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# Somebody Needs Your Algorithm

## Part I: The Ekahau Story

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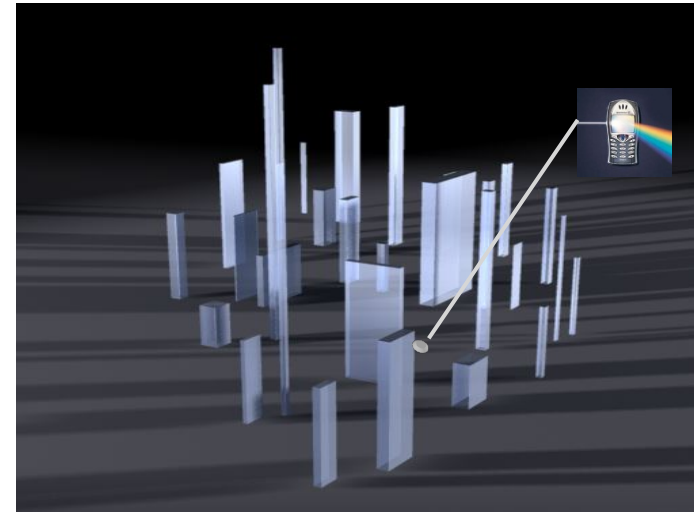
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**Department of Computer Science**



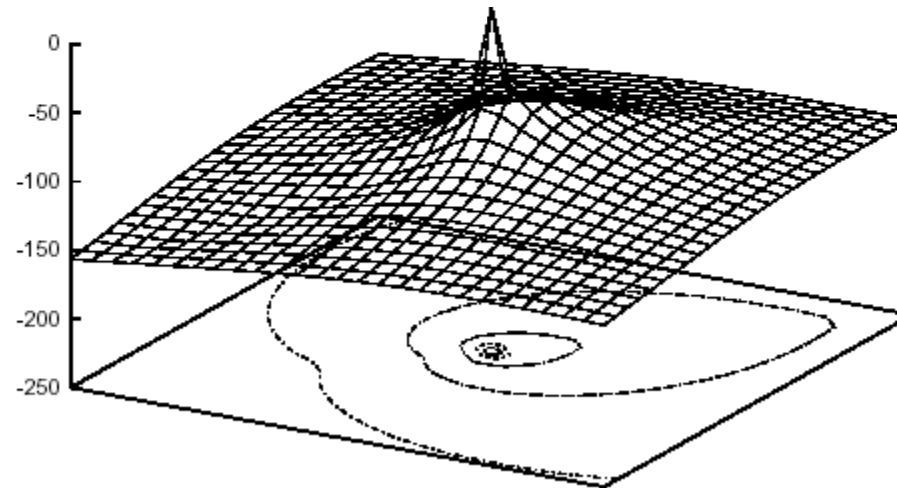
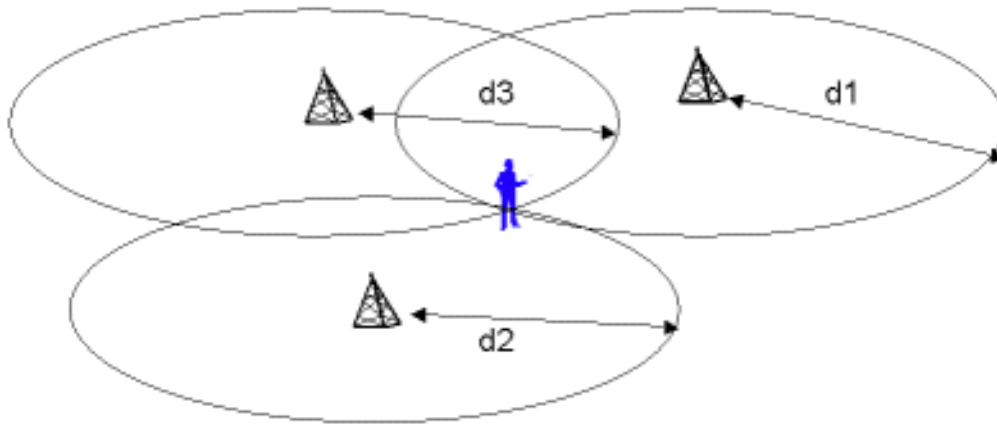
## The Positioning Problem

- Given some location-dependent observations  $O$ , measured by a mobile device, determine the location  $L$  of the device
- Why is this a good research problem?
  - The goodness of different solutions is extremely easy to validate (just go to a known location and test)
  - The results have immediate practical applications

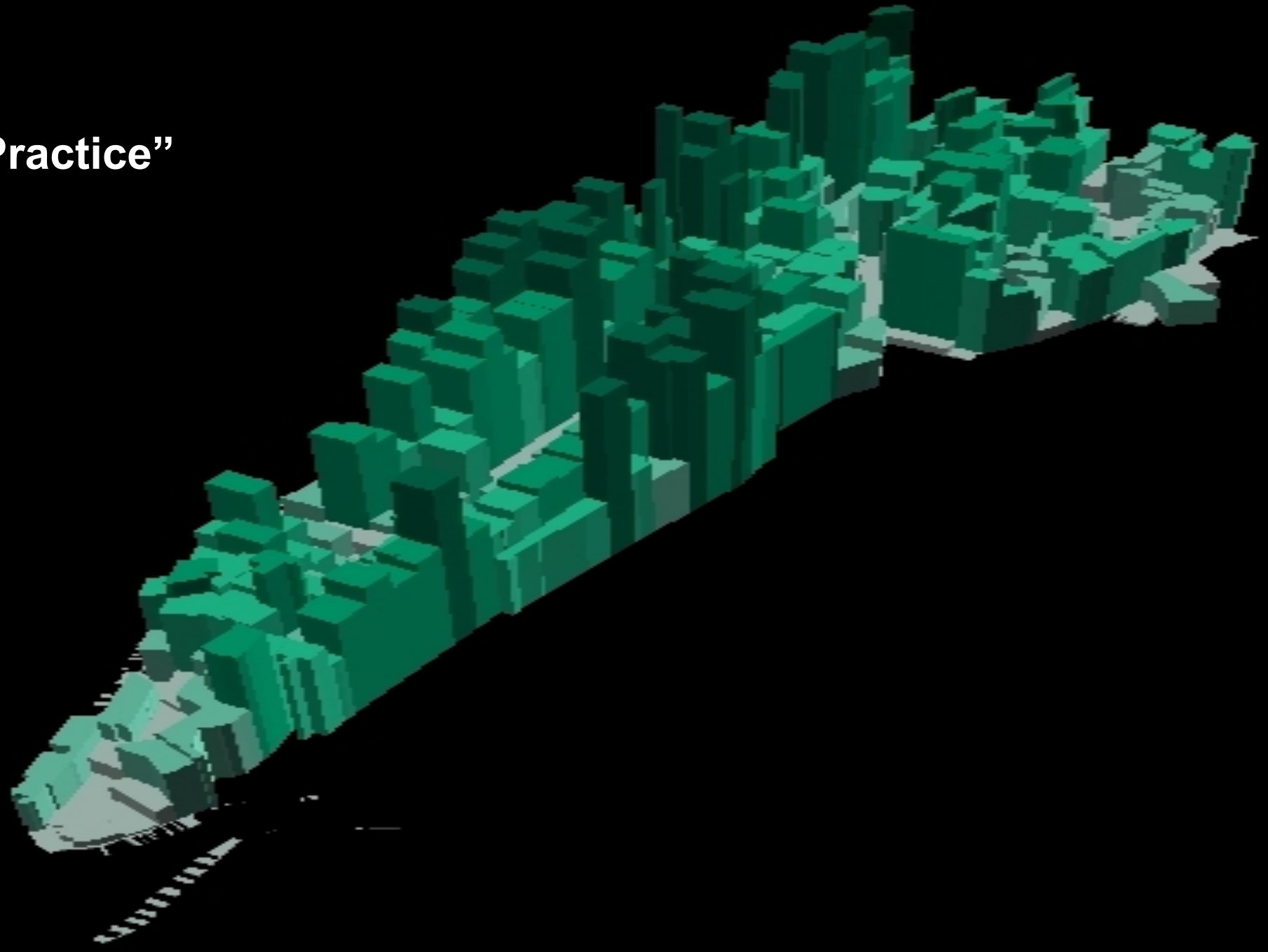




# “Theory”



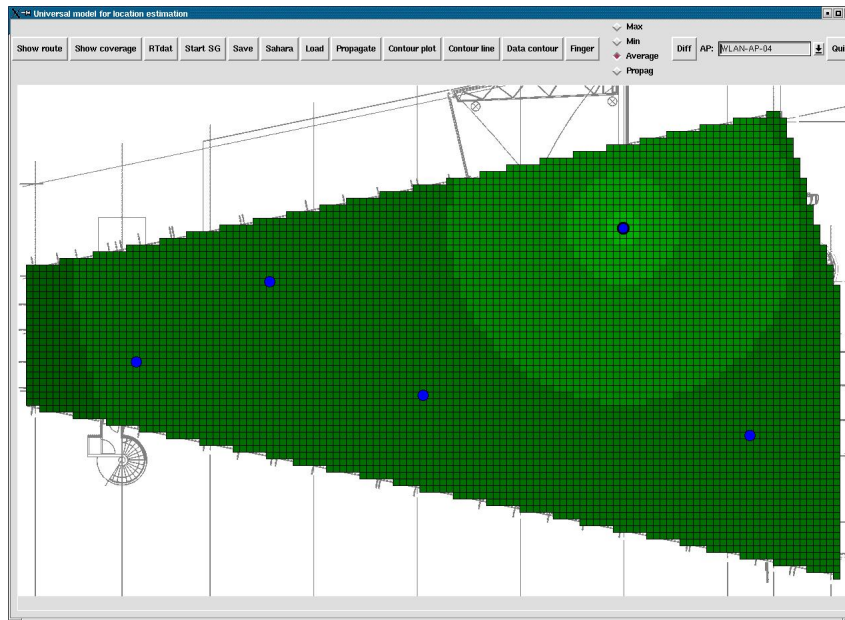
**”Practice”**



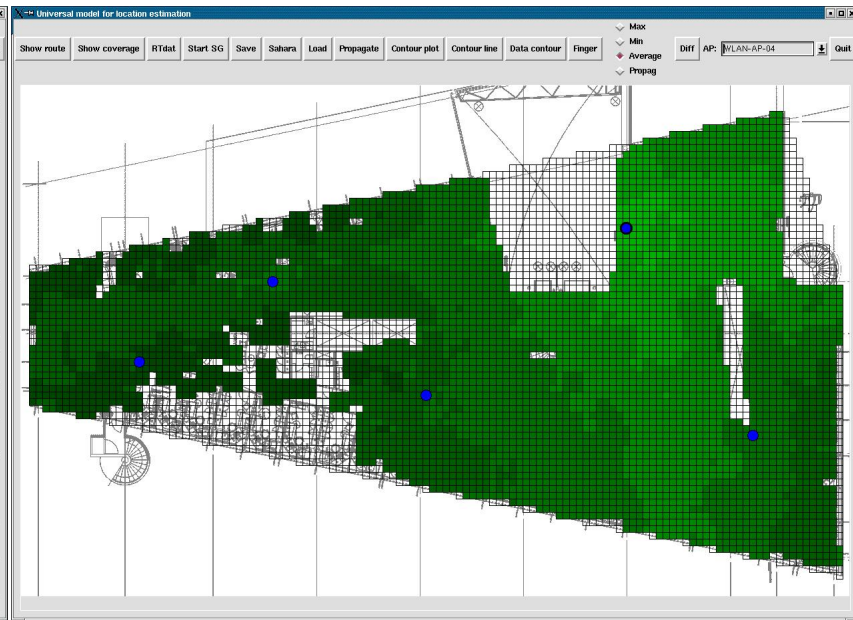


# The Signal Propagation Approach

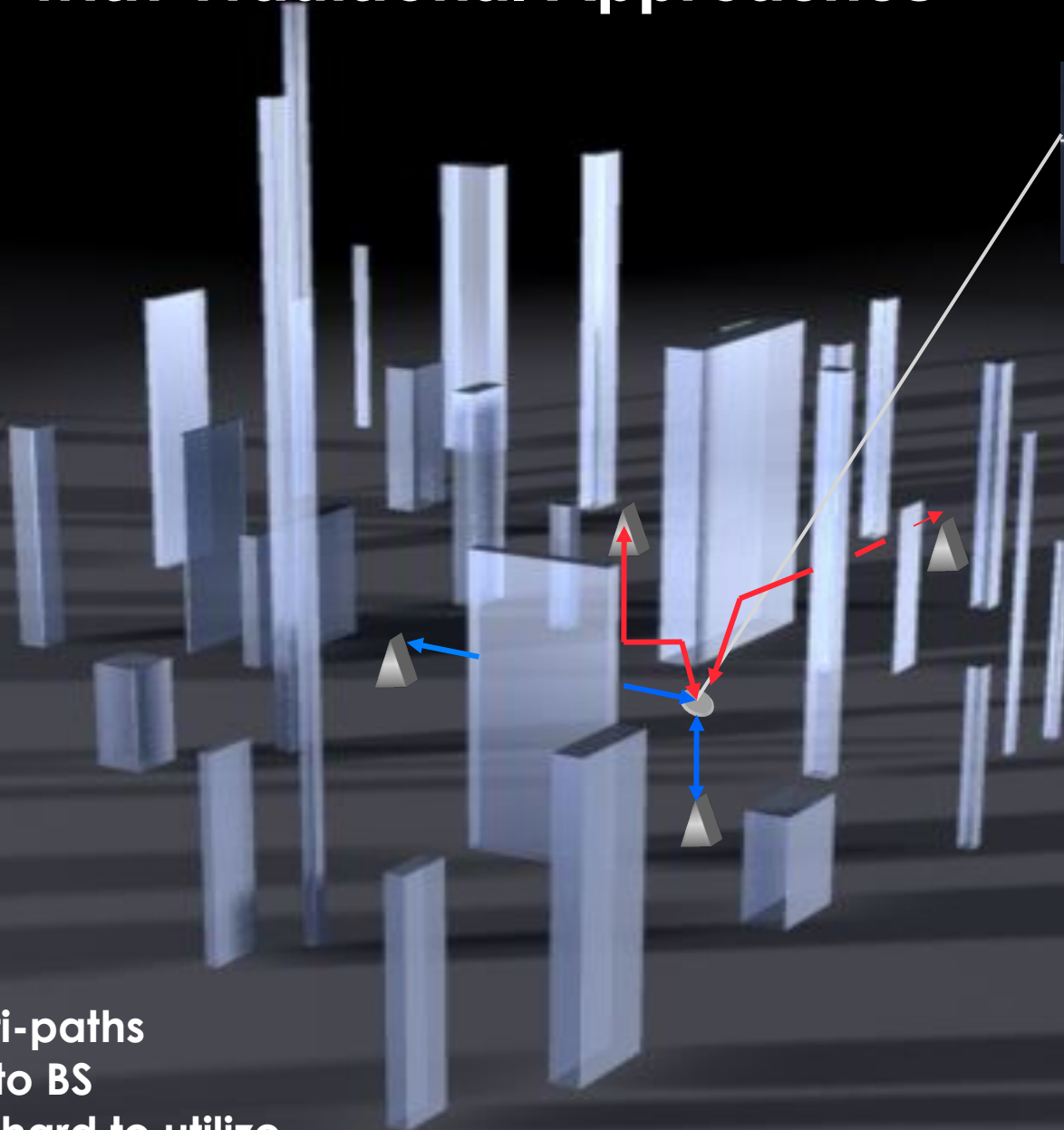
## Theory



## Reality



# Problems with Traditional Approaches



- reflections, multi-paths
- no line of sight to BS
- extra hardware hard to utilize



# A Probabilistic Approach to Positioning

$$P(L | O) = \frac{P(O | L) P(L)}{P(O)}$$

- A probabilistic model assigns a probability for each possible location  $L$  given the observations  $O$ .
  - $P(O | L)$  is the conditional probability of obtaining observations  $O$  at location  $L$ .
  - $P(L)$  is the prior probability of location  $O$ . (Could be used to exploit user profiles, rails etc.)
  - $P(O)$  is just a normalizing constant.
- How to obtain  $P(O | L)$ ?
  - ⇒ **Empirical observations + machine learning**

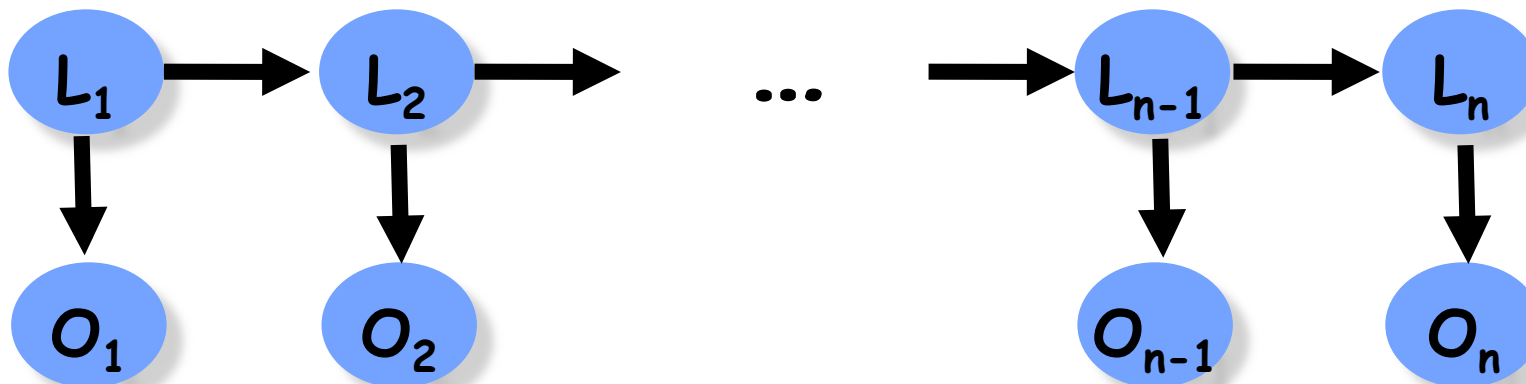






## Tracking with Markov Models

- Typically we have a sequence (history) of observations  $O_1, \dots, O_n$ , and wish to determine  $P(L_n | O^n)$
- Assumption:  $P(O_t | L_t)$  are known, and given location  $L_t$ , the observation  $O_t$  is independent of the rest of the history
- The model: a hidden Markov model (HMM) where the locations  $L_t$  are the hidden unobserved states
- The transition probabilities  $P(L_t | L_{t-1})$  can be easily determined from the physical properties of the moving object







# WiFi Positioning & Ekahau

- *P.Myllymäki, T. Roos, H.Tirri, P.Misikangas and J.Sievänen,. A Probabilistic Approach to WLAN User Location Estimation. International Journal of Wireless Information Networks, Vol. 9, No. 3, July 2002.*
- *T. Roos, P. Myllymäki, H. Tirri, A Statistical Modeling Approach to Location Estimation. IEEE Transactions on Mobile Computing, Vol. 1, No. 1, January-March 2002, 59-69.*
- *P. Kontkanen, P. Myllymäki, T. Roos, H. Tirri, K. Valtonen, H. Wettig, Topics in Probabilistic Location Estimation in Wireless Networks. Invited paper in Proceedings of the 15th IEEE Symposium on Personal, Indoor and Mobile Radio Communications, Barcelona, Spain. IEEE Press, 2004.*
- *P. Kontkanen, P. Myllymäki, T. Roos, H. Tirri, K. Valtonen, H. Wettig, Probabilistic Methods for Location Estimation in Wireless Networks. Chapter 11 in Emerging Location Aware Broadband Wireless Adhoc Networks, edited by R.Ganesh, S.Kota, K.Pahlavan and R.Agustí. Kluwer Academic Publishers, 2004.*

The screenshot shows the Ekahau website homepage. At the top, there is a navigation menu with links for Home, Solutions, Products, Company, Partners, and News, along with a search bar. The main content area features a large banner image of a hospital hallway with the text "Ekahau Wi-Fi based RTLS tracking and communication solutions". Below the banner are icons representing various industries: Healthcare, Retail, Logistics, Manufacturing, Government, Process Industries, and Other Industries. A "Latest News" section highlights "Ekahau RTLS Selected by University of Kentucky Healthcare...". Below this are four featured articles: "ekahau RTLS" (Best Wi-Fi based location tracking solutions), "ekahau Site Survey" (Professional 802.11 Site Survey and Planning Solution), "ekahau HeatMapper" (FREE Wi-Fi Coverage Mapping and Analysis Tool), and "ekahau Advantage" (#1 Acknowledged Performance Leader). A "Read more" button is present for each article. The footer contains the text "Home" and "Copyright © 2009 Ekahau, Inc. All Rights Reserved. | Legal Notices and Terms of Use."



# Success!



- Founded in 2000, several funding rounds since then
- First stock holders Henry Tirri (currently CTO of Nokia), Petri Myllymäki + 7 other members of the university research group
- Several awards: The European Information Society Technology Prize 2002, Technology Marketing Corporation: Best product of the year 2002, Software Industry Summit: Best commercialized innovation in Finland in 2002, Frost & Sullivan: Technology Leadership Award 2005, Red Herring (2008): one of the top 100 tech start-ups in North America, ...
- Offices in Americas, EMEA, and APAC
- Market leader in the chosen business sectors, over 100 resellers and over 10 000 users worldwide





## ...Success?

- Starting a spin-off is hard
- Running a company is even harder
- ...and most importantly, most of stuff you will be facing are not very interesting, and above all, just **NOT FUN!**

