

# RTS/CTS mechanism with 802.11 for indoor location

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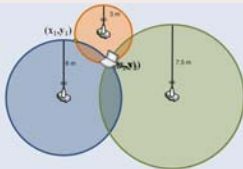
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- 1 Location approach
  - Wireless cellular location techniques
- 2 TOA Estimation
  - RTT measuring
  - Hardware design
- 3 Assessment of the system
  - Experimental Setup
  - RTT Measurements
  - Distance Estimation
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  - Conclusions and future work

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## Time of Arrival (ToA)



Time Difference of Arrival (TDoA)

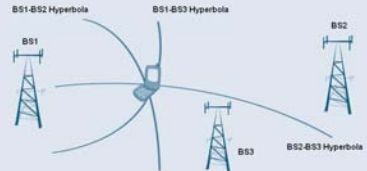
Angle of Arrival (AoA)

Received Signal Strength (RSS)

Time of Arrival (ToA)

Received Signal Strength (RSS)

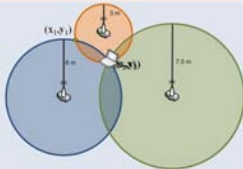
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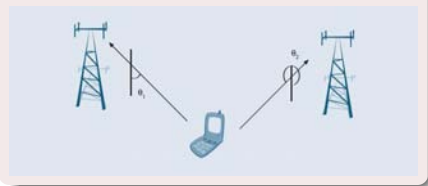
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## RTS/CTS handshake

AP processing time constant and independent of the traffic load

$$RTT = t_p + t_{proc} + t_p$$

Round Trip Time

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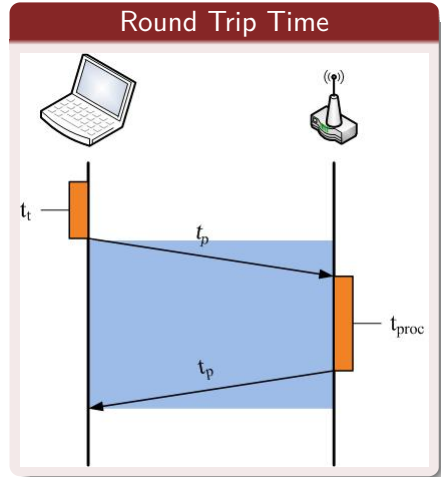
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$t_p$  RTS propagation time

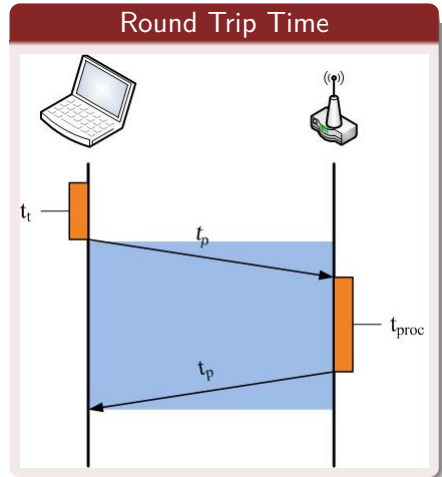


## RTS/CTS handshake

AP processing time constant and independent of the traffic load

$$RTT = t_p + t_{proc} + t_p$$

$t_{proc}$  AP processing time

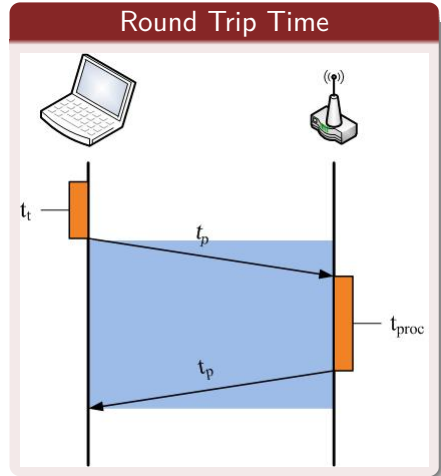


### RTS/CTS handshake

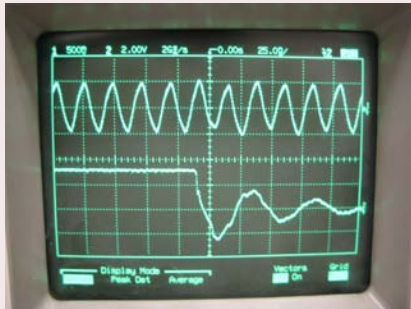
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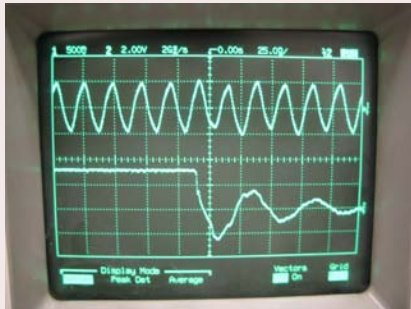


## RTS last bit departure

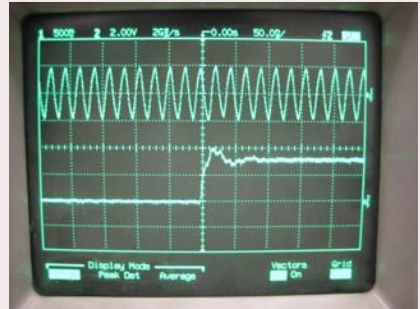


## CTS first bit arrival

RTS last bit departure



CTS first bit arrival



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# Hardware design

## Objectives

- 1 No need of synchronization
- 2 Improve PC clock resolution
- 3 System independence
- 4 Minimize hardware size
- 5 Keep the voltage constant and noise-free
- 6 Automation

## Solutions

- 1 RTT measurements
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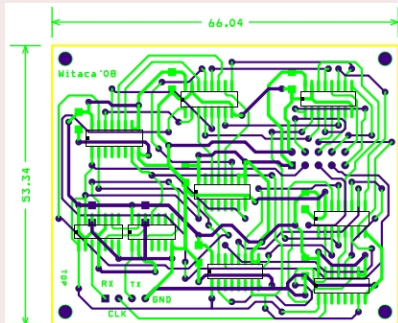
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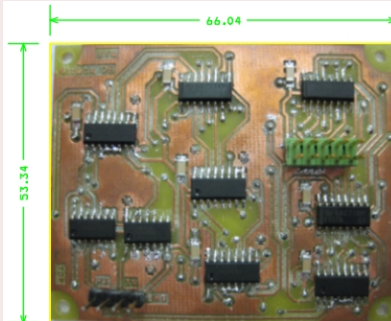
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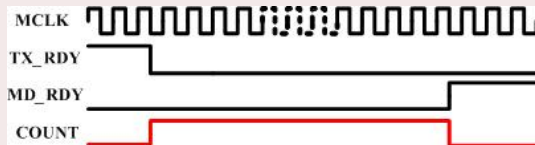
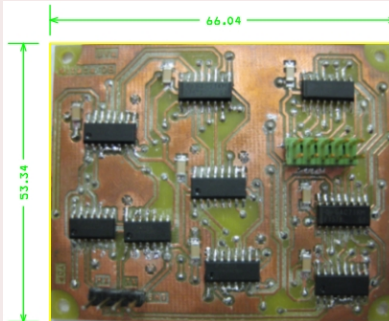
## Printed Circuit Board



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## Higher Technical School of Telecommunications Engineering

### Three scenarios

- $LOS_1$
- NLOS
- $LOS_2$

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- $LOS_1$
- NLOS
- $LOS_2$

Samples carried out along a corridor of the School

Analysis of the distribution of LOS measurements

$LOS_1$



## Higher Technical School of Telecommunications Engineering

### Three scenarios

- $LOS_1$
- **NLOS**
- $LOS_2$

Same scenario with a wall 20 cm width next to the AP

Analysis of the distribution of NLOS measurements

### NLOS



## Higher Technical School of Telecommunications Engineering

### Three scenarios

- $LOS_1$
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- $LOS_2$

Samples carried out outside of the School

Linear regression for estimating distances

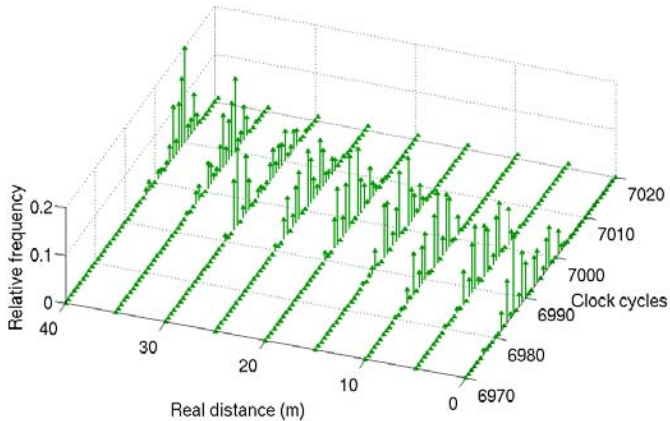
### $LOS_2$



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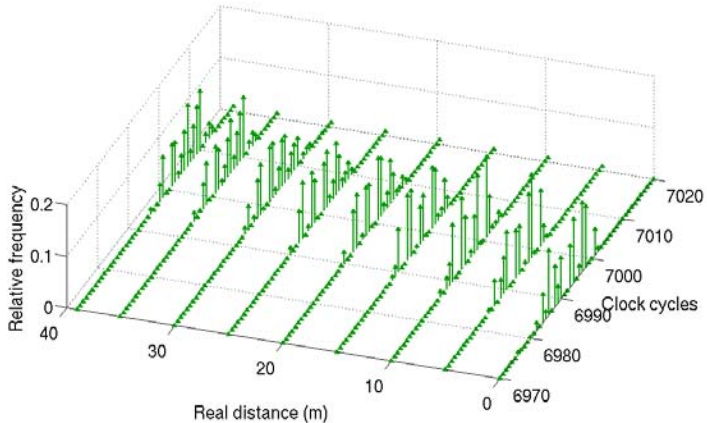
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## LOS<sub>1</sub>



Lilliefors (KS) test: Non-Normal data

## NLOS



Lilliefors (KS) test: Non-Normal data

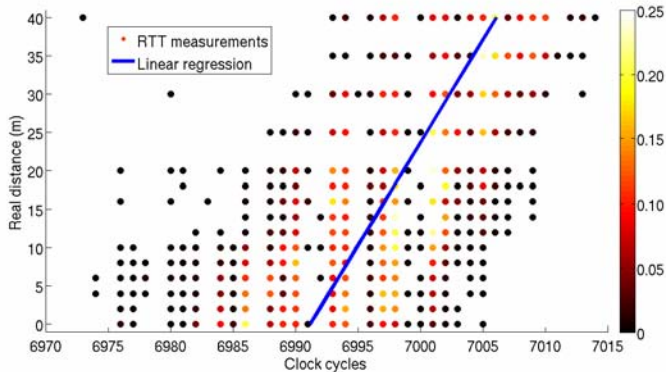


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# Distance Estimation

LOS<sub>2</sub>

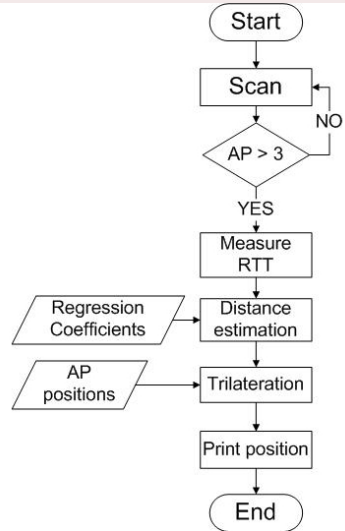
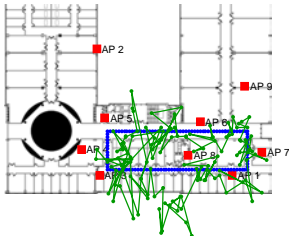


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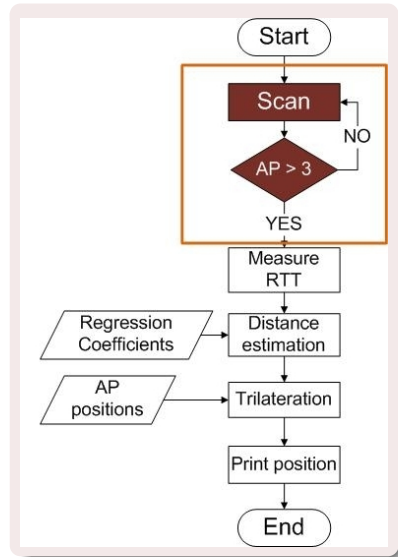
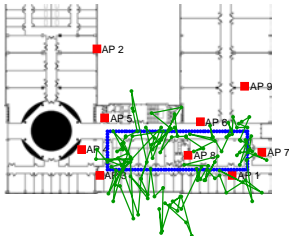
## Stages

- 1 Regression coefficients computation
- 2 APs selection
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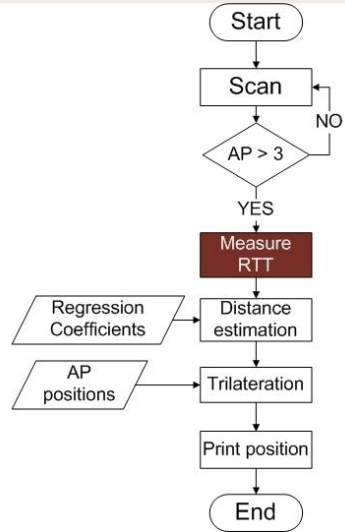
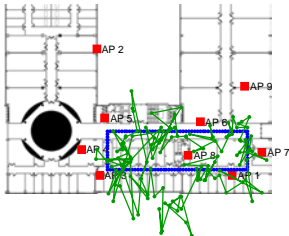
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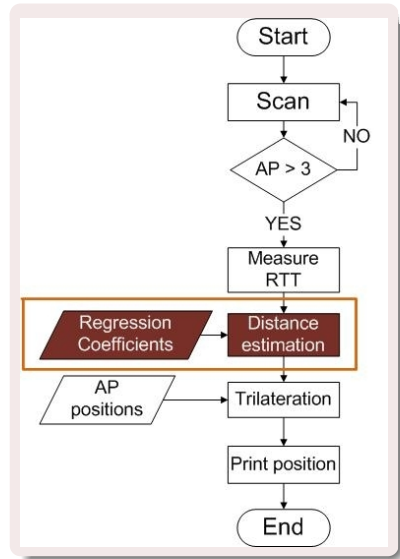
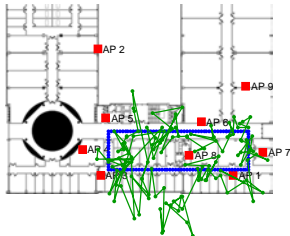
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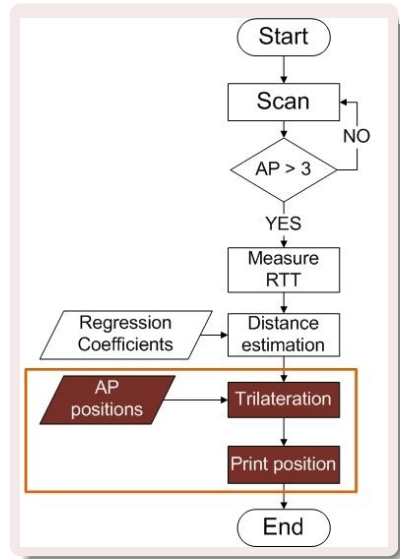
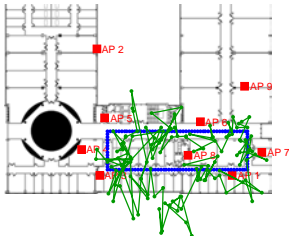
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- Accuracy of around 1m in distance estimation
- NLOS paths overestimate the distance
- Position is estimated in a real environment

## Future work

- Optimum geometric distribution of the APs
- Prior NLOS measurements correction
- Location tracking
- Channel characterization

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THANK YOU FOR YOUR  
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## Trilateration

