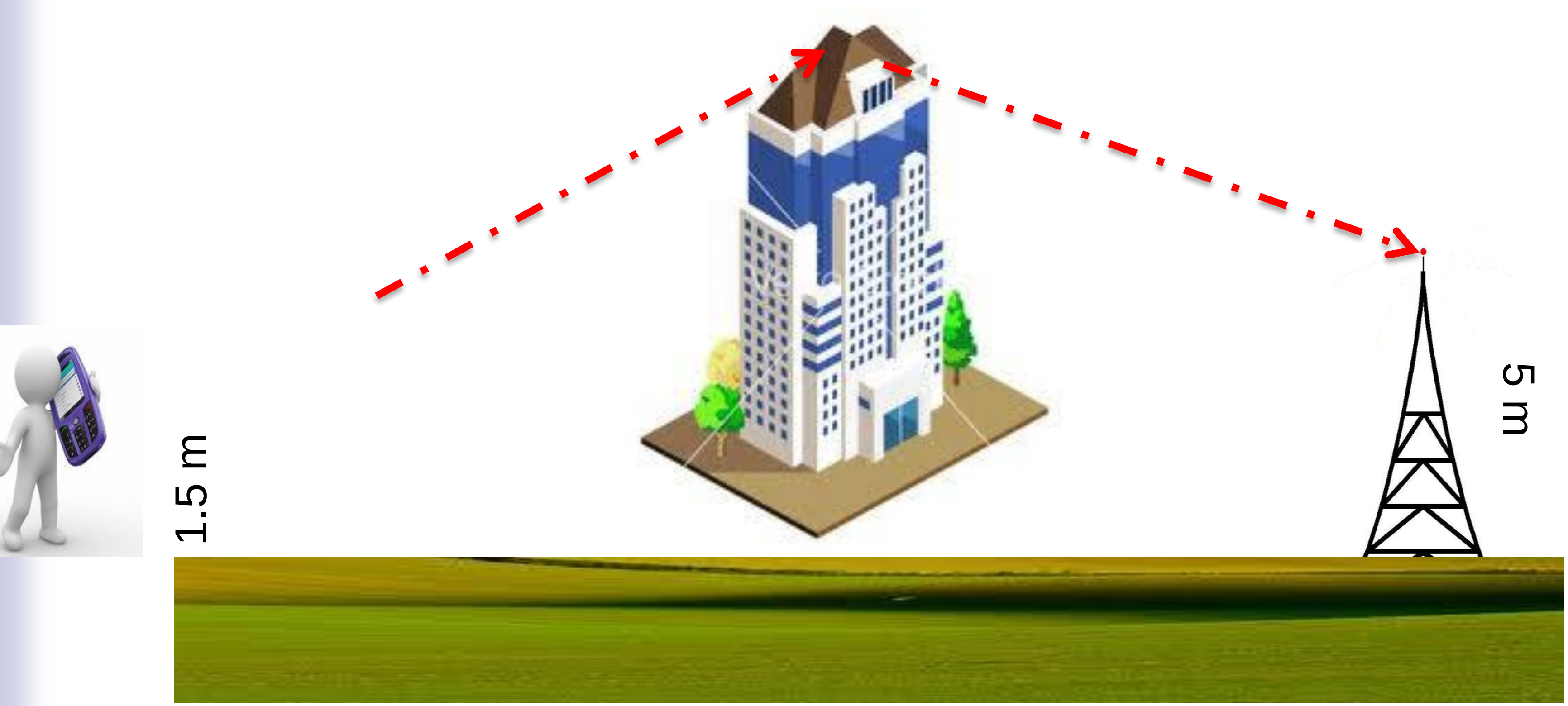
- The total area is 220 square meter
- 64 buildings: 20m width, 40m height
- Streets: width 20m.
- Subscribers: 492 users, 1.5m height
- Base Stations: one or three , 5m height

The Calculations



The Calculations



Simulation and Results

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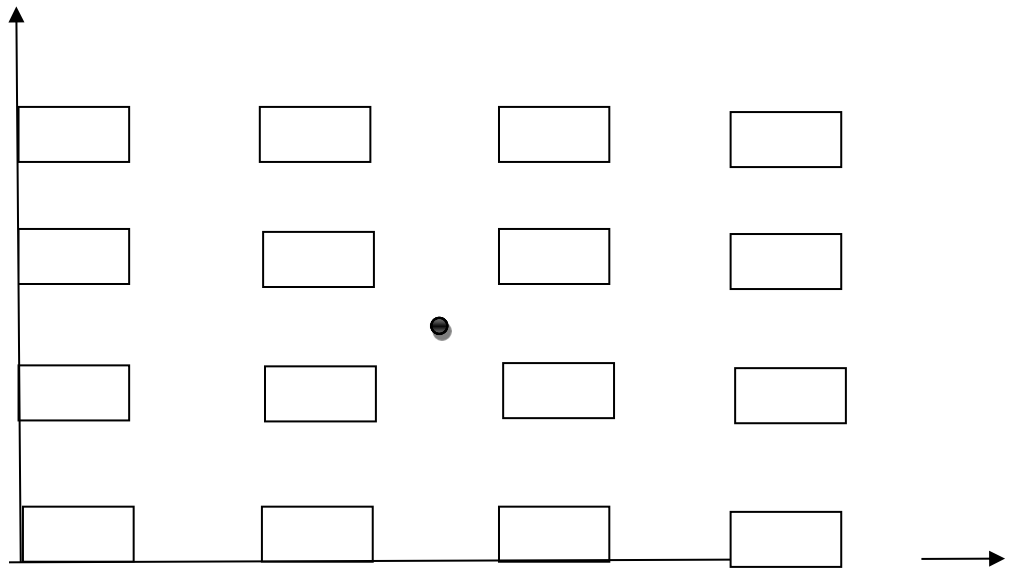

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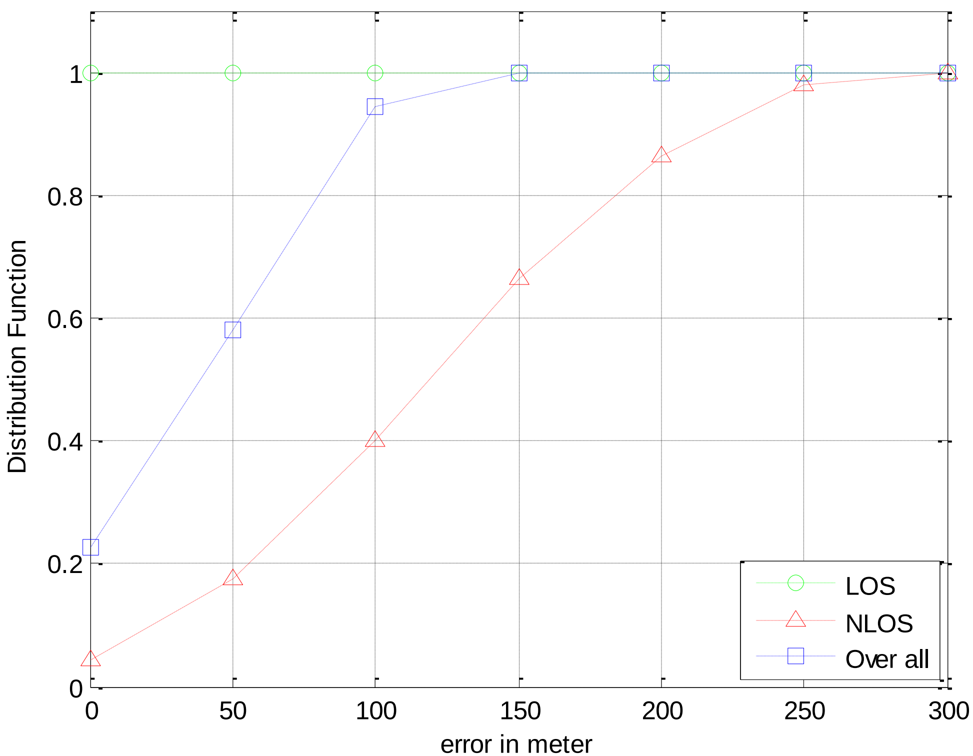
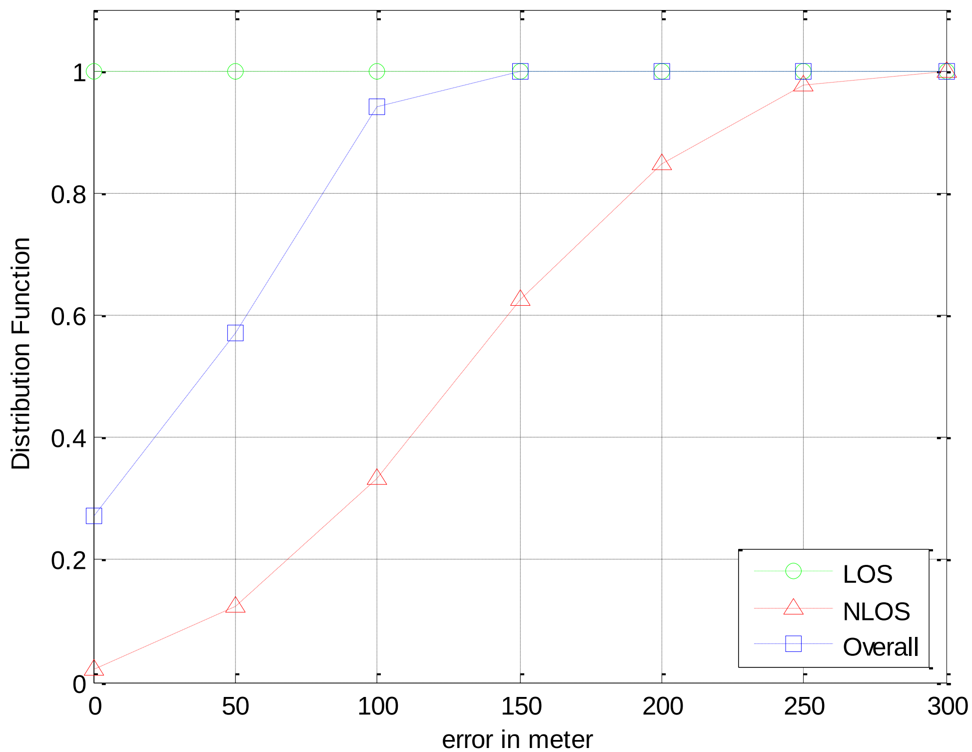
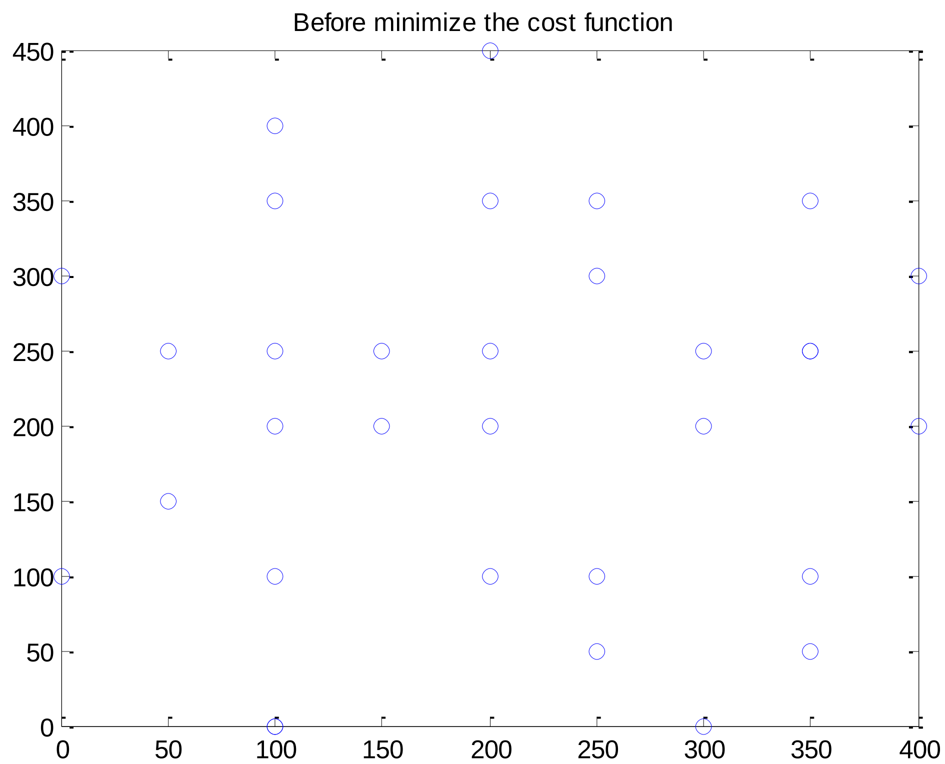
BS located at the center



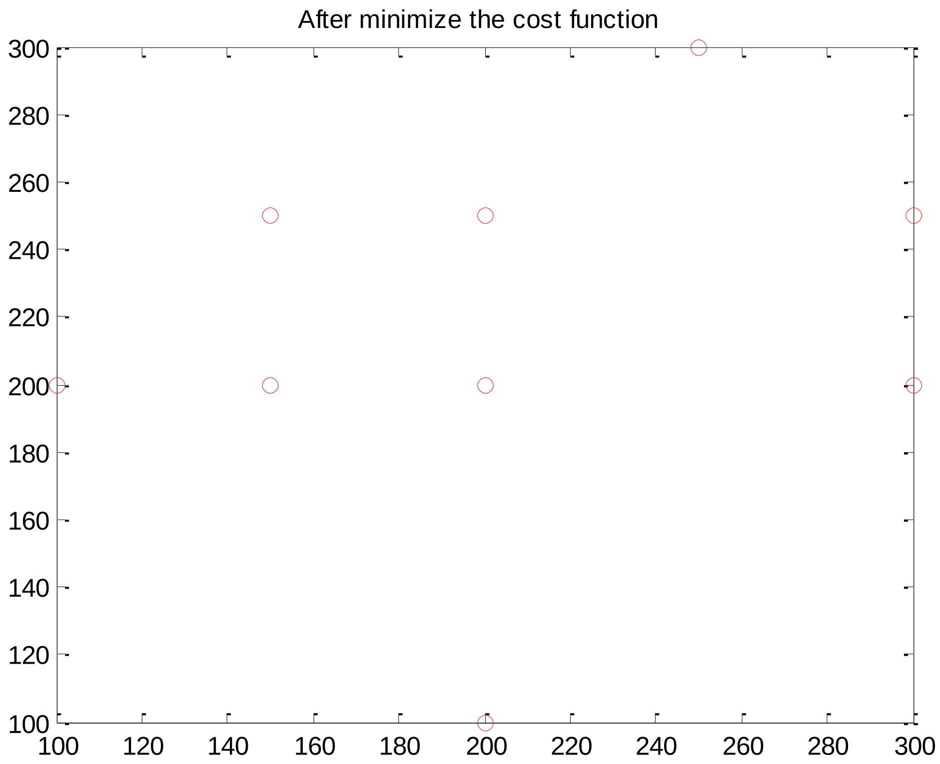
BS located at the corner



Multipath Components



Minimization of Multipath Components



Conclusion

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- ✓ **Identification of MT could be found using only a single-BS and some additional readily available data about the environment around the BS.**
- ✓ **The method is shown to predict the MT position with good accuracy.**
- ✓ **All simulation results comply with the U.S. FCC with an accuracy of 125 m in 67%**

Thank You for The Attention

Mobile-Based
Location Estimation
For Emergency Call Situations