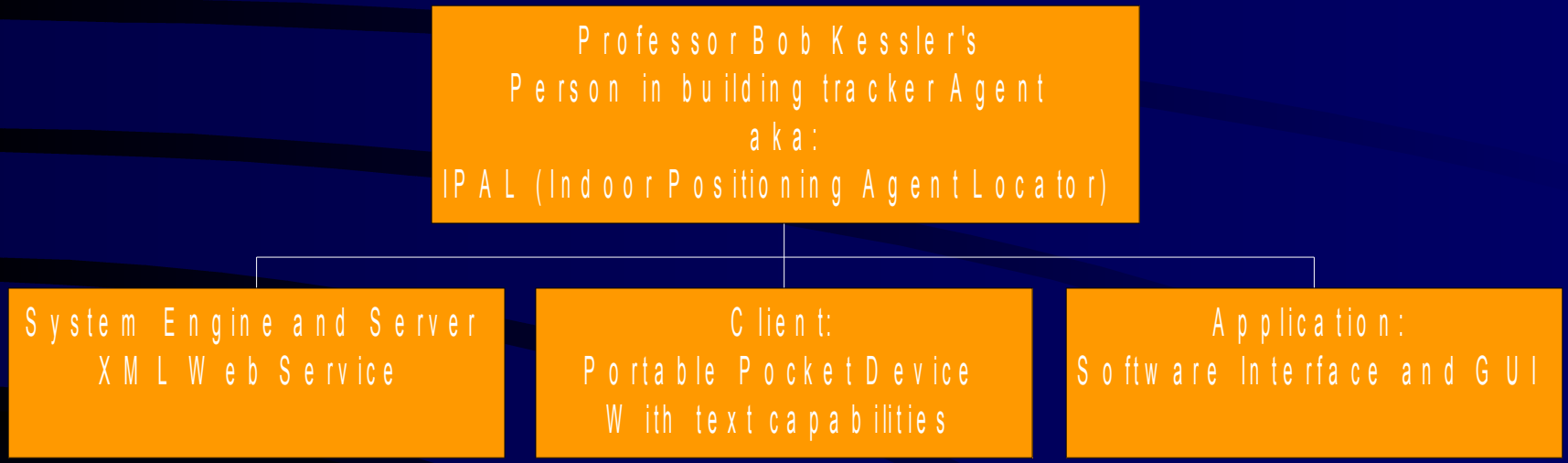
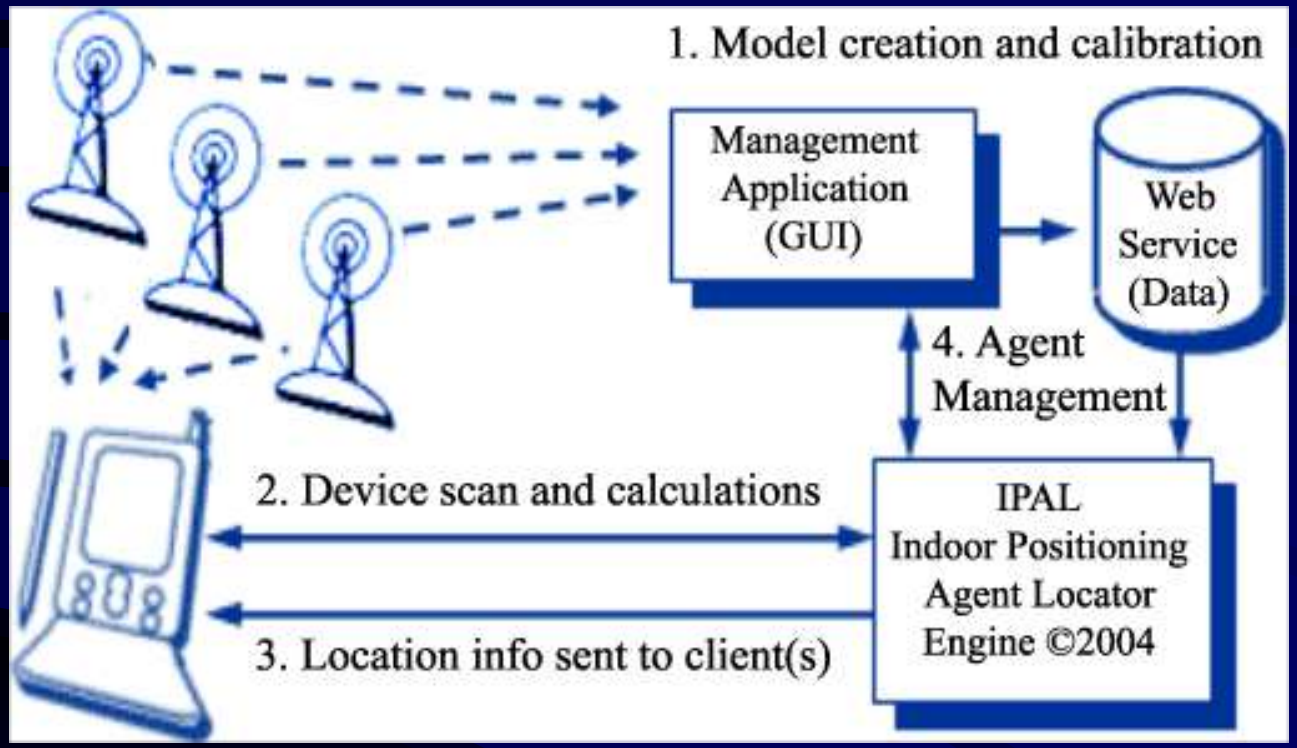
Indoor Positioning Thesis Interface



IEEE 802.11 IPAL Proposal



- Existing Infrastructure
- Industry Standard IEEE Interface
- Built in support for additional COM features

Application Server or Engine

Provides all background mathematical calculations needed to determine location.

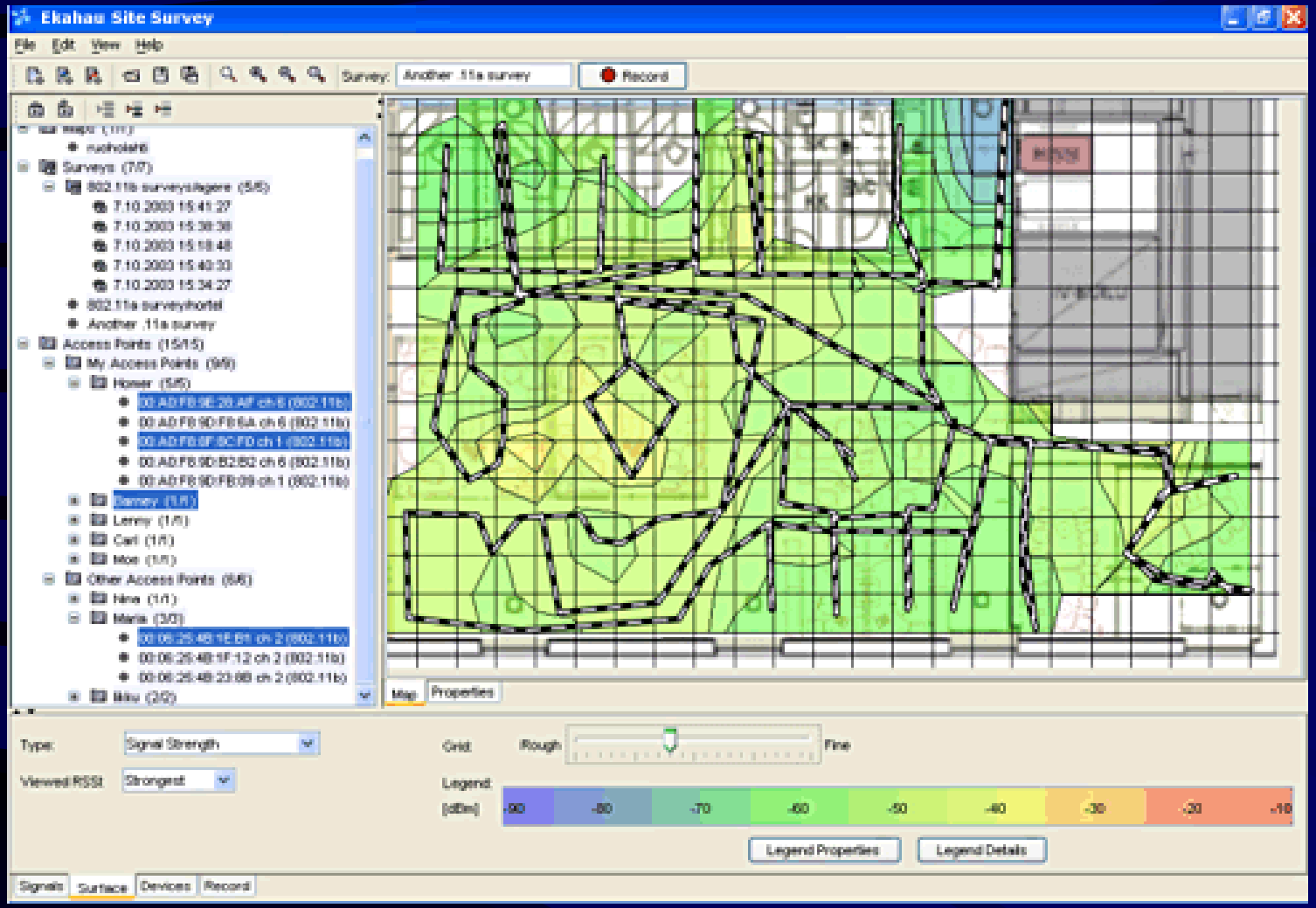
- SQL Server Database

Input and output communication with server is accomplished using:

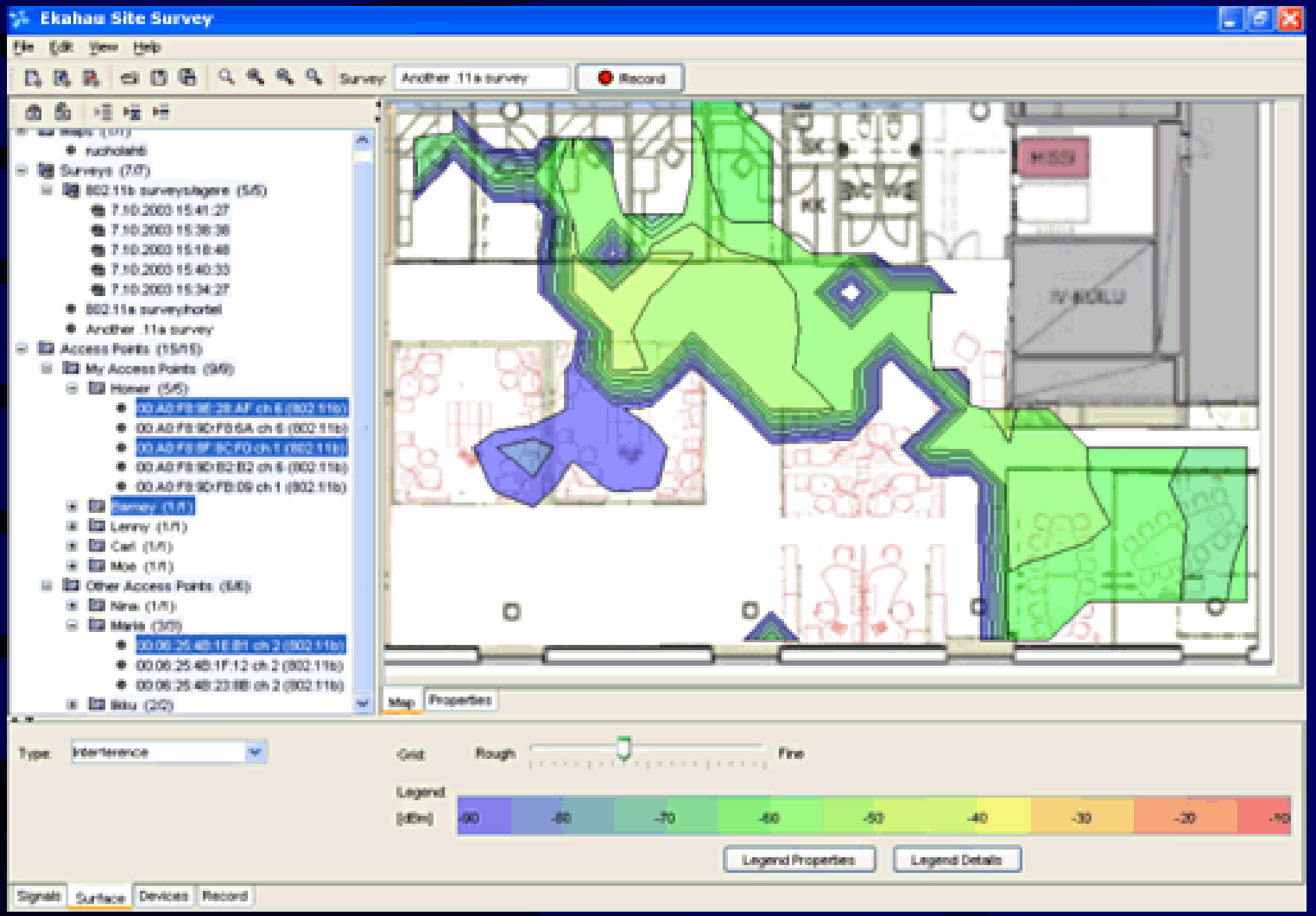
- Microsoft SOAP, an XML compliant “Web Service”
- Standard XML Agent Communication Language otherwise known as ACL.

Graphical User Interface

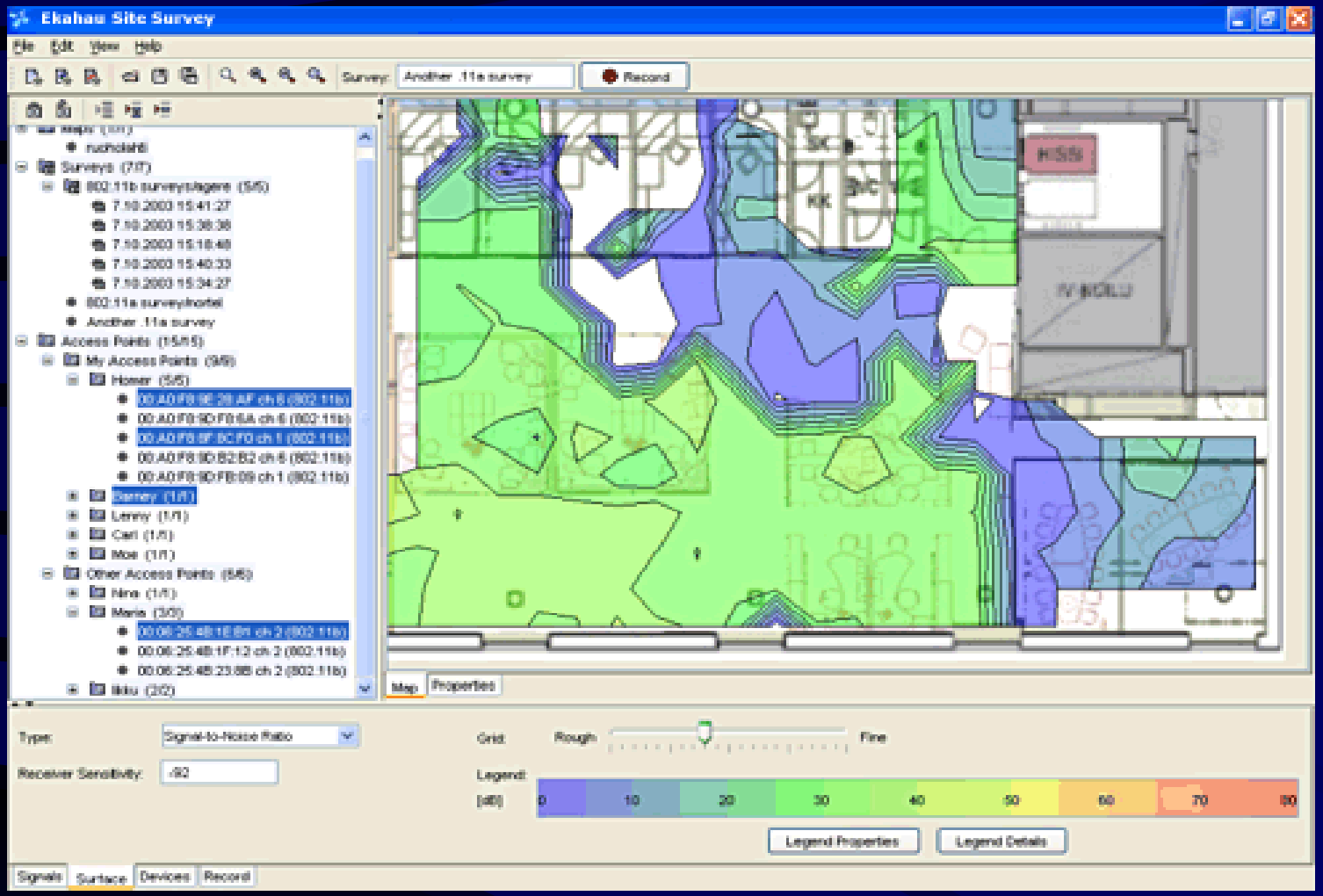
- A Macromedia GUI providing new client setup and calibration
- Communicates with Application Server using XML
- Location of a person or node from any web browser with flash reader installed
- And other possible features, such as a site map, that may prove useful



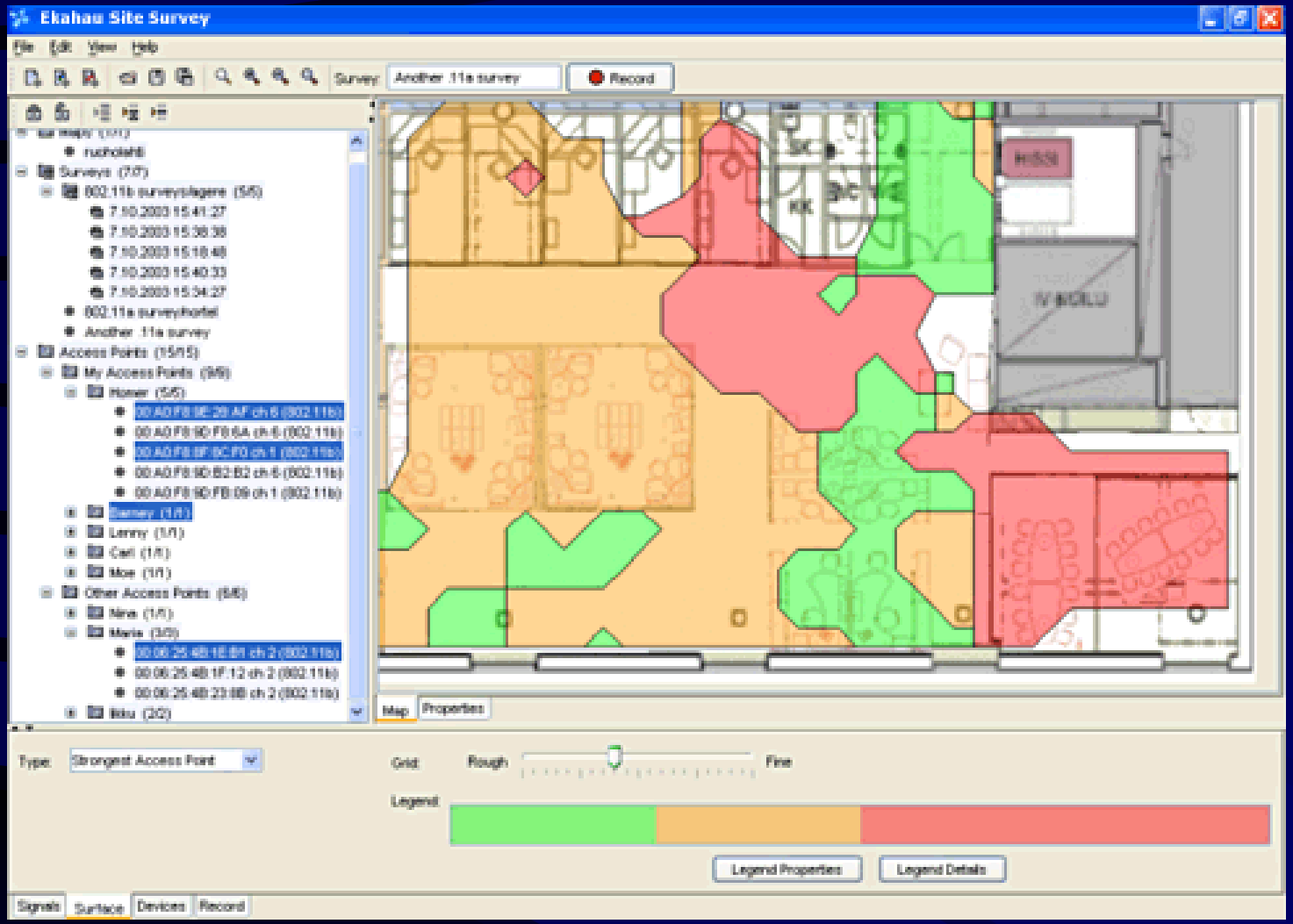
Signal Strength View displays the strongest RSSI at each location for the selected access points. The dotted line is the recorded site survey route. The grid lines are also turned on to see the accuracy of the visualization. [Ekahau, Inc]



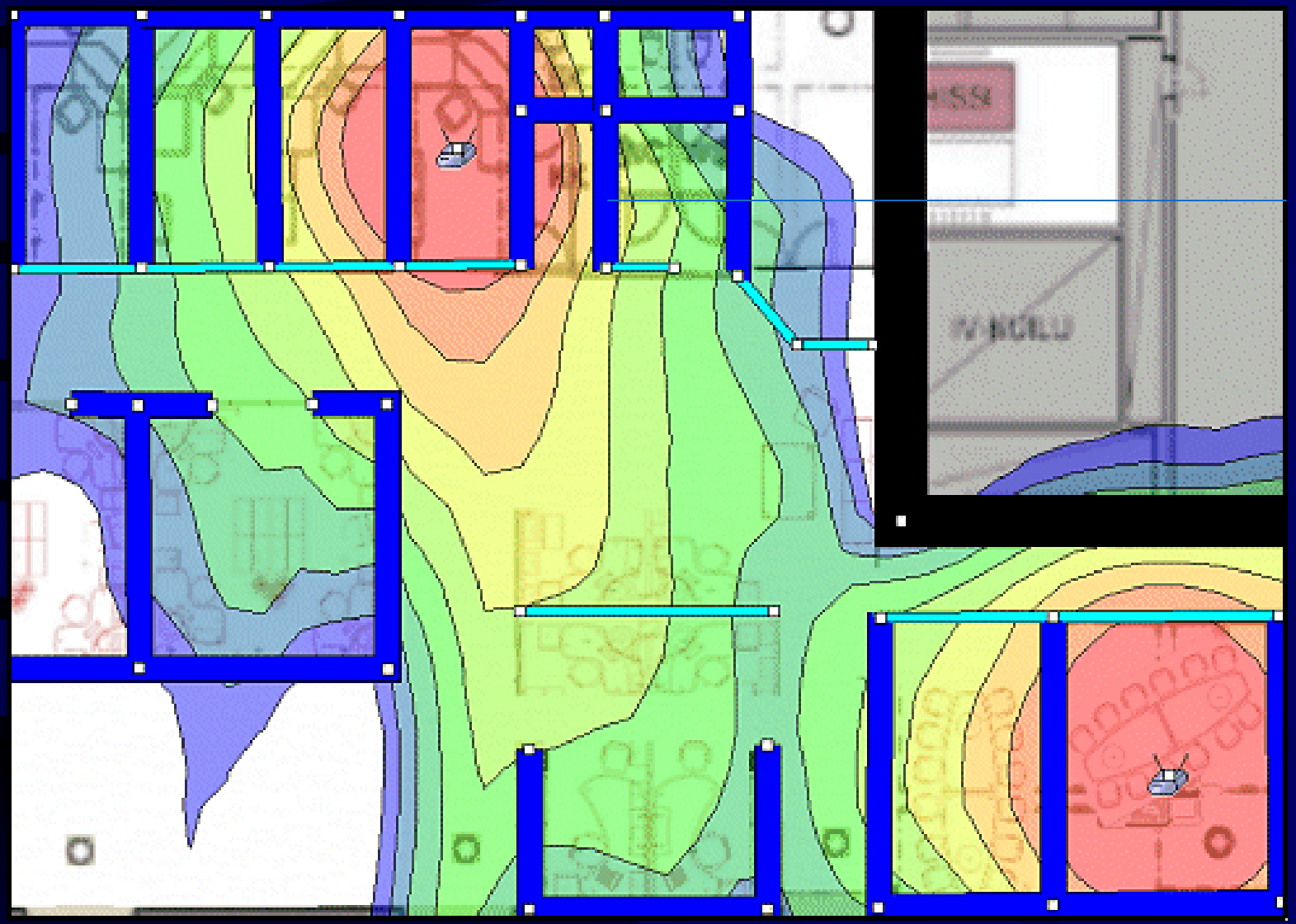
By investigating the **interference** surface you can find the optimal channels with minimum interference.
[Ekahau, Inc]



If the **Signal-to-Noise Ratio** is significantly lower than the signal strength, there's radio interference affecting your network performance.
The grid and survey route visualizations have been turned off.[Ekahau, Inc]



Visualizing the **strongest access points** per location. Specific color can be defined for each AP. [Ekahau, Inc]



The Planner supports quick wall and access point placement, and instantly reacts to changed parameters by displaying the expected coverage, data rate, etc.[Ekahau, Inc]

Client Software

A Windows CE based or other OS based embedded software package that responds to simple queries for the Application Server.

- Small XML Request and Responses
- Reports measured signal strength data of all access points within range.

Hardware Components Required

- A Microsoft .NET enabled Web Server connected to an IEEE 802.11 network
- IEEE 802.11 enabled PDA
- Minimum set of three IEEE 802.11 Access points

Interface Issues and Risks

- Obtaining signal strength data from wireless access points – Access Point model
- Obtaining signal strength data from wireless nodes
- What is the best way to analyze the signal strength information for determining position?
- Signal discrimination and qualification

Access Point Model

Pros:

- All 802.11 device positions may be queried and located without having to install or write different client software for each device

Cons:

- Not all access points have solutions for reporting signal strength of available clients
- Client under test goes into power save mode or some other low-power broadcasting mode

Client or Node Software Model

Pros:

- Built in signal strength capabilities
- In a large network where there are a large number of clients this method may prove best

Cons:

- Requires a client software package that works with different wireless NIC card drivers and operating systems
- Location determination is limited to nodes with installed client software package

So Which Model?

- Both if possible
  - Numeric signal strength measurements are identical with both models
  - We know client model will work so I will start here with one client.
  - Implement Access Point model at home
    - Limit discovery period to 2 weeks
  - If previous step is success try to implement on Campus in MEB and/or EMCB

How to analyze the signal strength information for determining position?

- **Nearest Neighbor**
- Microsoft "RADAR's" **Empirical Model**
- **Radio Propagation Model**

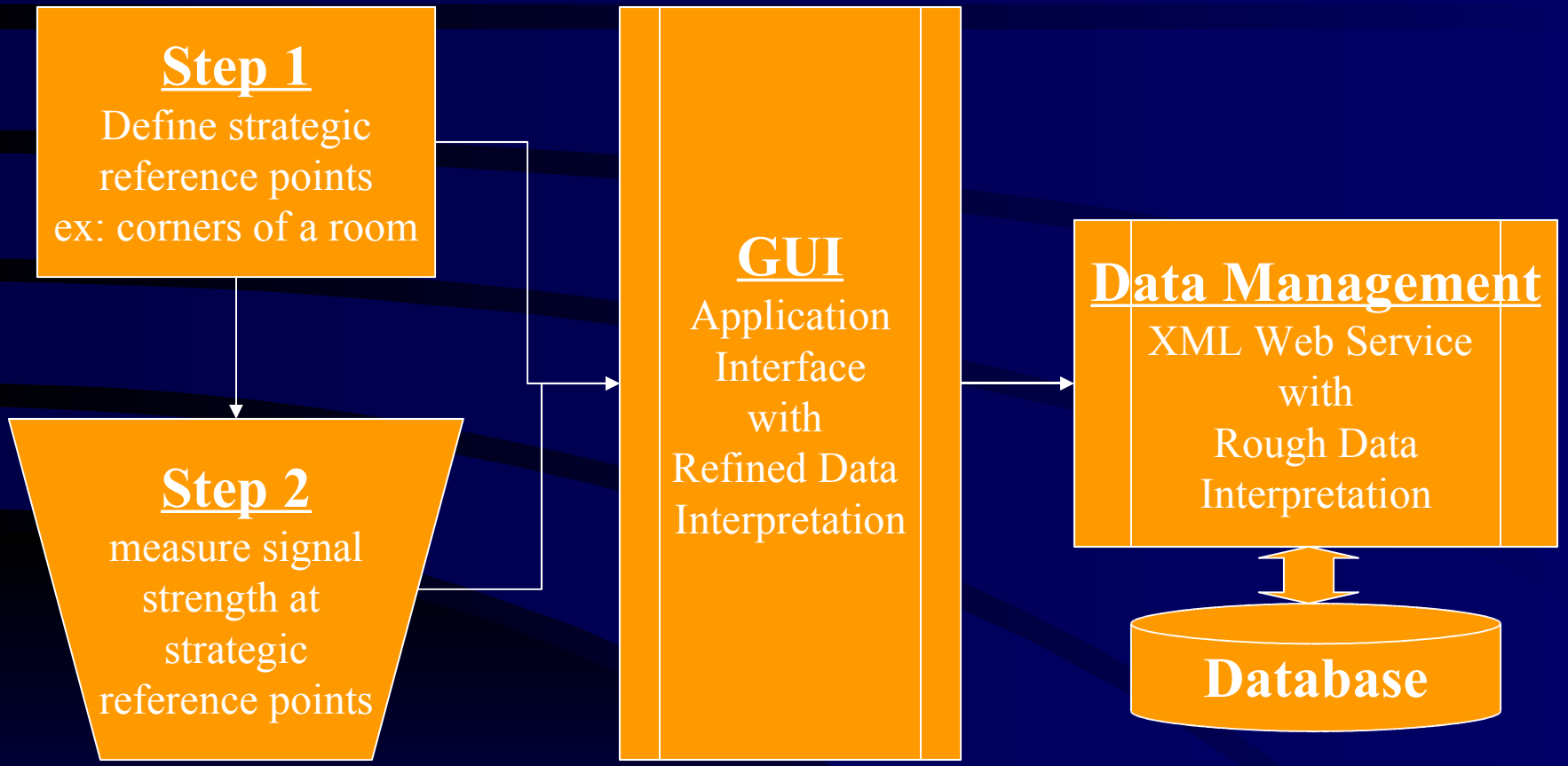
Nearest Neighbor

- The nearest Access point is the location of the client
  - Accurate up to about 6 to 12 meters (size of a room)
  - Works where less than three Access Points are available
  - Simple to implement
  - No client calibration required

Empirical Model

Uses the nearest neighbor(s) in signal space (NNSS) algorithm. An initial calibration is performed through recording signal strength measurements ss'1, ss'2, and ss'3 into a database for future comparisons. The idea is to compute the distance (in signal space) between the observed set of SS measurements, (ss1,ss2,ss3), and the recorded SS, (ss'1,ss'2,ss'3), at a fixed set of locations, and then pick the location that minimizes the distance [Bahl and Padmanabhan].

System Calibration



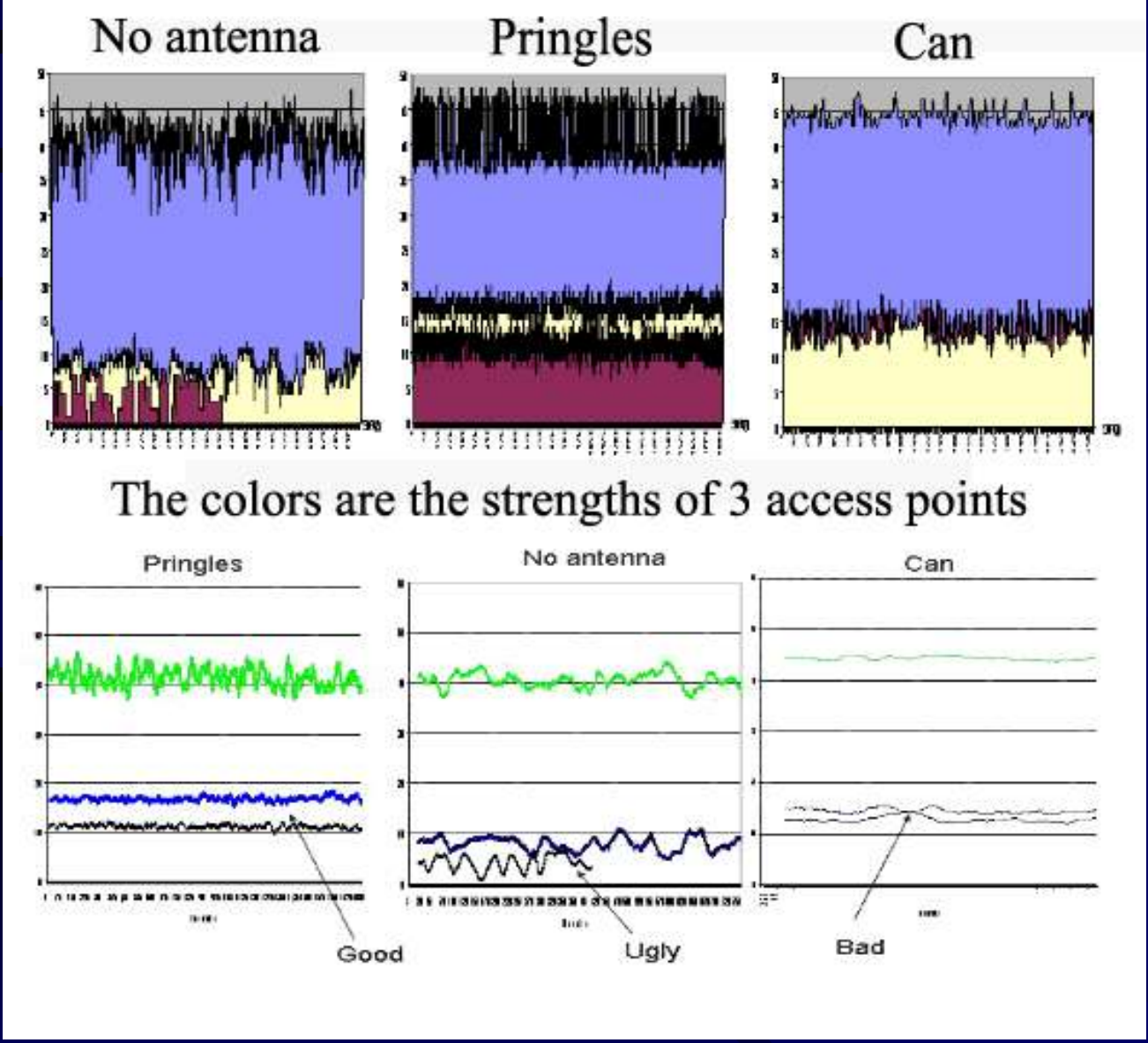
Radio Propagation Model

Using a mathematical model of indoor signal propagation, we generate a set of theoretically-computed signal strength data akin to the empirical data set. The data points correspond to locations spaced uniformly on the floor. The NNSS algorithm can then estimate the location of the mobile user by matching the signal strength measured in real-time to the theoretically-computed signal strengths at these locations. It is clear that the performance of this approach is directly impacted by the "goodness" of the propagation model [Bahl and Padmanabhan].

Signal Discrimination and Qualification

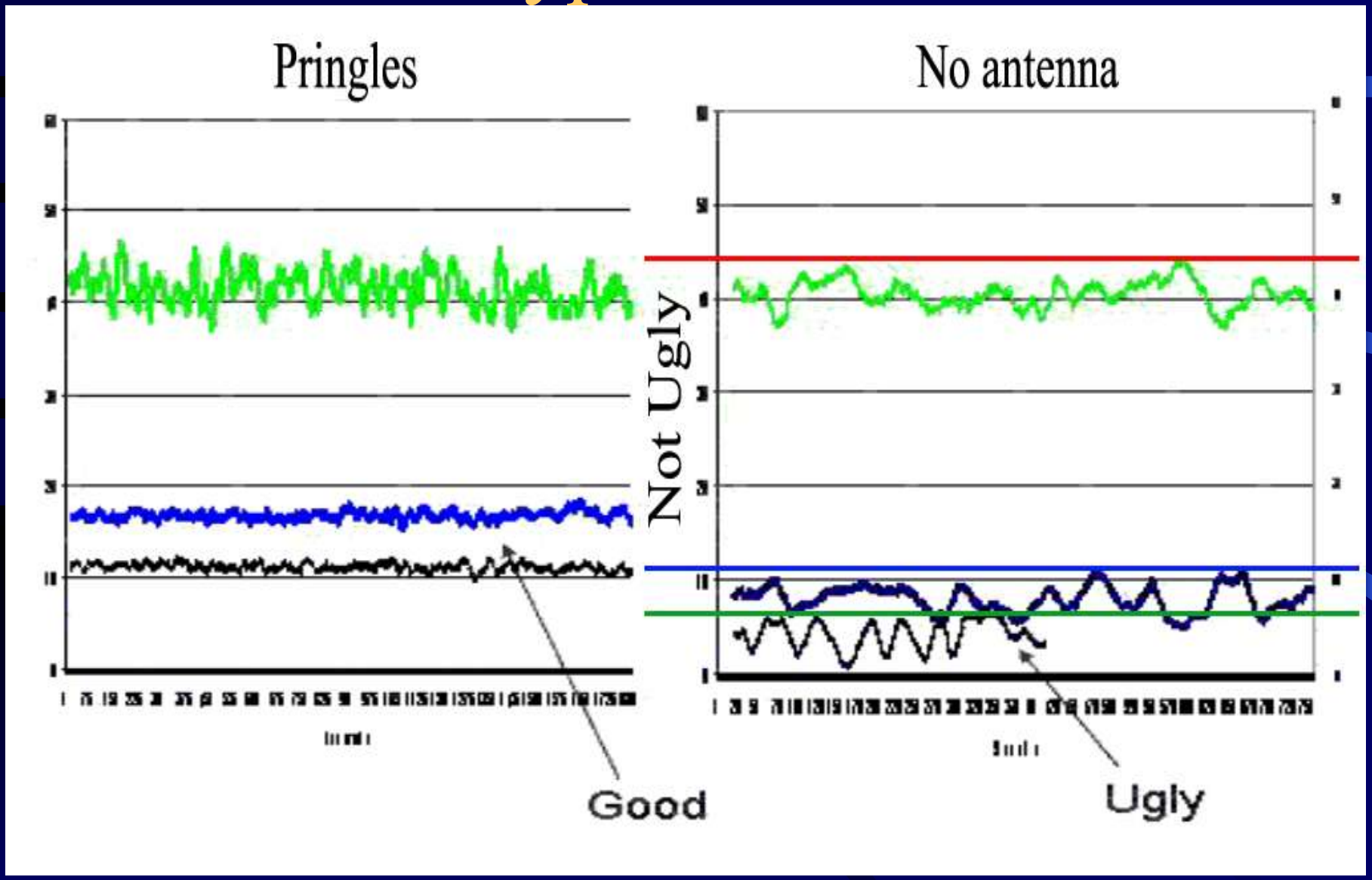
Pictures Speak Volumes about Portability

Available Research



Research by Kalid Azad, Princeton University undergraduate Student

My Peak Measurements Hypothesis



My Peak Measurements Hypothesis Basis

- Few environmental variables will amplify a broadcasted RF signal
- Best signal to determine location is the most unobstructed or non-attenuated signal
  - Proof: Bahl and Padmanabhan with Microsoft during their “RADAR” research found “Max Signal Strength Across Orientations” is more accurate

Proposed Schedule Flows Week 1 through 2:

- Develop and write client/server software tests for acquiring signal strength information from an 802.11 client.

Week 3 through 4:

- Attempt to develop and write software tests for acquiring signal strength information from multiple 802.11 Access points about individual nodes broadcasting their MAC addresses using my home network.

Week 5 through 6: (If access point model successful)

- Attempt implementation of access point model in EMCB and/or MEB.
  - This will also require getting special user rights to access the system.
- If I fail to implement the access point model then I will move on to the next stage in development.

Week 7 through 8:

- Address additional concerns about obtaining data from access points and clients.
- Collect data through rigorously testing signal strength measurements in a variety of controlled and uncontrolled environments.
- Compare and contrast the use of both models.

Week 9 through 10:

- Employ two or three algorithms or techniques for calculating the location of a client.
- Evaluate the difficulty, speed, and result quality of each algorithm when providing each with real-time data.
- Choose one or two methods that will best implement the overall objective of locating the room our client is in.
  - It might be nice to allow a user to select from more than one location calculation algorithm. Especially since my final software package is the product that will demonstrate my research.

Week 11 through 14:

- Create a Macromedia Flash form based GUI for interacting with Web Service
  - This will include a point and click graphical mapping interface
- Build the .NET web service for interacting with Flash GUI.
  - Stores and retrieves location information in and from an SQL Server database.

Week 15 through 16:

- Write an alpha software package for the collection of signal strength measurements and location calculation.
  - This includes an easy to use and port client location calibration interface.

Week 17 through 18:

- Write a beta software package for the collection of signal strength measurements and location calculation.
- Must be configurable using a simple GUI interface.
- Include support for simultaneous multithreaded device location monitoring and user interaction.

Week 19 through 20:

- Generate user documentation and help files for the beta package.
- Rap up as many loose ends as possible.

Week 21 through 22:

- Port the required software routines and functionality into the .NET Application Server.
- Dress up the user interface and GUI.
- Work as many kinks out of the system as possible.

Week 23 through 24:

- Bring complete working system to a candidate release phase.
- Test the system, tweak the system, demonstrate the system, and perform even more system tests.
- Let someone who is computer illiterate try to use the system.
  - Defined : Computer illiterate – Someone who thinks a CD-ROM drive is a fancy cup holder
- Tweak and test the system again.
- Release the candidate.

Week 25 through 28:

- Complete my research
- Finish writing the Thesis.

Week 29 through 32:

- Allow more time for things like
  - Sickness
  - Homework
  - Midterms
  - Quality Assurance
  - Emergency vacations to Brazil.

Work Sited

Kalid Azad. “Indoor positioning using 802.11b wireless networks.” 1 January 2003. February 20, 2003 <http://www.princeton.edu/~kazad/resources/cs/cs398.htm>

Paramvir Bahl and Venkata N. Padmanabhan. “RADAR: An In-Building RF-based User Location and Tracking System.” Microsoft Research. 2000. 12 March 2005 <http://research.microsoft.com/~padmanab/papers/infocom2000.pdf>

Ekahau, Inc. “Long Term Research In Positioning.” 2004. 12 March 2005 <http://www.ekahau.com>