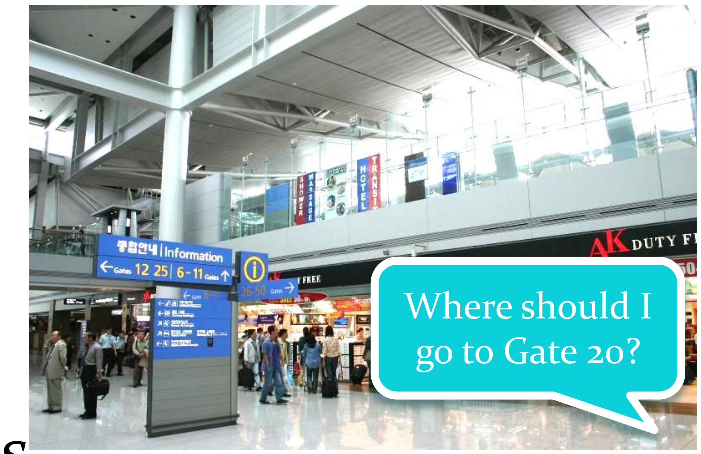
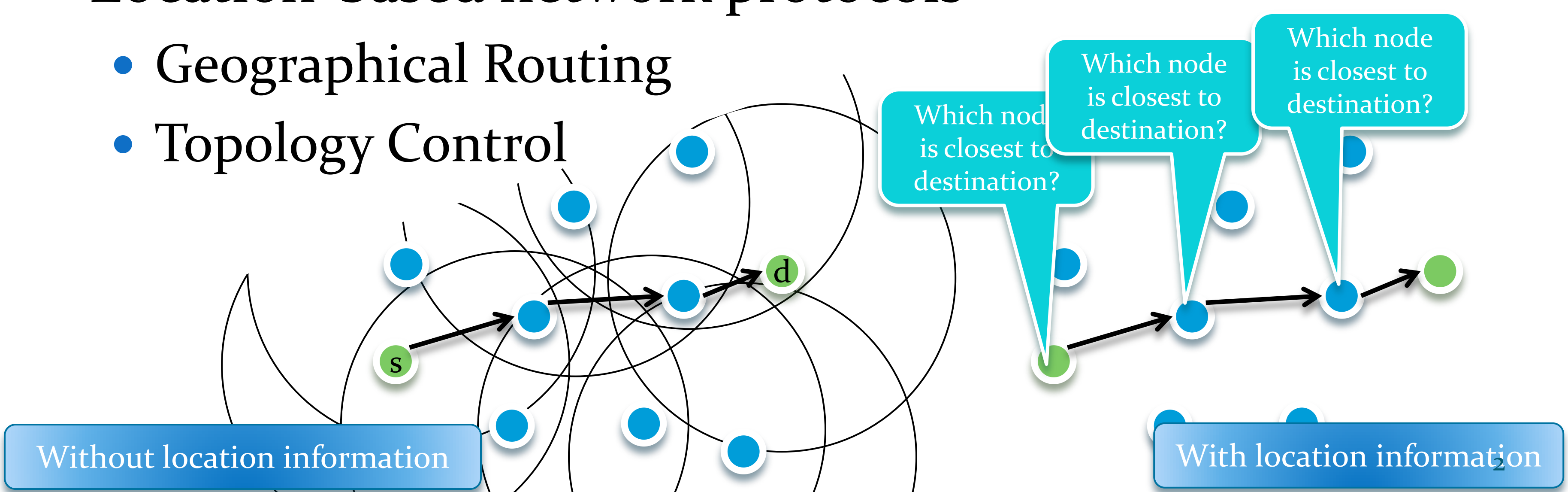
Localization

Junseok Kim
Wireless Networking Lab (WINLAB)
Konkuk University, South Korea
http://usn.konkuk.ac.kr/~jskim

Why Localization is important

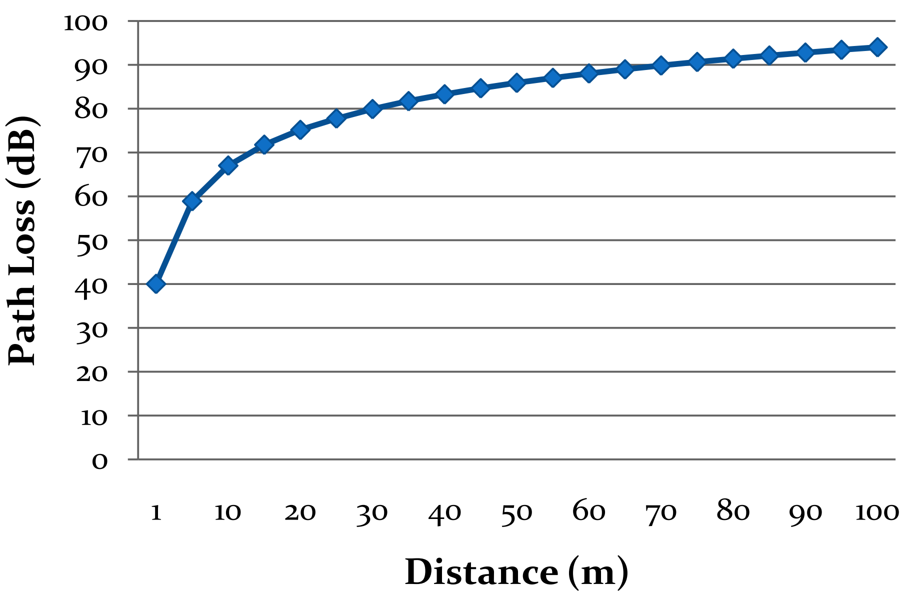
- Location-based applications
  - Personal navigation
  - Tracking shipments
  - Monitoring patients
- Location-based network protocols
  - Geographical Routing
  - Topology Control





Path loss vs. Distance

- Path loss is the reduction in power of an electromagnetic wave as it propagates through space
- Distance can be estimated by path loss model



Log distance Path loss Model

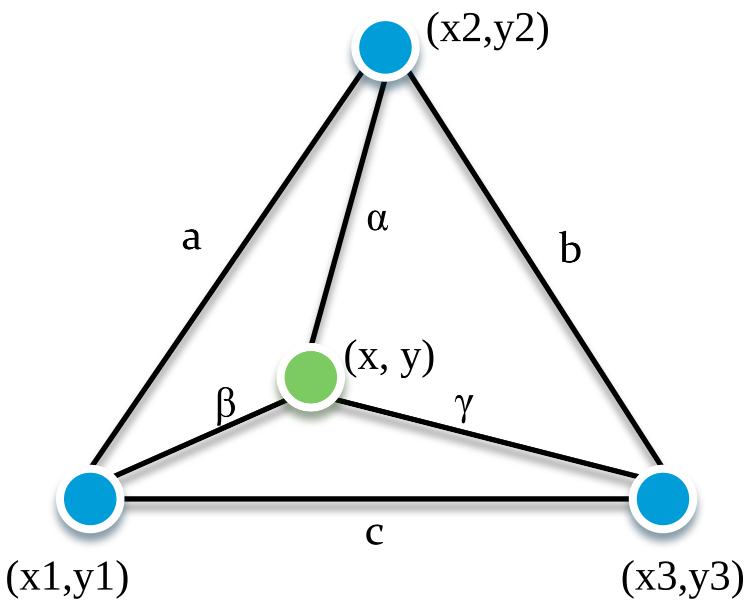
$$\overline{PL} = \overline{PL}(d_0) + 10n\log\frac{d}{d_0}$$

$$d = d_0 \cdot 10^{\frac{PL - PL(d_0)}{10n}}$$

- n: path loss exponent which indicates the rate at which the path loss increases with distance
  - n is about 1.5~2.8 in indoor
- d_o: close-in reference distance which is determined from measurements close the transmitter
- d: distance between sender and receiver
- $PL(d_o)$: path loss at distance d_o
  - $PL(d_o)$ is about 38~42dB in indoor

Trilateration

- Somehow complicated calculating
- Not precise because of variation of Path loss



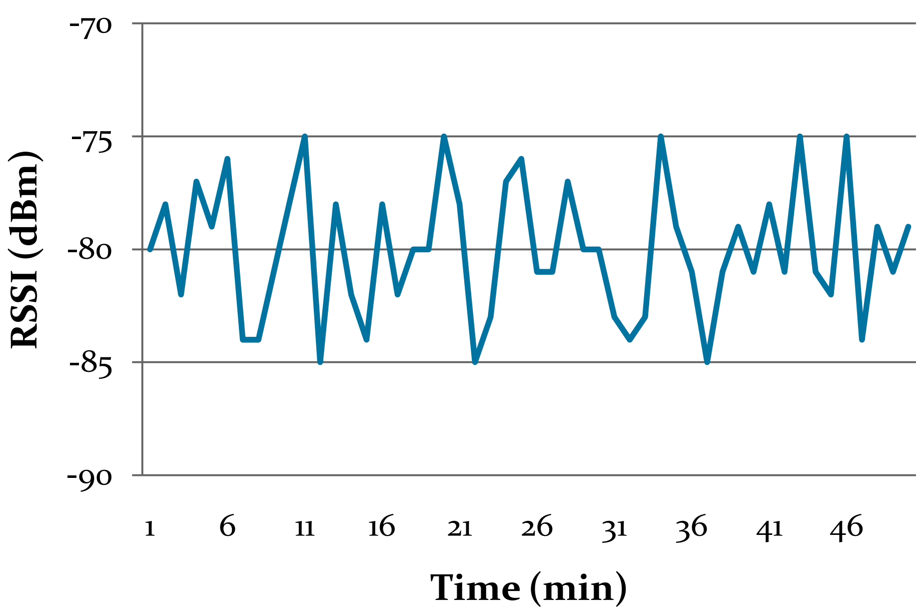
$$\alpha^2 = (x - x_1)^2 + (y - y_1)^2$$
$$\chi^2 = (x - x_3)^2 + (y - y_3)^2$$
$$\beta^2 = (x - x_2)^2 + (y - y_2)^2$$

$$x = \frac{\left(\frac{\alpha^2 - \beta^2 + a^2}{2}\right)(y_3 - y_1) - \left(\frac{\alpha^2 - \chi^2 + b^2}{2}\right)(y_2 - y_1)}{(x_2 - x_1)(y_3 - y_1) - (y_2 - y_1)(x_3 - x_1)}$$

$$y = \frac{\left(\frac{\alpha^2 - \chi^2 + b^2}{2}\right)(x_2 - x_1) - \left(\frac{\alpha^2 - \beta^2 + a^2}{2}\right)(x_3 - x_1)}{(x_2 - x_1)(y_3 - y_1) - (y_2 - y_1)(x_3 - x_1)}$$

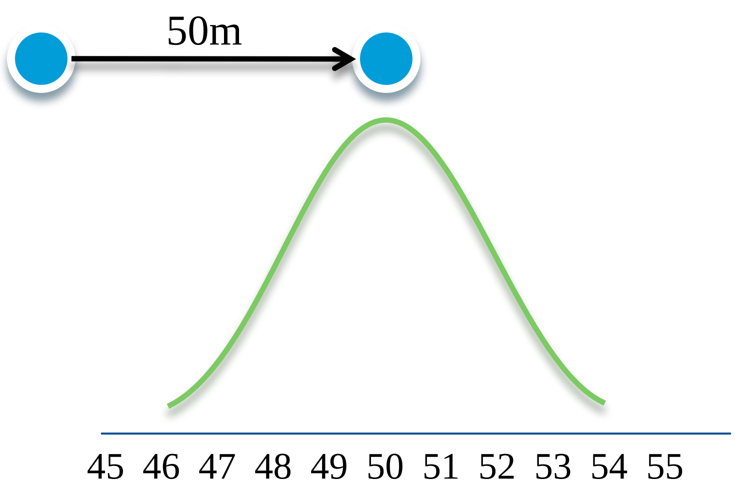
RSSI vs. Time

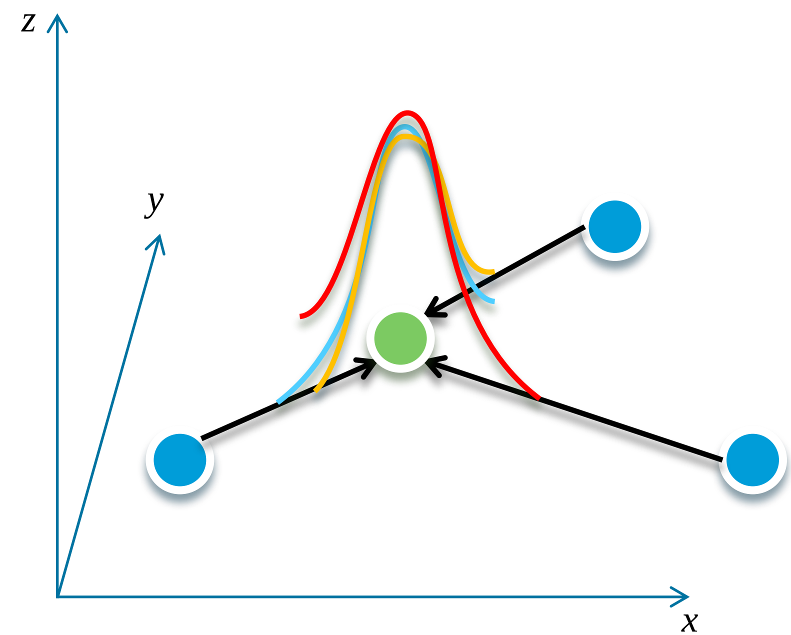
- RSSI value fluctuates due to environmental changes
  - RSSI: Receive Signal Strength Indicator



Maximum Likelihood Estimation (MLE)

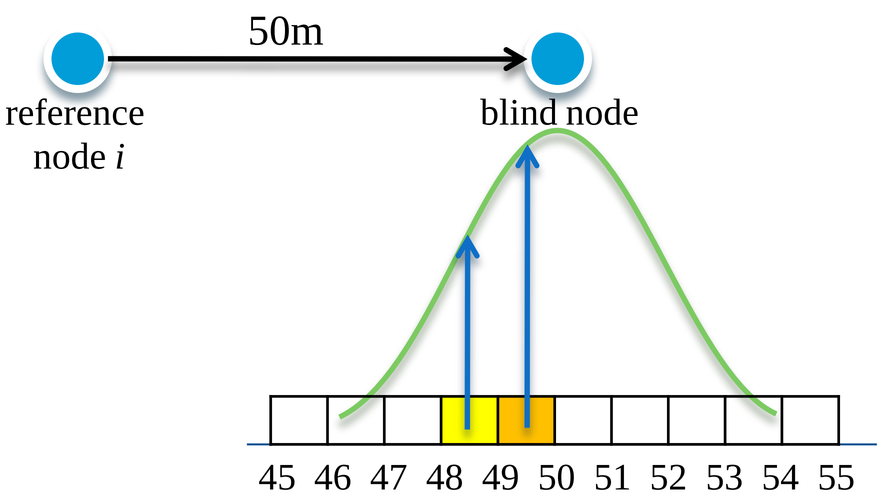
- Use probability to improve accuracy





MLE (Cont.)

- Divide region into many cells and find the cell with the highest probability of blind node being located



Estimated RSSI value at distance of sender to a cell

$$\boldsymbol{d} = \boldsymbol{d}_0 \cdot 10^{\frac{\boldsymbol{PL}-\boldsymbol{PL}(\boldsymbol{d}_0)}{10\boldsymbol{n}}}$$

Measured RSSI value at receiver

$$\boldsymbol{p}(\boldsymbol{s}_i \mid \theta_j) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(\frac{-(x-\mu)^2}{2\sigma^2} \right)$$

Gaussian distribution

variance of RSSI measurements

probability of blind node being located at *j*-th cell in a view of reference node *i*

MLE (Cont.)

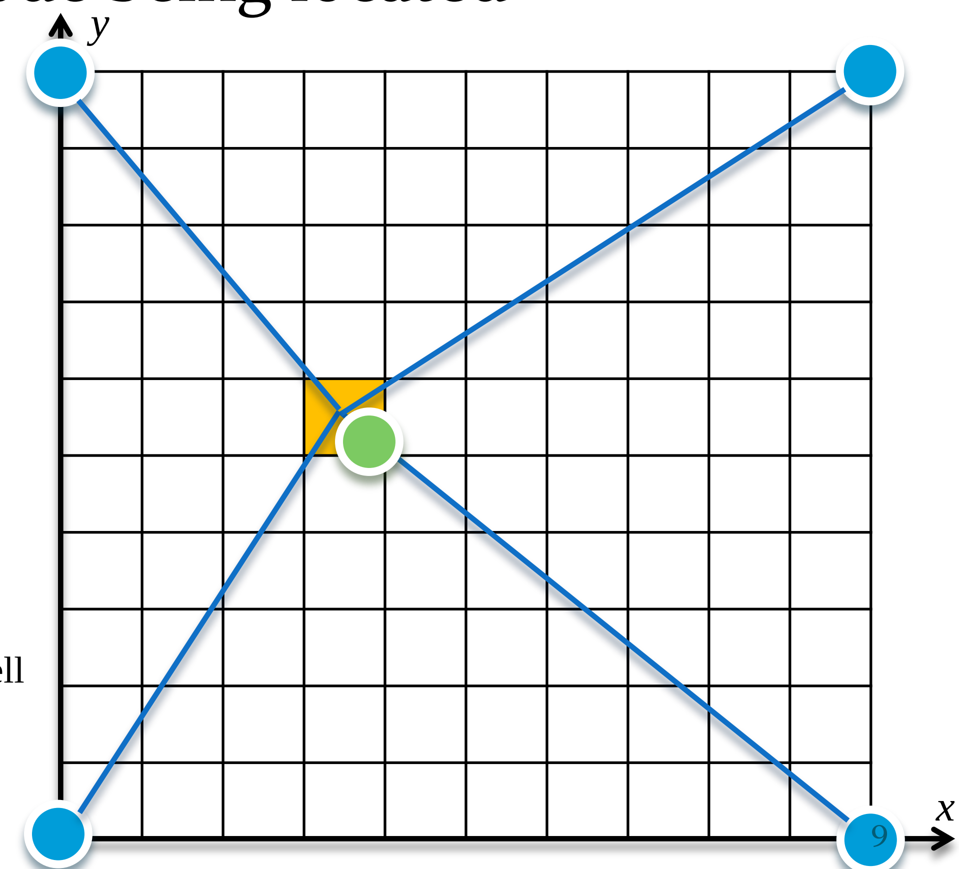
- Divide region into many cells and find the cell with the highest probability of a node being located

the number of reference node

$$L(\theta_j) = \prod_{i=1}^{m} p(s_i \mid \theta_j)$$

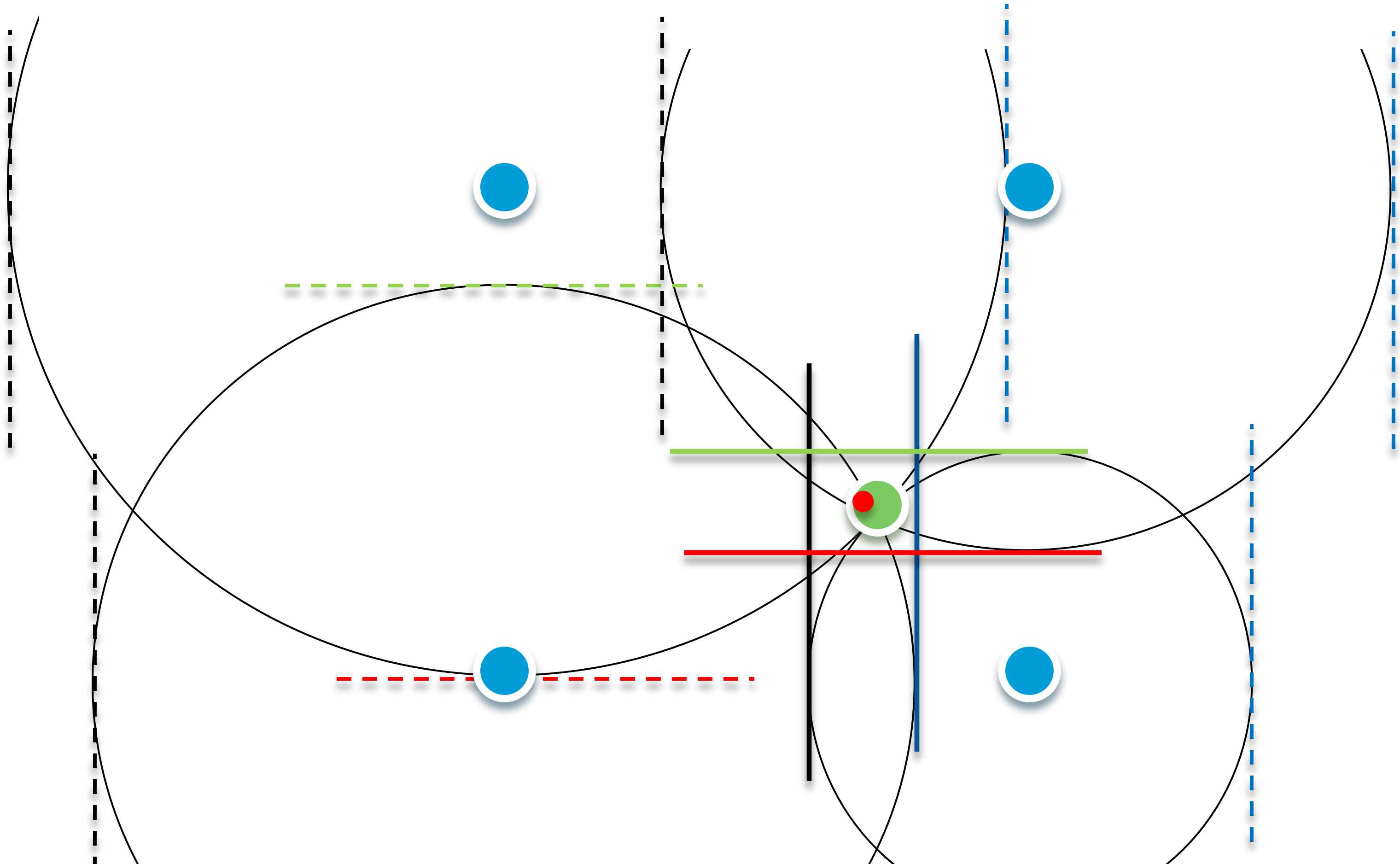
probability of blind node being located at *j*-th cell

probability of blind node being located at *j*-th cell in a view of reference node *i*



Min-Max Bounding Box

- Very easy and simple but less accurate than MLE



Q and A