Wireless Networking CS4222/5422

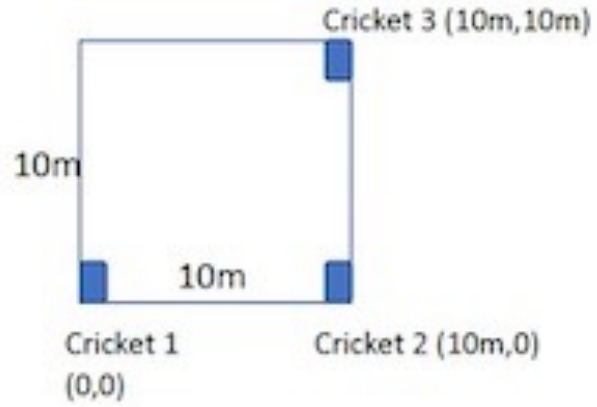
Tutorial 5

Kanav Sabharwal

kanav.sabharwal@u.nus.edu

Slide Credits: Soundarya Ramesh

Q1



	C1	C2	C3
Radio Timestamp (s)	1.0	1.0	1.0
Audio Timestamp (s)	1.028	1.020	1.020

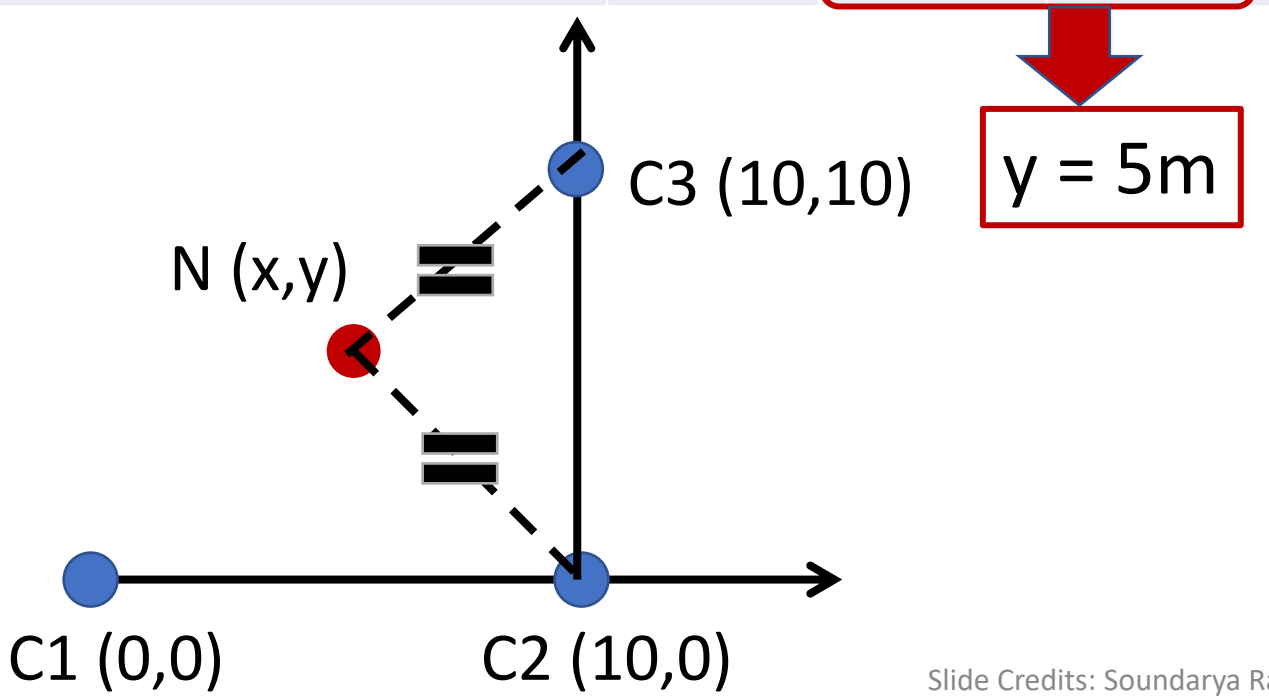
The figure shows a 2D square of 10m by 10m with three cricket nodes placed at different locations. The table shows the wall clock time for the radio and audio signals from the node to be localized to reach each of the three cricket nodes.

Assume that the speed of light is 2x10^8 m/s and the speed of sound is 300m/s. You can also ignore the processing time.

Estimate the (x,y) coordinates of the node to be localized in meters, using cricket 1 as the origin (0,0).

Estimate the location of the node to be localized giving the (x,y) coordinates in meters.

	C1	C2	C3
Radio Timestamp (s)	1.0	1.0	1.0
Audio Timestamp (s)	1.028	1.020	1.020



<u>At Cricket Node C1</u>

Time diff. $t_{audio} - t_{radio}$

$= d/c_{audio} - d/c_{radio}$

$\approx d/c_{audio}$ (as $d/c_{radio} \approx 0$)

$= 0.028s$

Hence, distance d

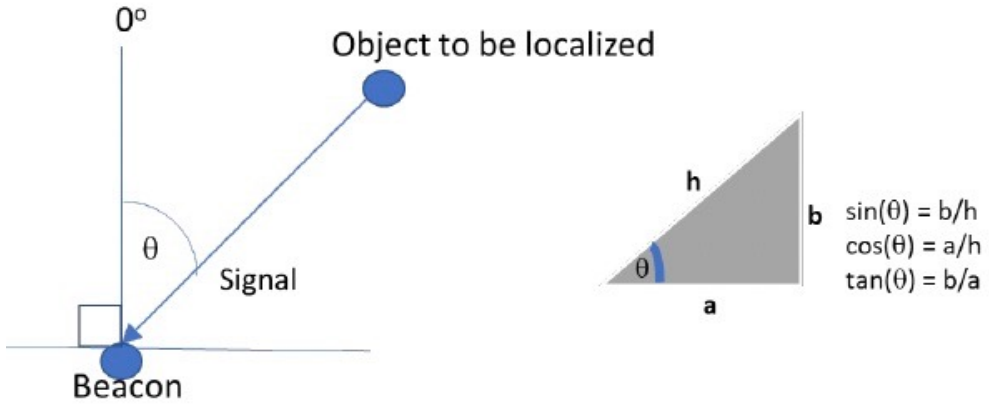
$= 0.028 \times 300 = 8.4m$

➔ $x^2 + y^2 = (8.4)^2$

➔ $x = (8.4^2 - 5^2)^{0.5} = 6.75m$

Slide Credits: Soundarya Ramesh

Q2

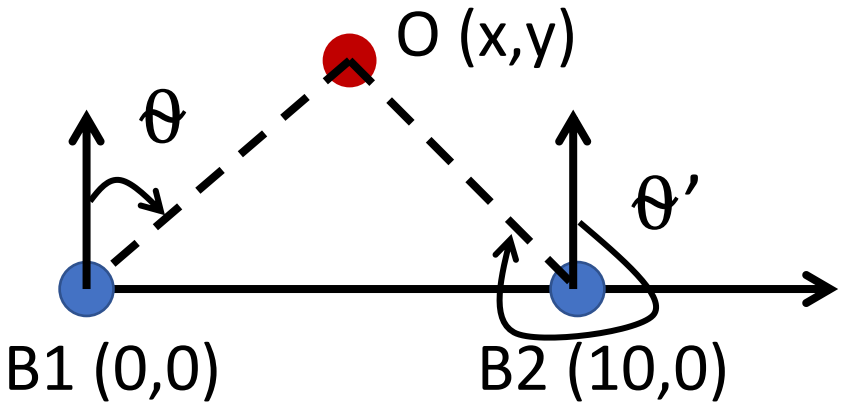


Localization can also be done by measuring the angle of (signal) arrival. In the figure, the signal angle of arrival is theta degree. The right figure provides reference for some basic trigonometric relationships.

Consider a 2-D plane with two beacons. Beacon 1 is located at (0,0) and beacon 2 at (10,0). Let the (unknown) position of the object to be localized be (X,Y). The angle of signal arrival from the object to Beacon 1 is 40 degree and the signal angle of arrival from object to Beacon 2 is 300 degree.

Write down 2 equations that **determines the unknown location (X,Y)** and find the values of X and Y.

Determine the unknown location (X,Y) and find the values of X and Y.



Eq 1

$x / y = \tan(\theta)$

$= \tan(40°) = 0.8391$

Eq 2

$(10 - x) / y = \tan(360 - \theta')$

$= \tan(60°) = 1.732$

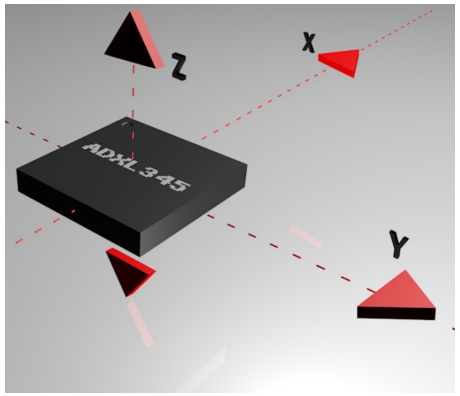
$y = 3.889$

$x = 3.263$

Q3

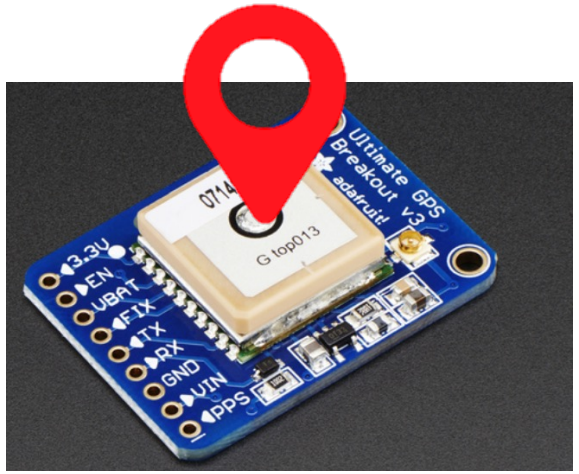
You are tasked to design an app that tracks the user's location using GPS. The GPS sensor consumes 400mW of energy, while the accelerometer sensor consumes only 5mW. You know that the user is mostly stationary when using the app. How can you design an **energy-efficient and accurate app that can track the user's outdoor location**? Explain your approach and its advantages.

Outline an energy efficient approach that can track the user's location.



Accelerometer

5mW



GPS

400mW

- Use accel as trigger to detect motion
- Wake GPS only if motion is detected
- Energy efficient as accel consumes 1/80th the energy consumed by GPS
- Sufficiently accurate although GPS used only occasionally

Additionally, we can use the accelerometer to estimate small changes in location and rely on the GPS less frequently for distance measurement. This approach can be sufficiently accurate as location changes are infrequent and we only use the GPS occasionally.

Q4

The ALOHA and slotted ALOHA protocols have a maximum channel utilization of 18% and 36%, respectively. However, the CSMA/CA protocol can achieve much higher utilization. How does CSMA/CA do this? Explain the main **difference between CSMA/CA and ALOHA protocols and how it affects the channel efficiency**.

Explain how CSMA/CA can achieve much higher utilization.

CSMA/CA - Carrier Sense Multiple Access with Collision Avoidance

- Reduces collision significantly → by transmitting only when channel is idle [Carrier Sensing]
  - If collision detection overhead < Packet retransmission overhead

Thank you

Feel free to contact me at kanav.sabharwal@u.nus.edu for any clarifications