Calibration as Parameter Estimation in Sensor Networks

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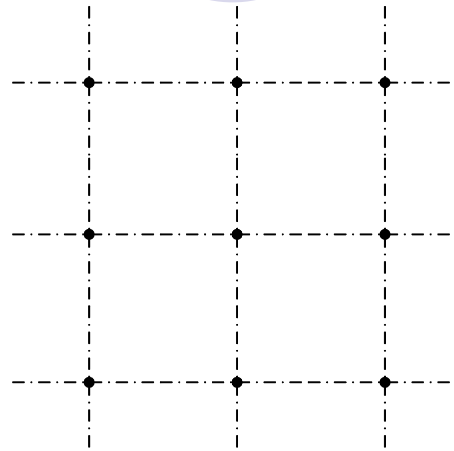
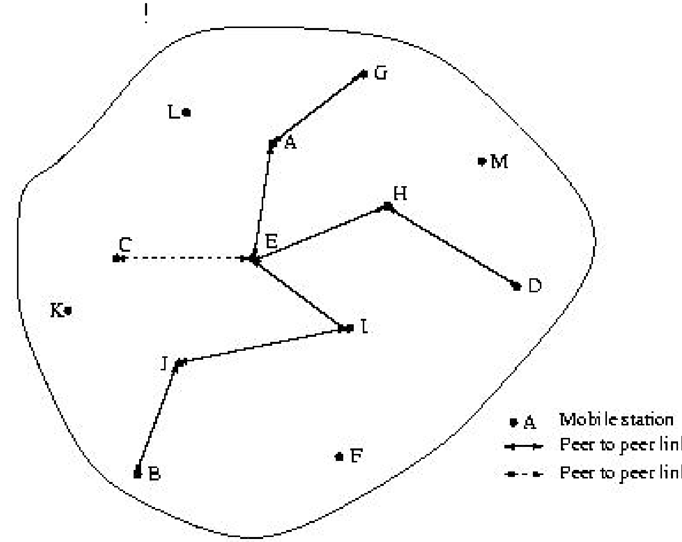
Agenda

- Localization and Calibration Problems
- Literature Review
  - Calibration function with linear regression
  - Iterative calibration
  - Mean calibration
- Proposed Macro-calibration
  - Joint calibration
- Generalization as Parameter Estimation
  - Reflection on RBS
  - Relative Calibration
- Conclusion

Localization and Calibration Problem

- Awareness of location is important in ad-hoc sensor networks
  - Infrastructure to provide position and distance
  - GPS module and ultrasonic receivers
- Radio Frequency (RF) and acoustic pulse transmission introduce large variation
  - Simple hardware
  - Heavy duty calibration





Literature Review

- Device Calibration
  - Hardware tuning
  - Calibration Function

$$r^* = f(r, \beta)$$

- Linear Regression
  - Valid to ONE TX/RX pair
  - Complexity of n^2
  - Separation Problem

$$r^* = \beta_1 + \beta_2 \times r$$

- Iterative Calibration
  - Declare one TX as reference to calibrate
  - Iterate with RX as reference
- Mean Calibration
  - Assume Gaussian distributed variation in device
  - Calibrate all TX/RX as mean value

Joint Calibration

- The model

$$d^* = B_T + B_R + G_T \times d + G_R \times d + |F_T - F_R| \times d + f_o(O_T, O_R) \times d$$

  - Omit non-linear terms
  - Complexity 4n var. in n^2-n equations
  - Parameter estimation avoids separation problem yet keeps TX/RX models

Generalization

- What if NOT distance we are concerned?
  - Time/Sync [OSDI 2002]
  - Phase offset: Offset Matrix according to pair of receivers with Gaussian dist. parameters
  - Clock Skew: least square linear regression
  - Multi-hop time sync
- $$Offset(i,j) = \frac{1}{m}\sum_{k=1}^{m}(T_{j,k} - T_{i,k})$$

Conclusion

- Existing Methods
  - Traditional linear regression: Separation Problem
  - Iterative calibration: Error Propagation
  - Mean calibration: Ignore the errors with Gaussian model
- Joint calibration
  - System model
  - Parameter estimation
- Generalization
  - Time Varying Model?
  - Extension to synchronization scenario…