# Automated Intelligence: models and learning

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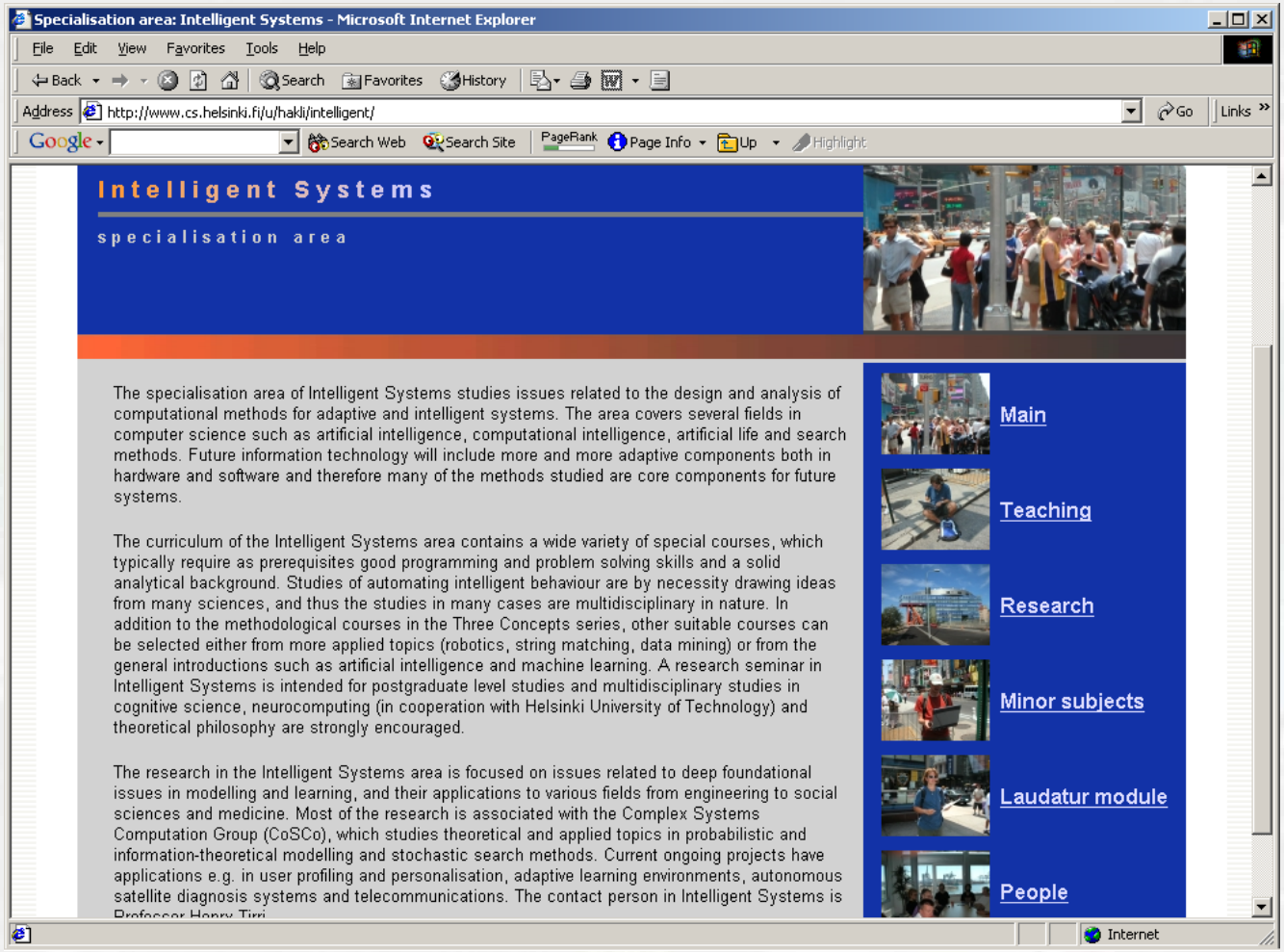
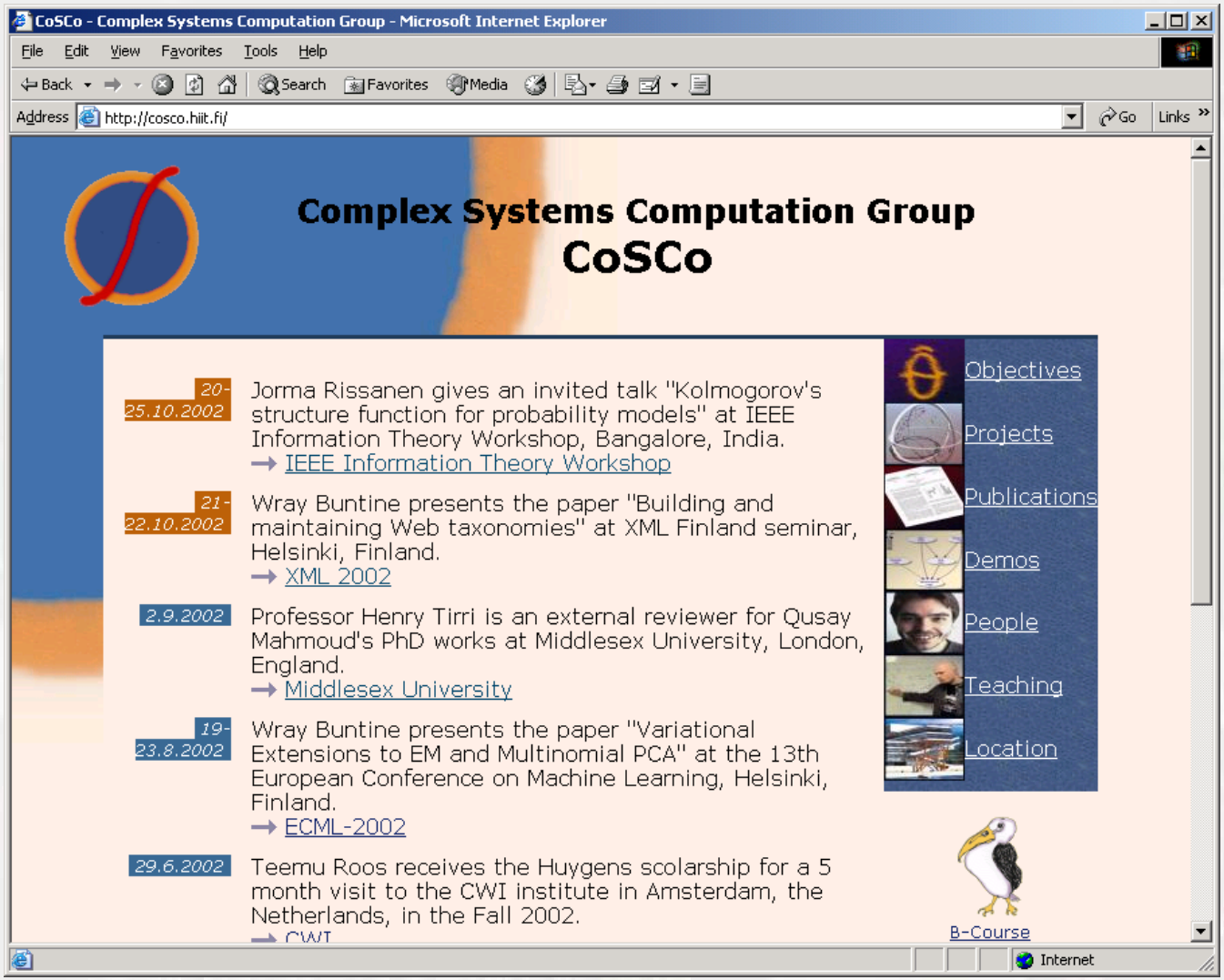
# http://www.cs.helsinki.fi/u/hakli/intelligent (address will change!)

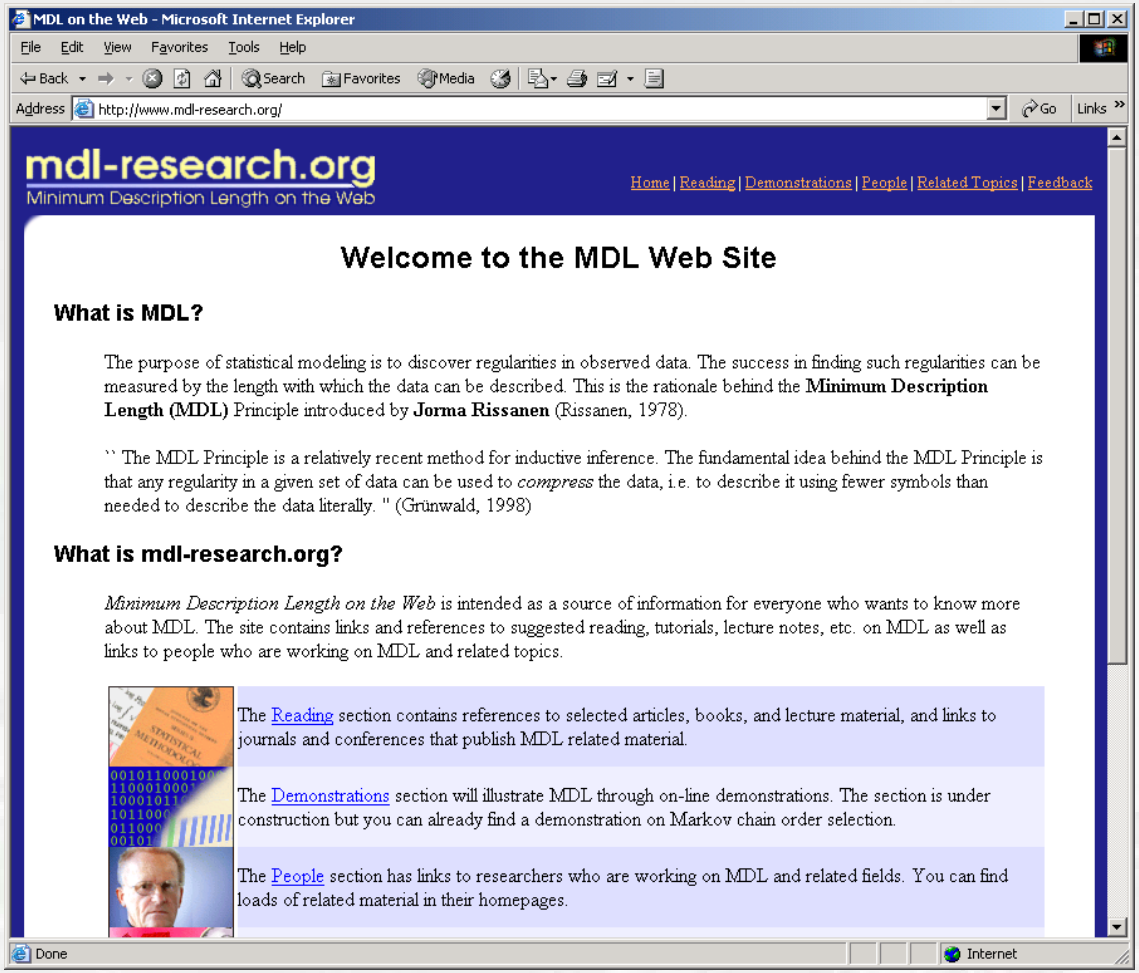


# http://cosco.hiit.fi/

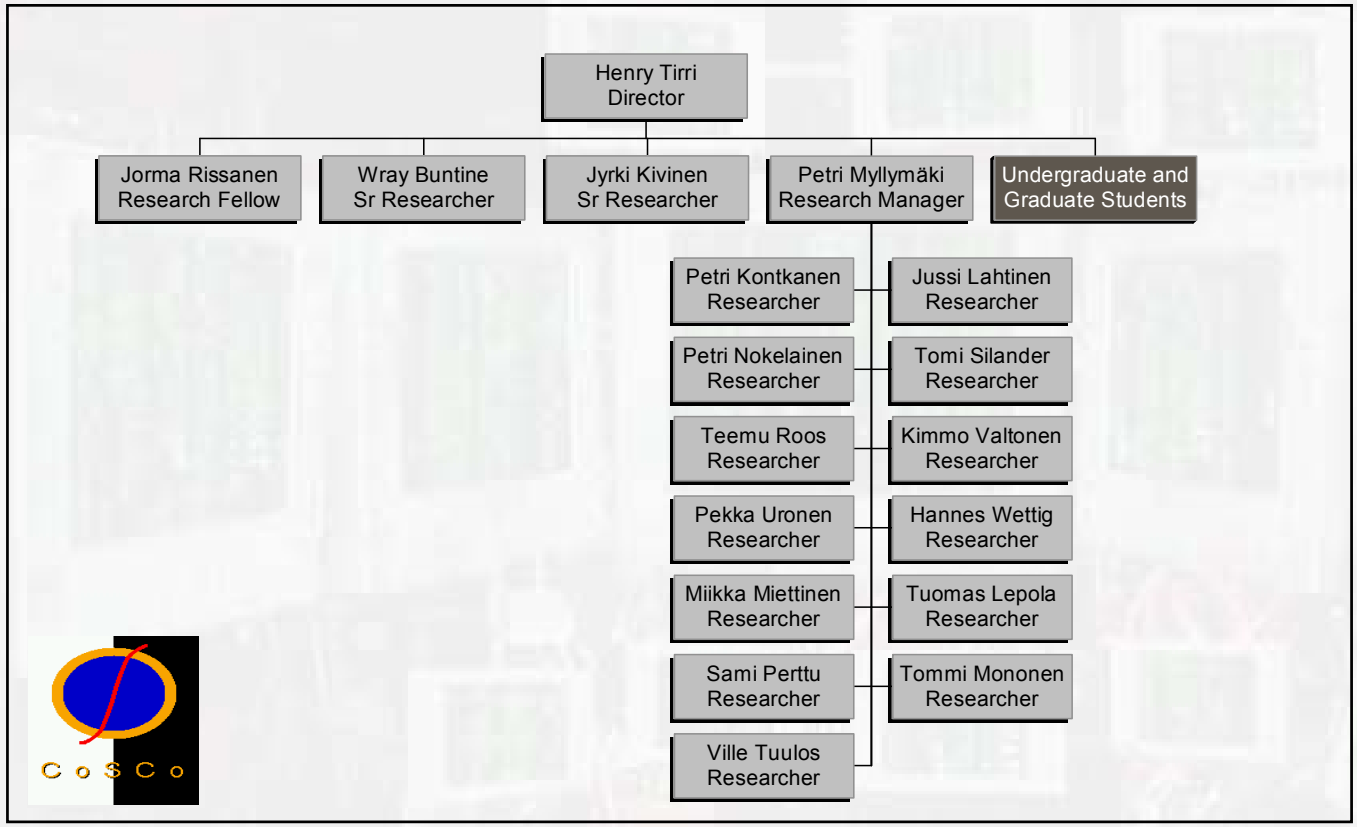


# mdl-research.org

Minimum Description Length on the Web



# Complex Systems Computation Group




- Peter Cheeseman, NASA
- Phil Dawid, Univ. College London
- Dawid Dowe, Monash University
- Peter Grünwald, CWI
- Thomas Richardson, Univ. of Washington
- Linus Torvalds, Transmeta
- Pekka Ruohotie, University of Tampere
- Kimmo Kaski, Helsinki University of Technology
- Hannele Niemi, University of Helsinki
- Jaakko Kurhila, University of Helsinki

# Intelligence?

- Computer science is considering ways to make things automated
- Artificial Intelligence, Adaptive and Intelligent Systems, Computational Intelligence … all try to figure out how could intelligence be automated?
- Intelligent behavior can be characterized by learning/adaptation
- In order to learn one needs to remember and generalize (world is never repeating itself!)
- In order to generalize one needs models

# Research in general

- Artificial Intelligence (AI) (knowledge reresentation, reasoning logic, expert systems, Machine learning…)
- Computational Intelligence/Soft Computing (neural networks, fuzzy systems, evolutionary computing)
- Adaptive and Intelligent Systems (AI)
- Artificial Life, Complex Systems Research

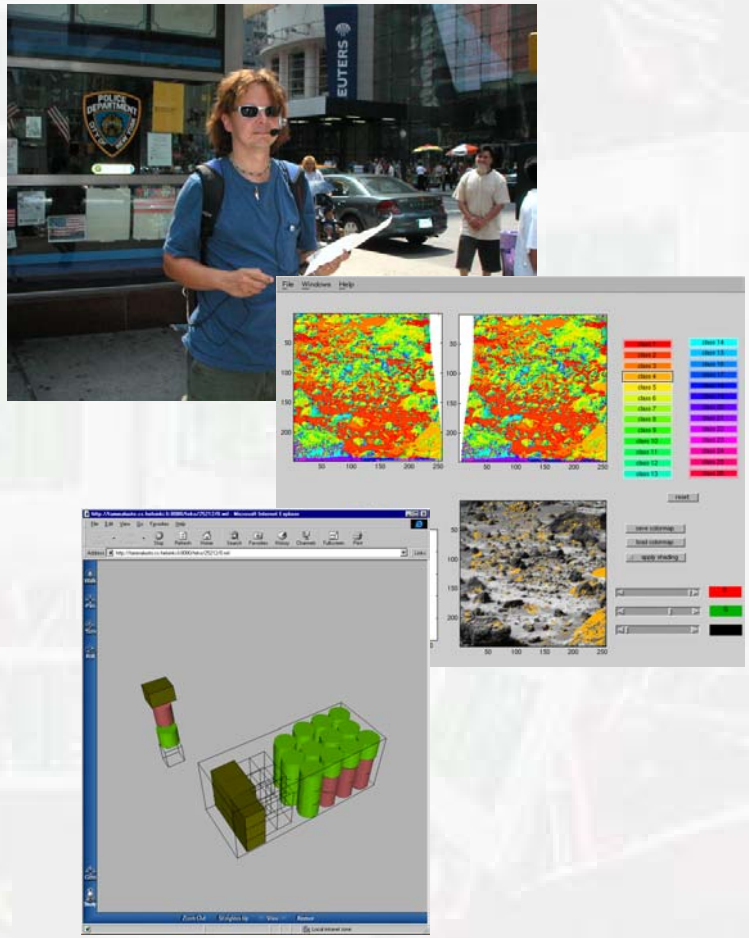
**The terms in the field are really confusing** 

# Research areas

- Probabilistic and information-theoretic modeling in sciences and business
  - Bayesian and Causal Networks
  - Information-theoretic modeling approaches
  - Very Large Scale Data Analysis
  - Competitive online statistics
- Stochastic optimization in complex domains
  - simulated annealing
- Tools and theory for E-learning

# Student: So what is it like to do research in AI?

- Great fun!
- Some hacking
- some math
- Some gaming
- Some technology "freaking"
- Some science fiction

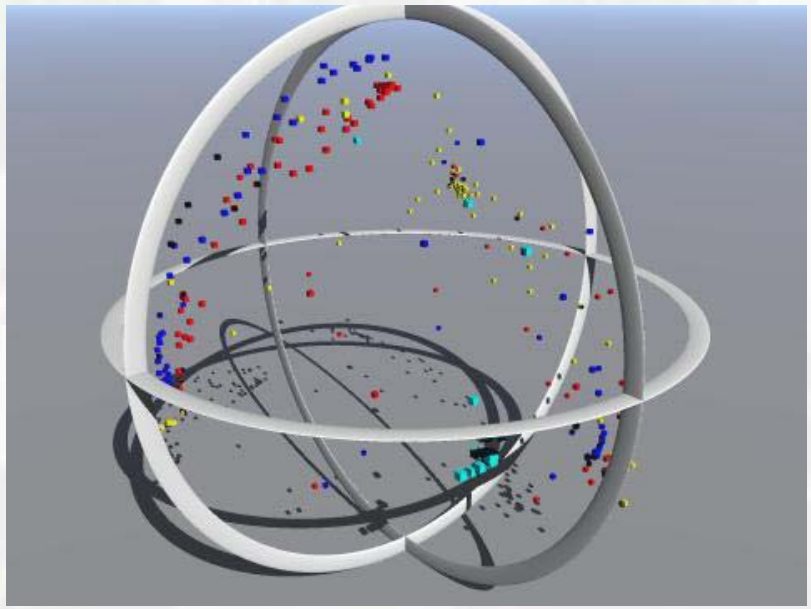


# Current areas of interest

- Building (predictive) models from very large data sets (DeepC)
- Finding the position of a mobile device (LocIt)
- Personalization (PAI,LockUp)
- Intelligent Search
- Collaborative tools for e-learning (EDUCO, OurWeb)

# DeepC

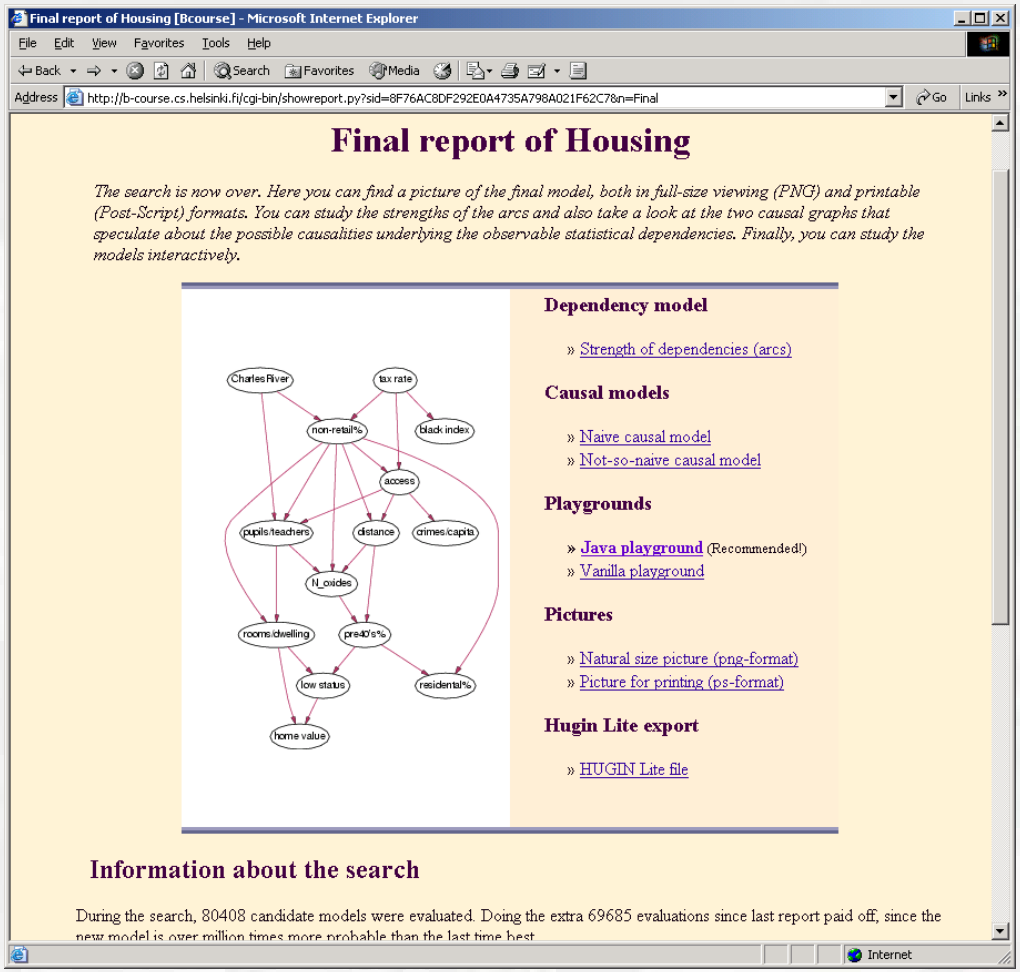
## Very Large Scale Data Modeling



# Quick Summary

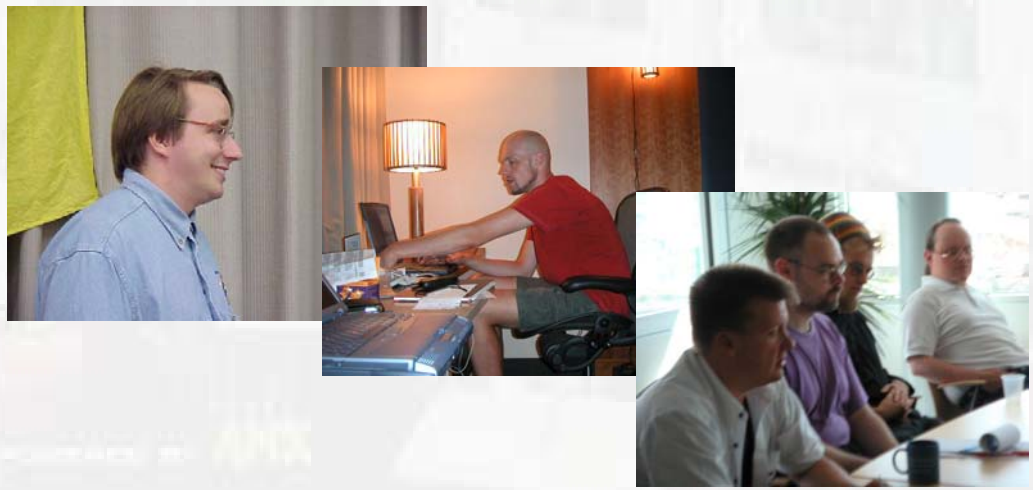
- Designed for dependency analysis with graphical models
- ASP architecture (works with most browsers)
- inference of Bayesian networks (and elementary causal networks)
- "tutorial style" user interface
- no user modifiable parameters
- interactive tool for inference
- extendible platform (v 2.0 classification)

# B-course Data Analysis Server (http://b-course.cs.helsinki.fi)



# So what "science" was needed?

- Theory, heavy theory
- Empirical work with data sets …
- Multidiciplinary cooperation
- Brilliant hacking (B-course had predecessors: D-Side,BAYDA)



# "On the shoulders of Giants"

Andrey Nikolaevich Kolmogorov

Rev. Thomas Bayes

# Bayes vs. MDL

Under regularity conditions $-\log P_{NML}(x^n \mid M) =$

$$-\log P(x^n \mid \hat{\theta}_i(x^n)) + \frac{k}{2}\log\frac{n}{2\pi} + \log\int\sqrt{\det I(\theta)}d\theta + o(1)$$

Under regularity conditions $-\log P_{Bayes}(x^n \mid M) \approx$

$$-\log P(x^n \mid \hat{\theta}_i(x^n)) + \frac{k}{2}\log\frac{n}{2\pi} - \log w(\hat{\theta}) + \log\sqrt{\det I(\theta)}d\theta + o(1)$$

If we take Jeffrey's prior

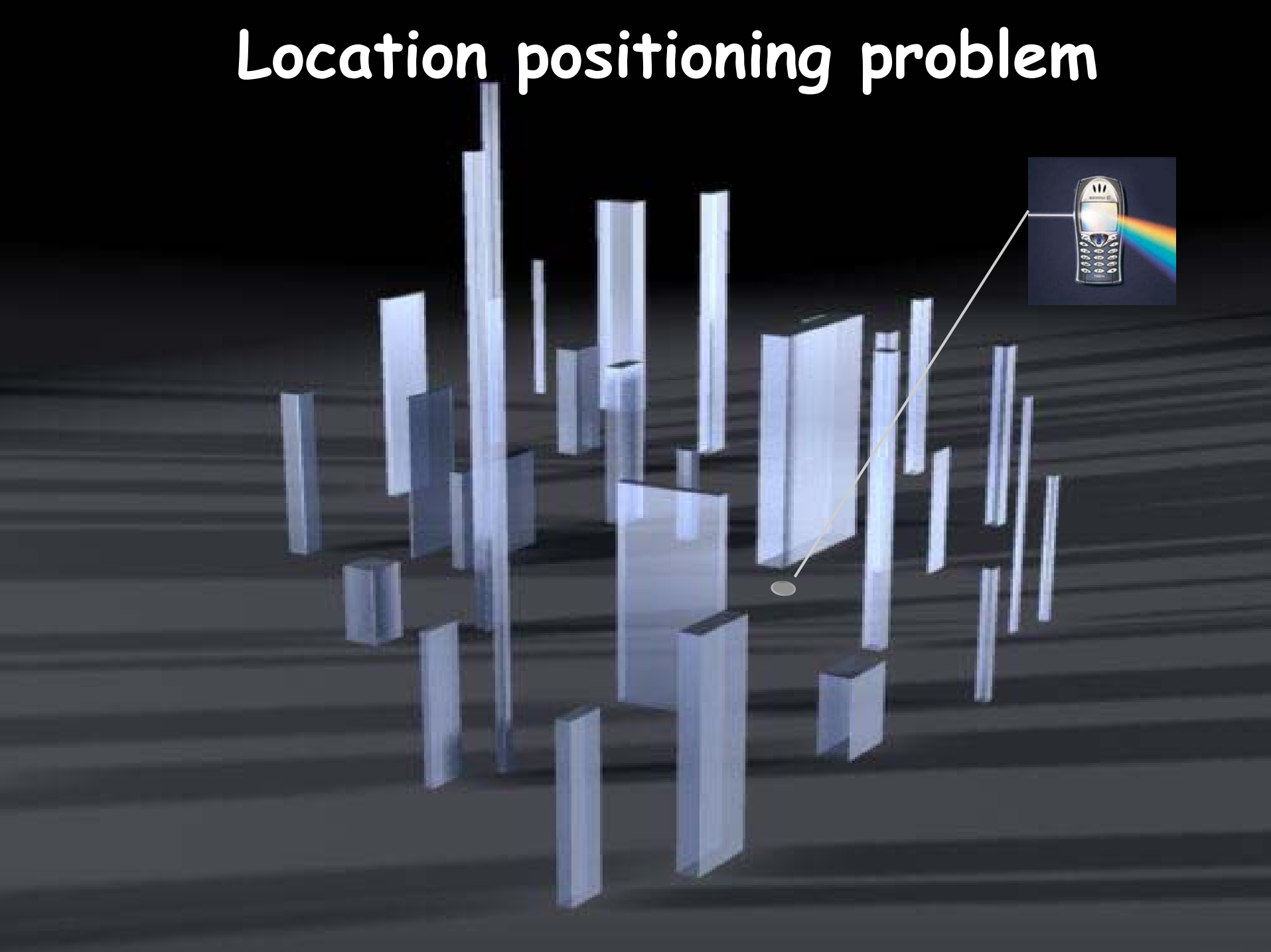
$$w(\theta) = \sqrt{\det I(\theta)} \Big/ \int_{\theta}\sqrt{\det I(\theta)}d\theta \quad \text{.....} \ \☺$$


# LocIt

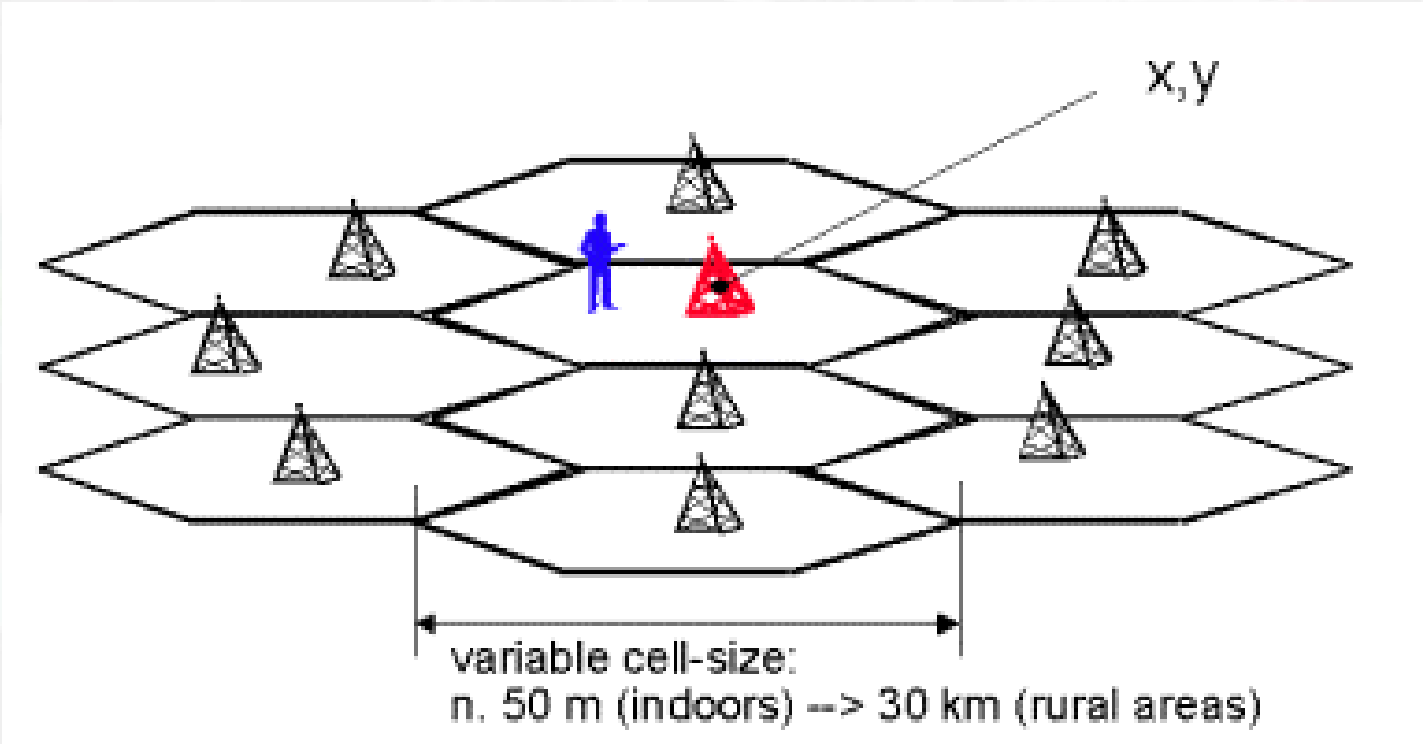
## Mobile Device Positioning

# Mobile Positioning: Manhattan Trial

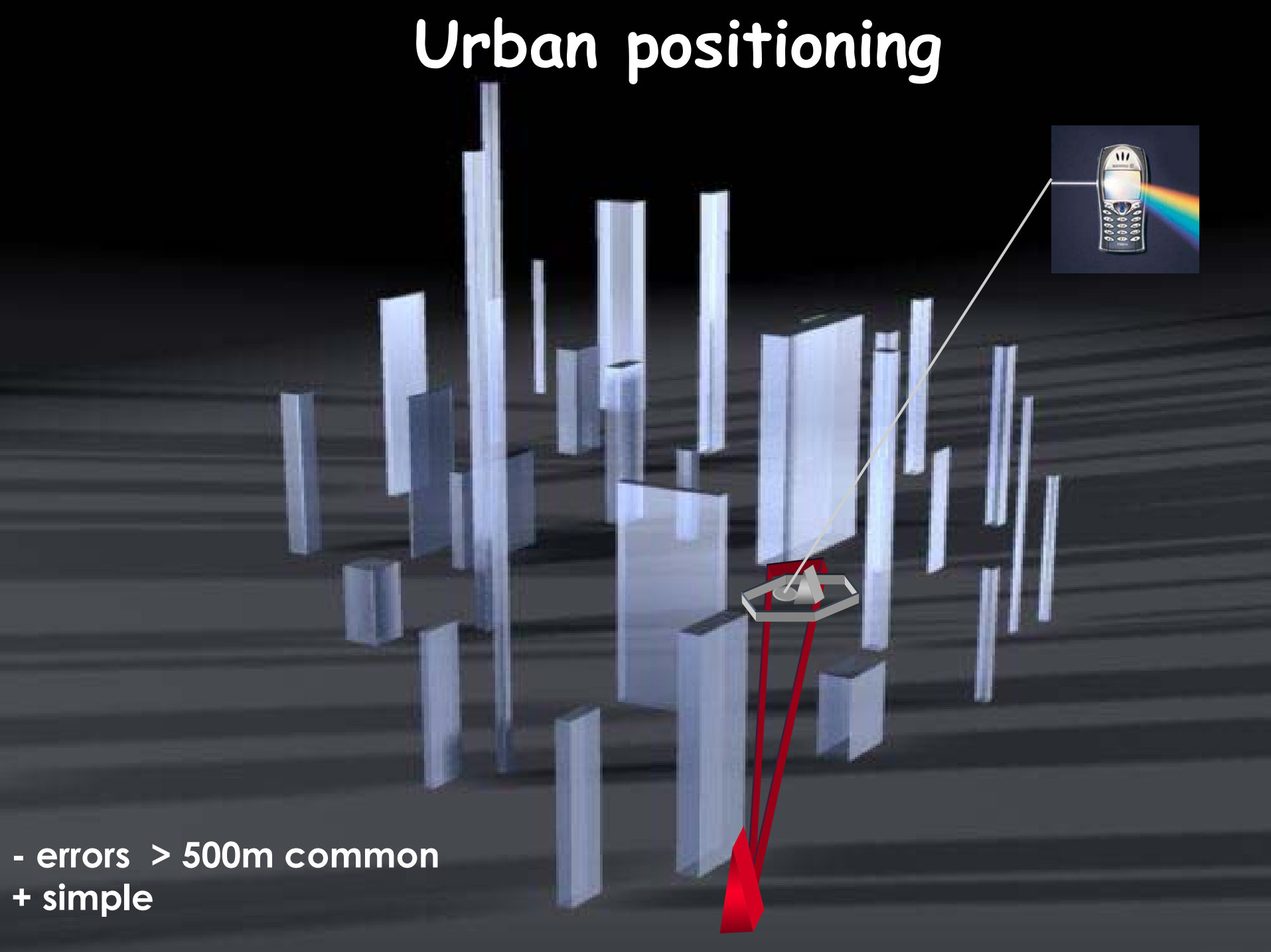
# Location positioning problem



# Cell ID

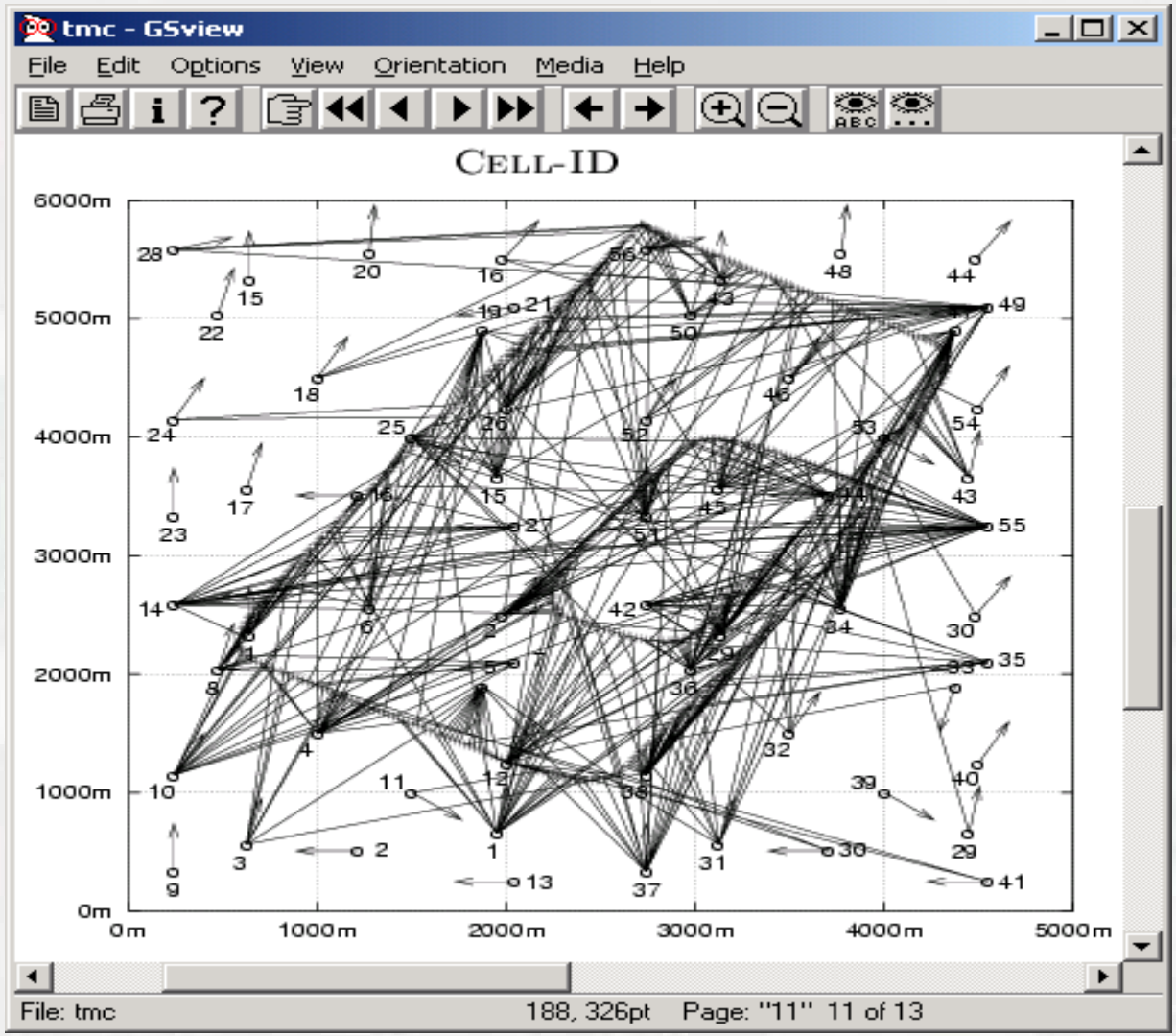


# Urban positioning

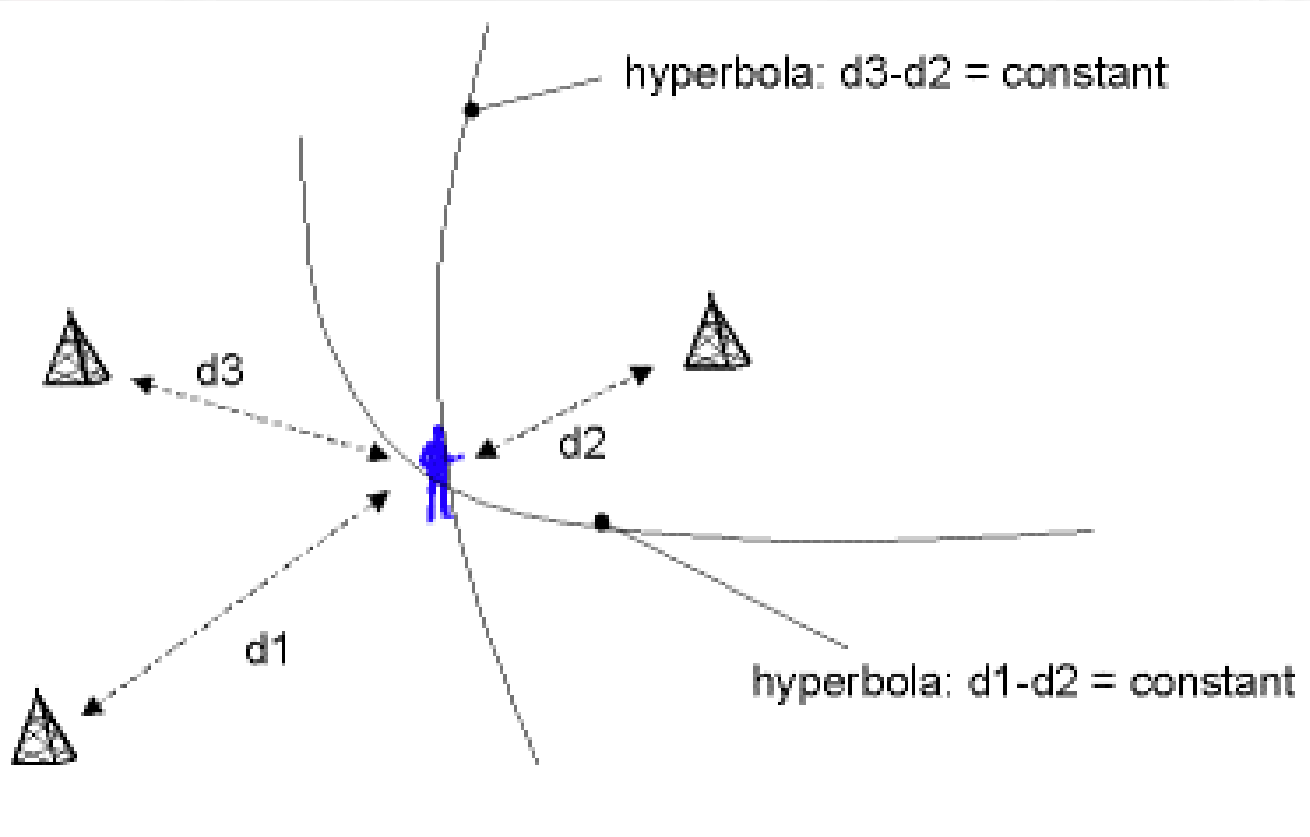


- errors > 500m common
+ simple

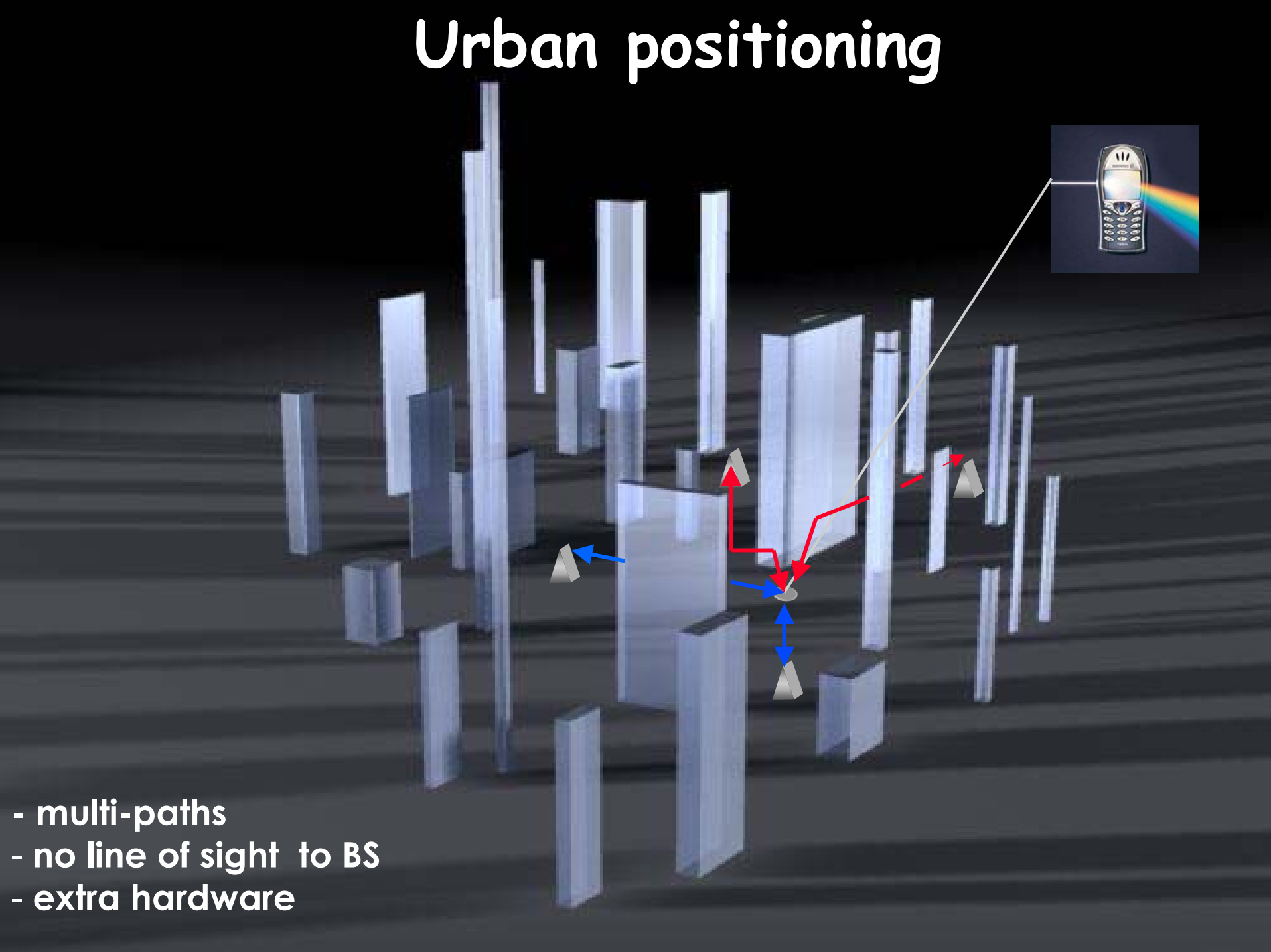
# Cell ID errors



# Enhanced Observed Time Difference (E-OTD)

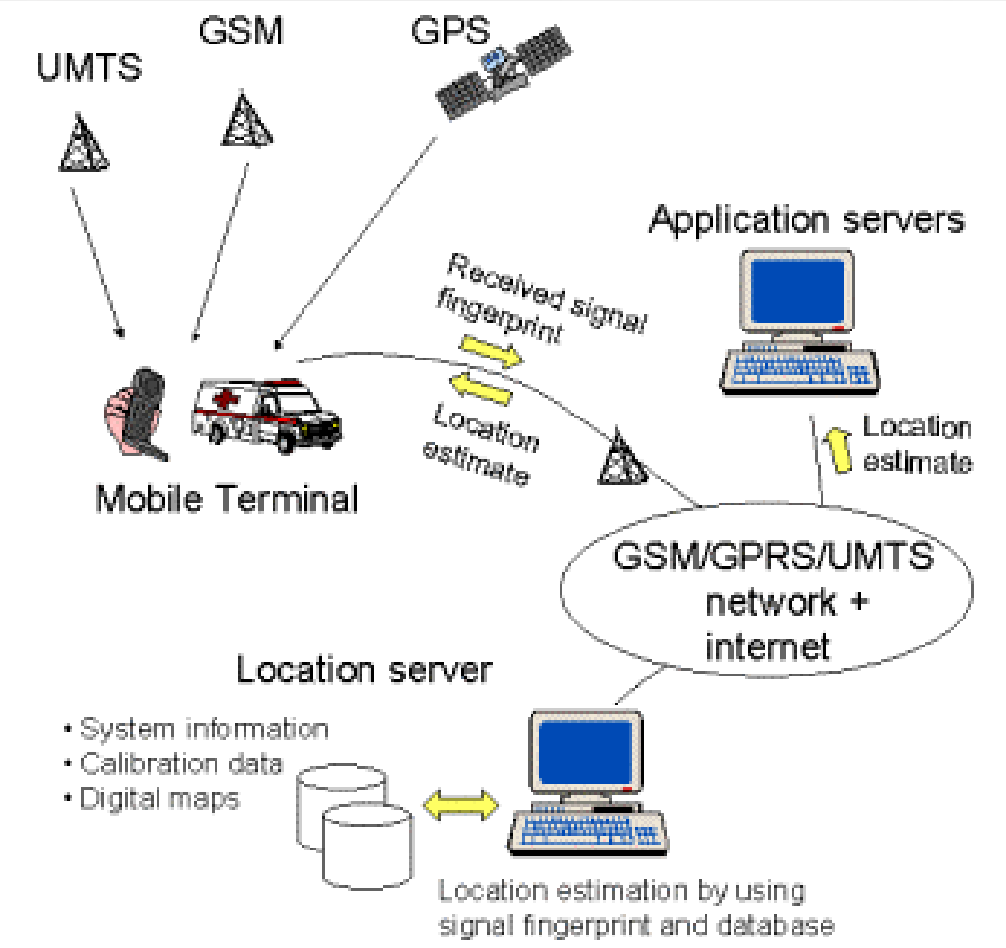


# Urban positioning

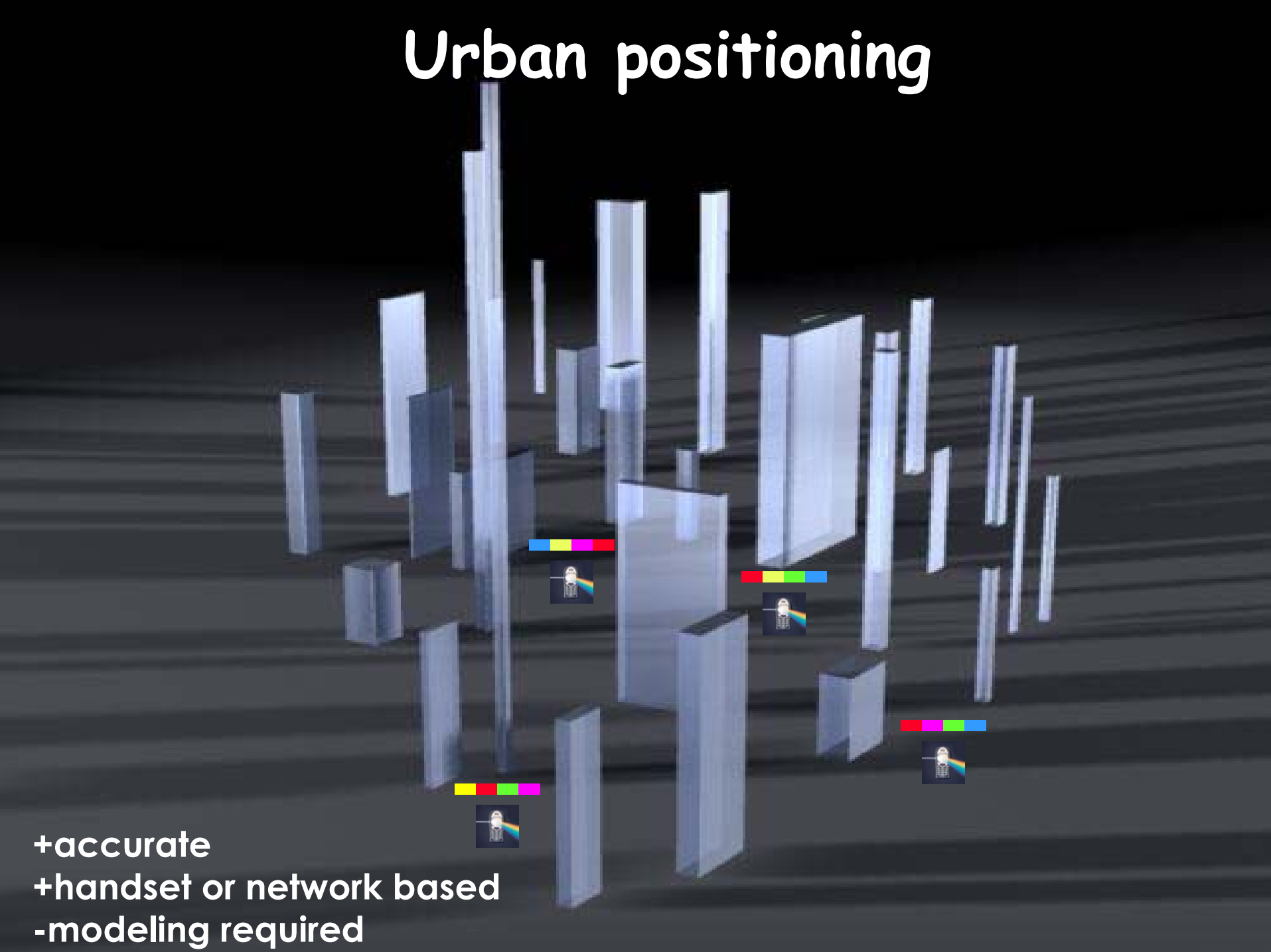


- multi-paths
- no line of sight to BS
- extra hardware

# Modeling approach



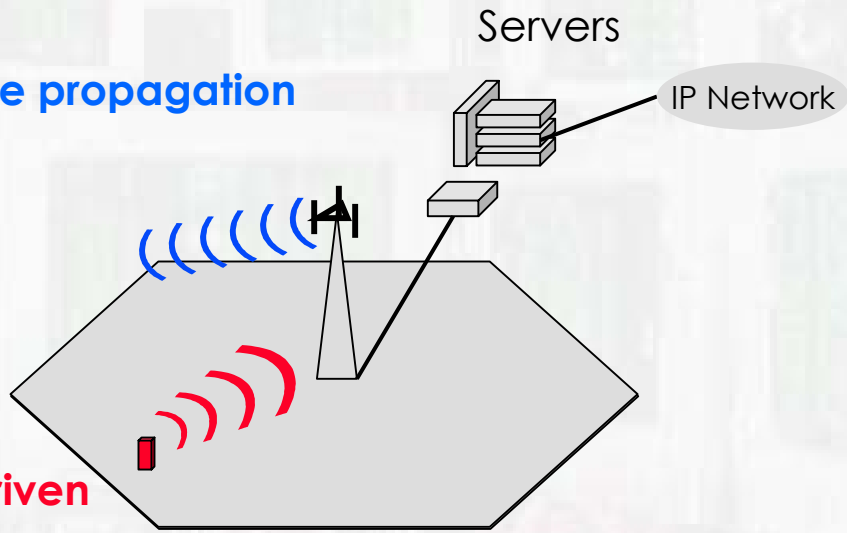
# Urban positioning



+accurate
+handset or network based
-modeling required

# Modeling alternatives

"Downlink modeling: the propagation models (GM level 1)"




"Uplink modeling: data driven models (GM level 2)"

# Modeling architectures

- three modeling architectures varying in
  - data gathering,
  - network information requirements,
  - accuracy
- GeoMode Network (GM-N)
- GeoMode Data (GM-D)
- GeoMode Hybrid (GM-H)

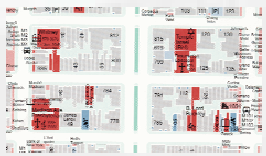
# GM Network (GM-N)

Network information

Phone fingerprint

**GM-N model builder**

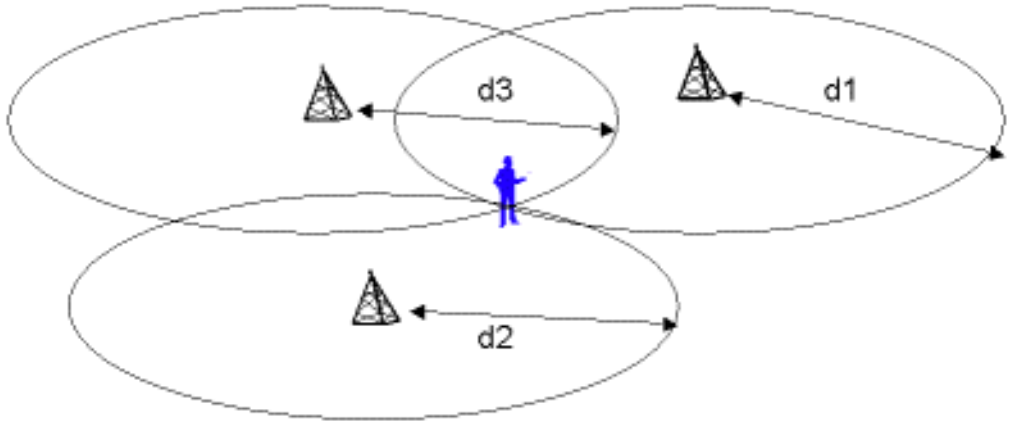
**GM-N runtime model**

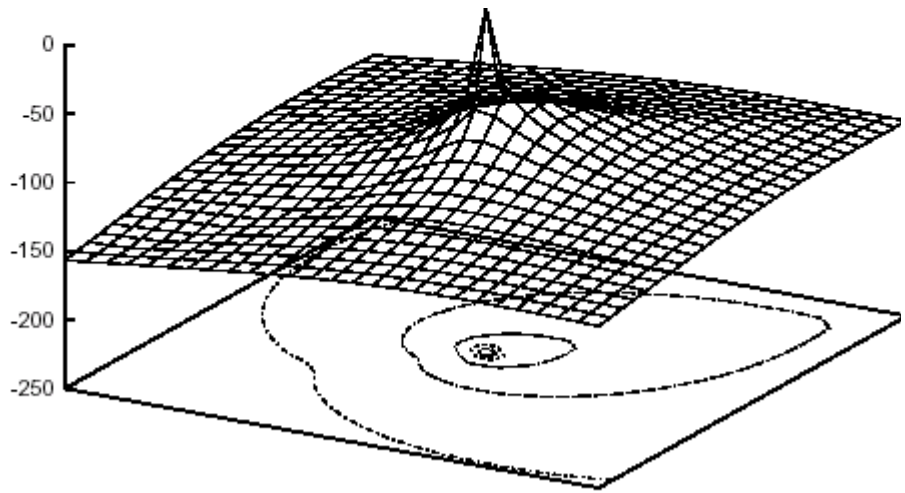


Coordinates

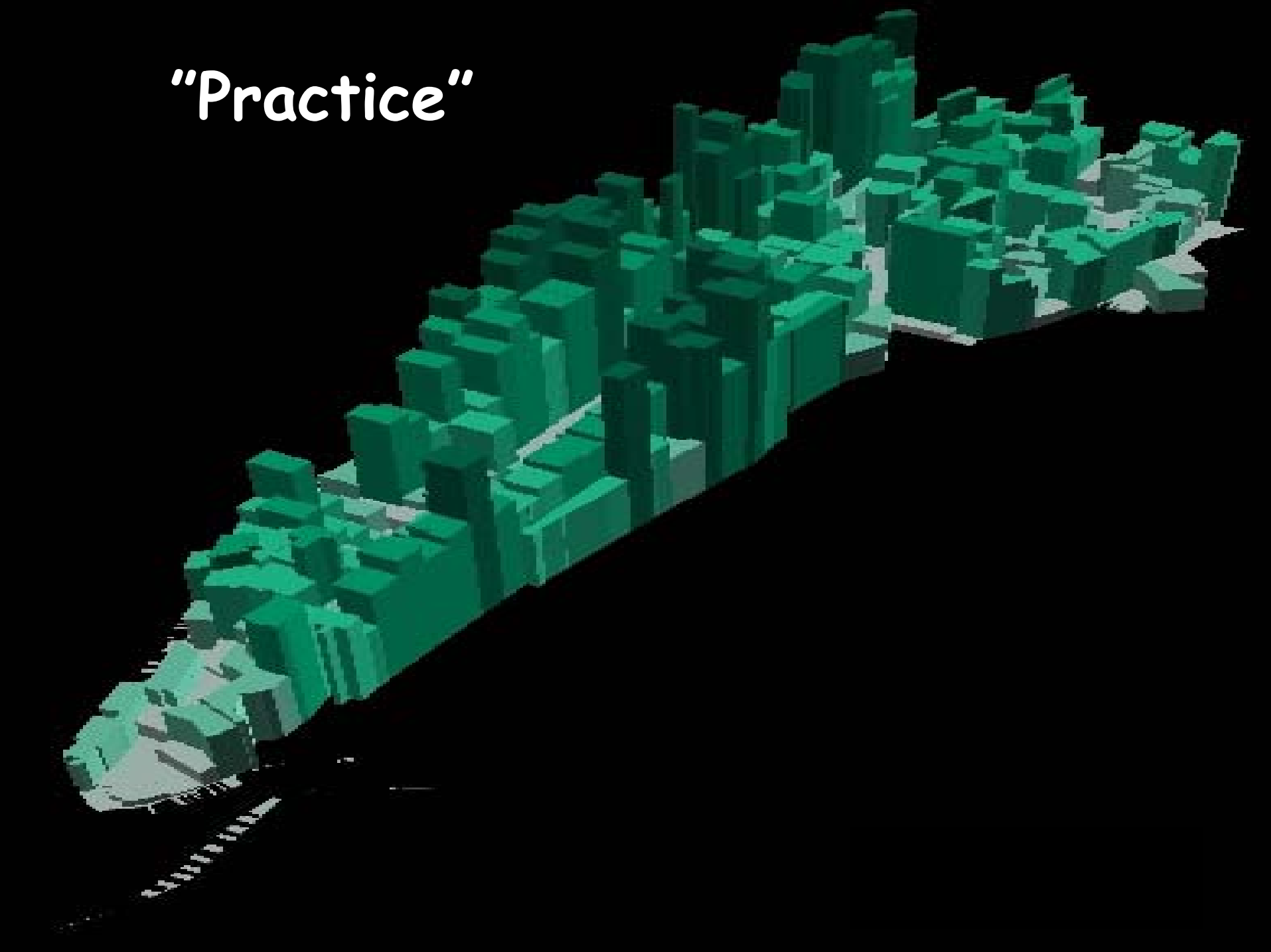
Parameter tuning measurements

# "Theory"

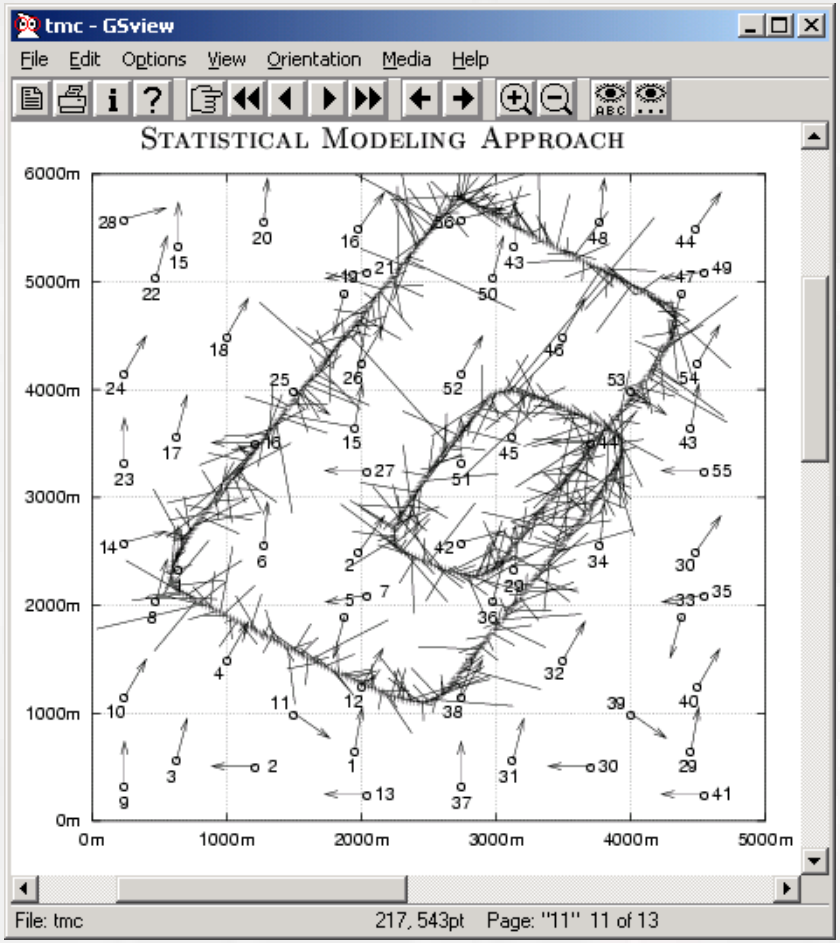


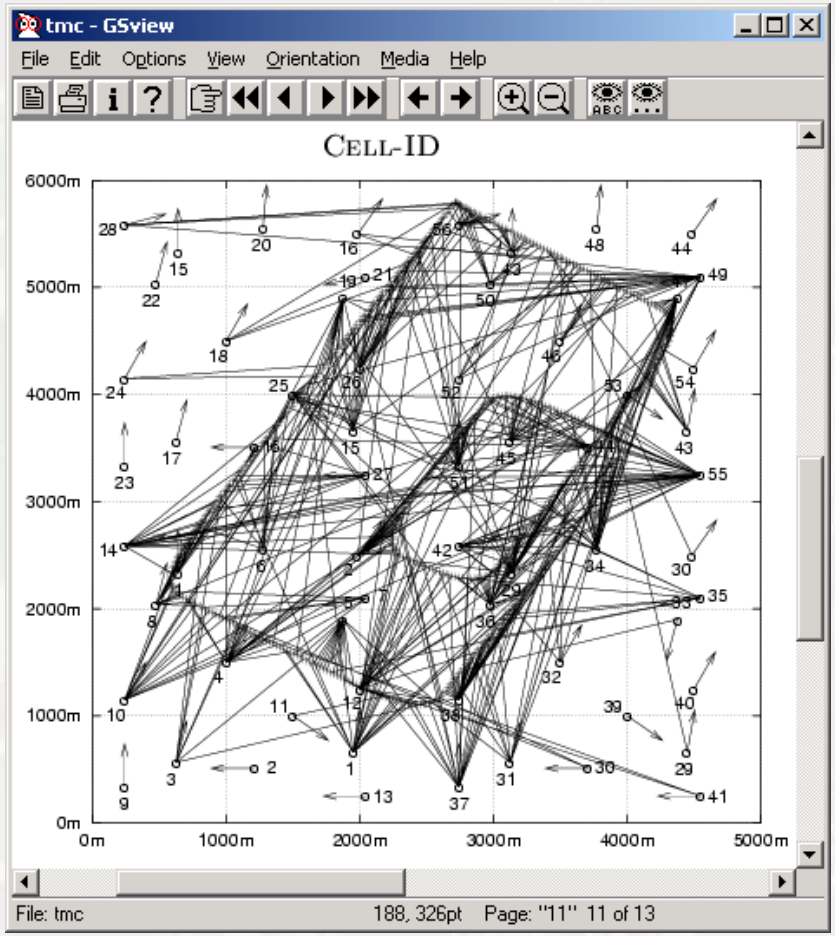



# "Practice"



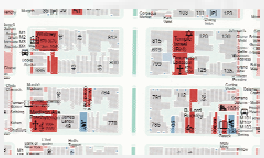
# GM-N vs. Cell ID errors visualization



# GM Data (GM-D)

Fingerprint data gathering



Calibration testing

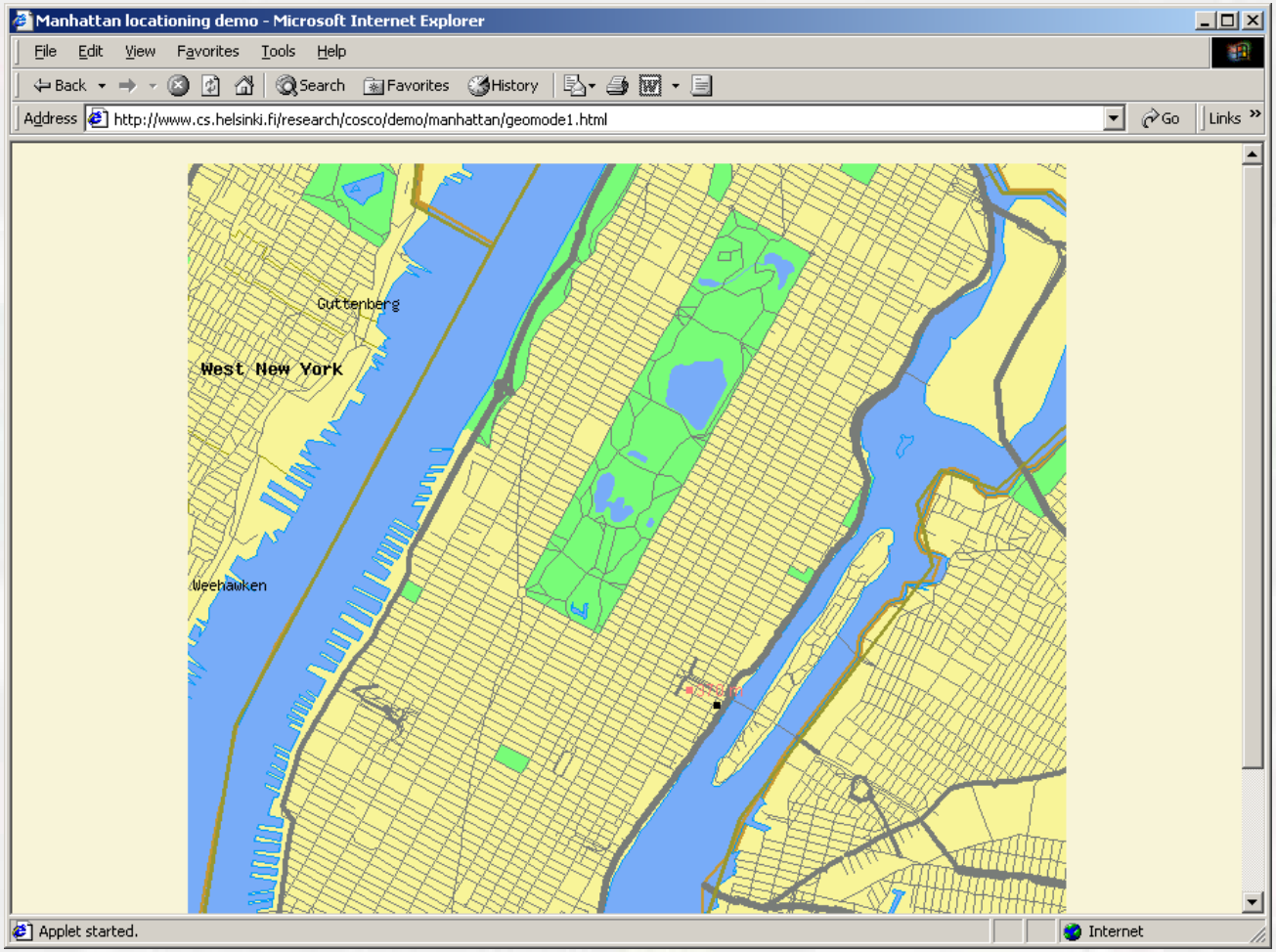
GM-D model builder

GM-D runtime model

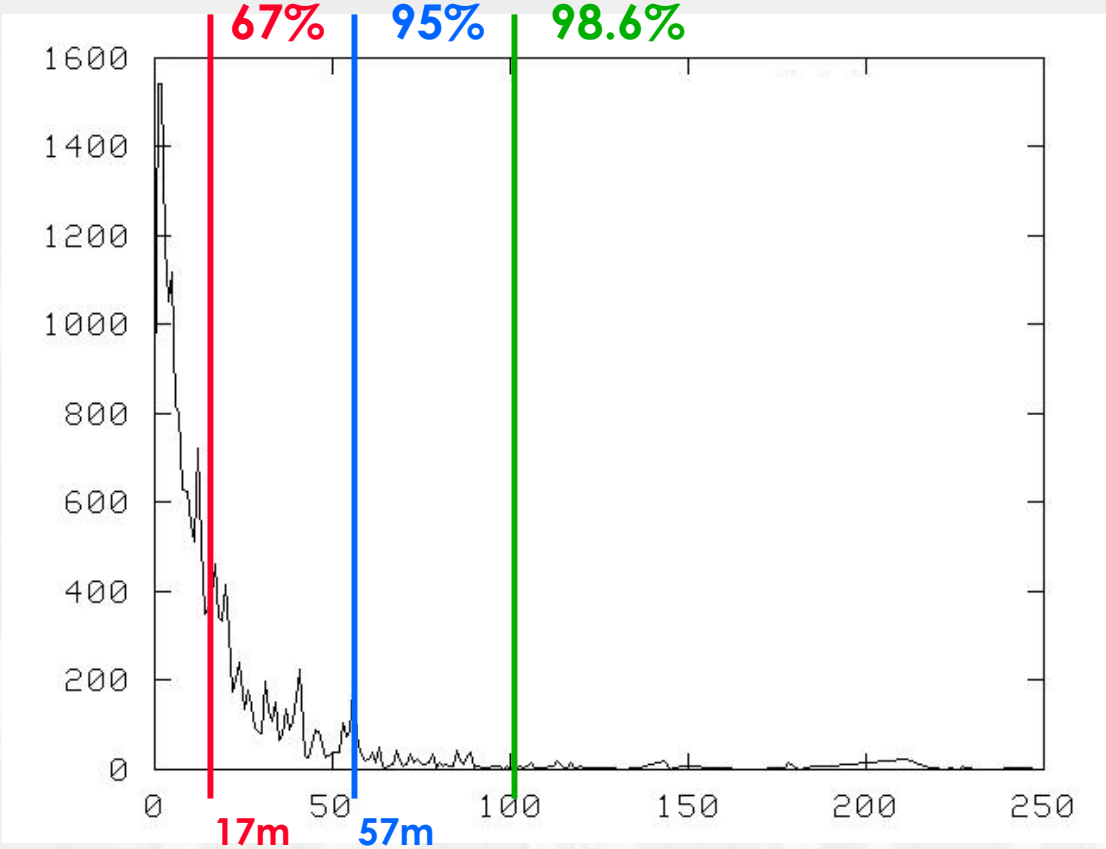
Phone fingerprint

Coordinates

# NYC Trial 2001

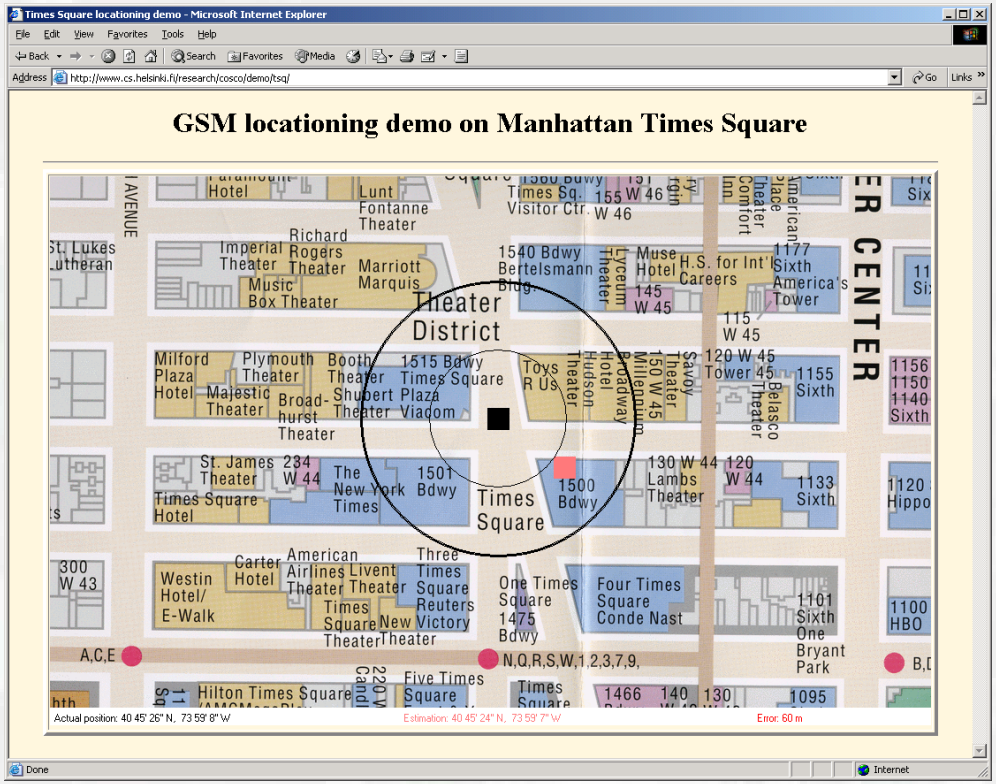


# Accuracy NYC Trial 2001

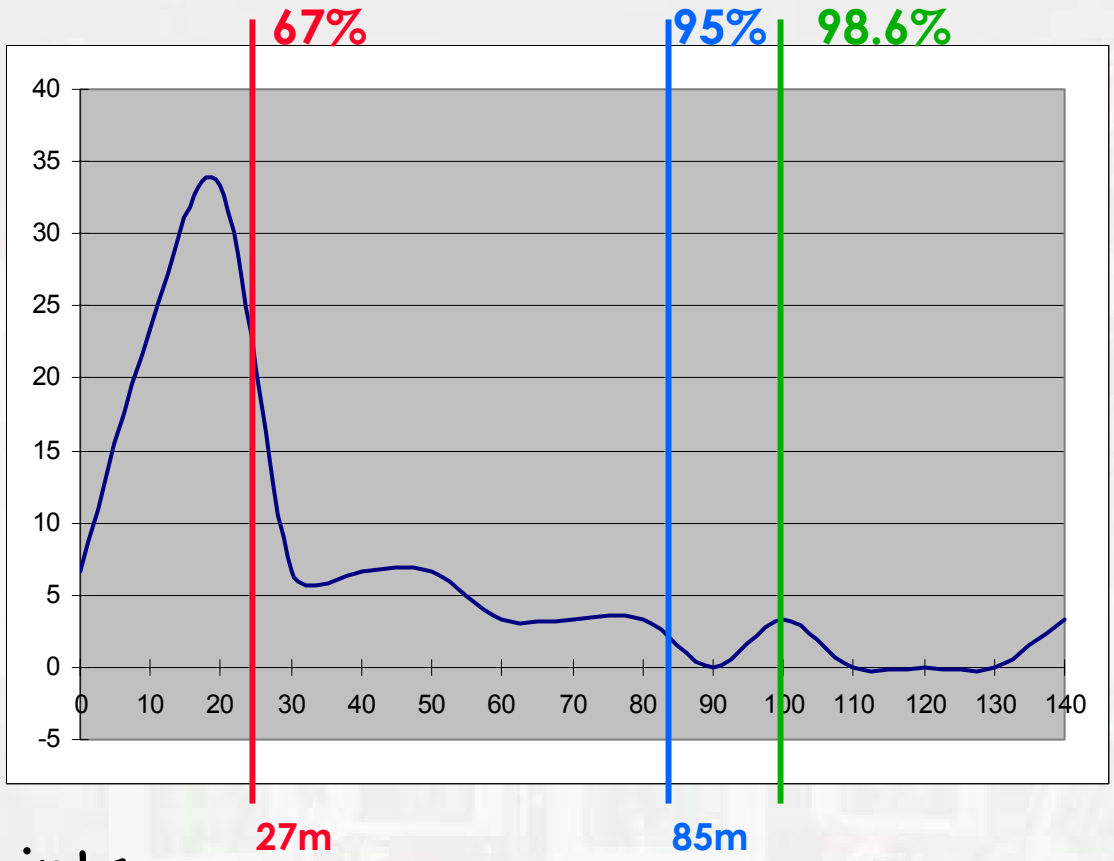



- 20166 points
- tracking; testing done in a car;

# Trials: Manhattan 2002

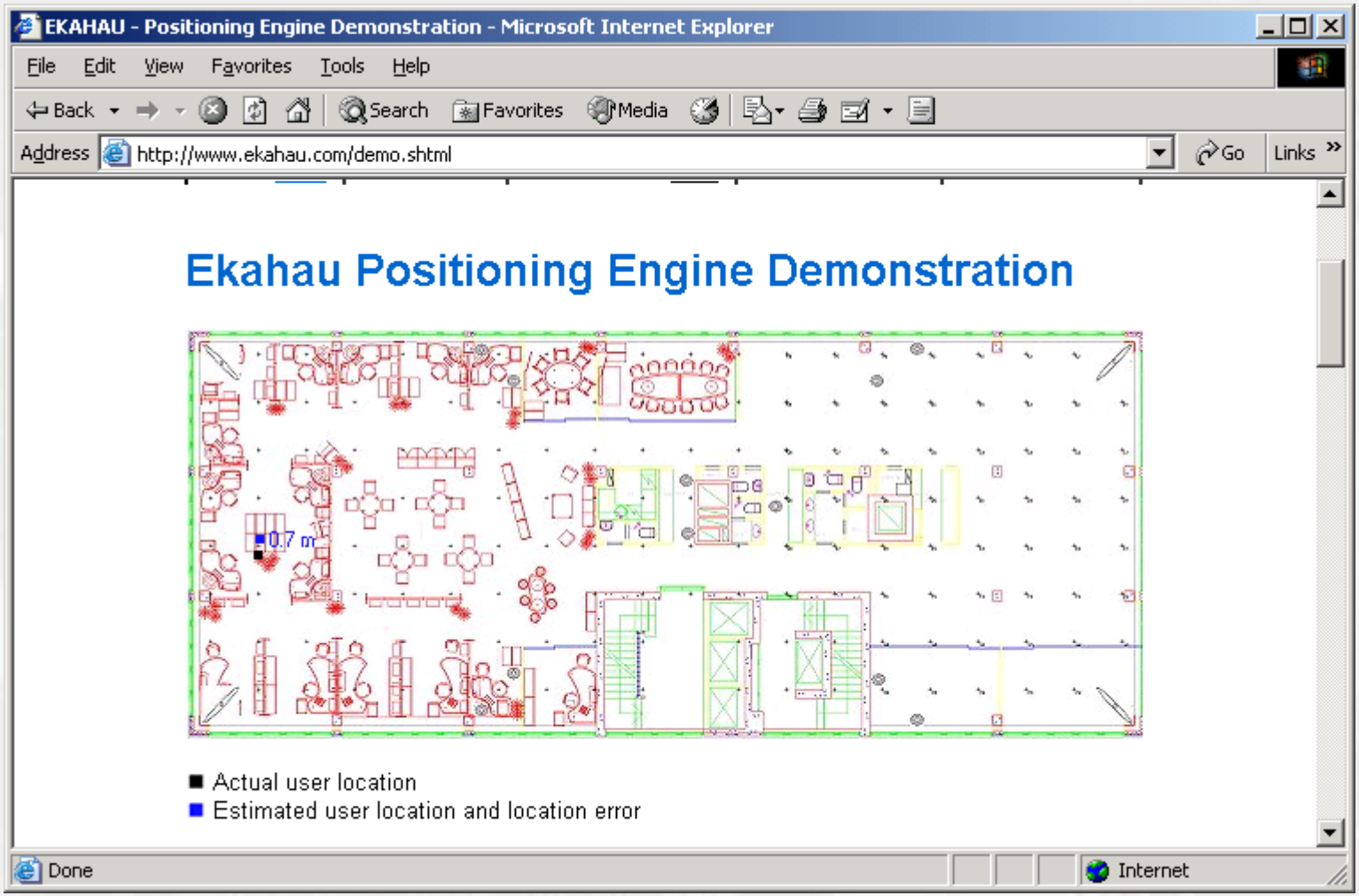



# Accuracy NYC Trial 2002



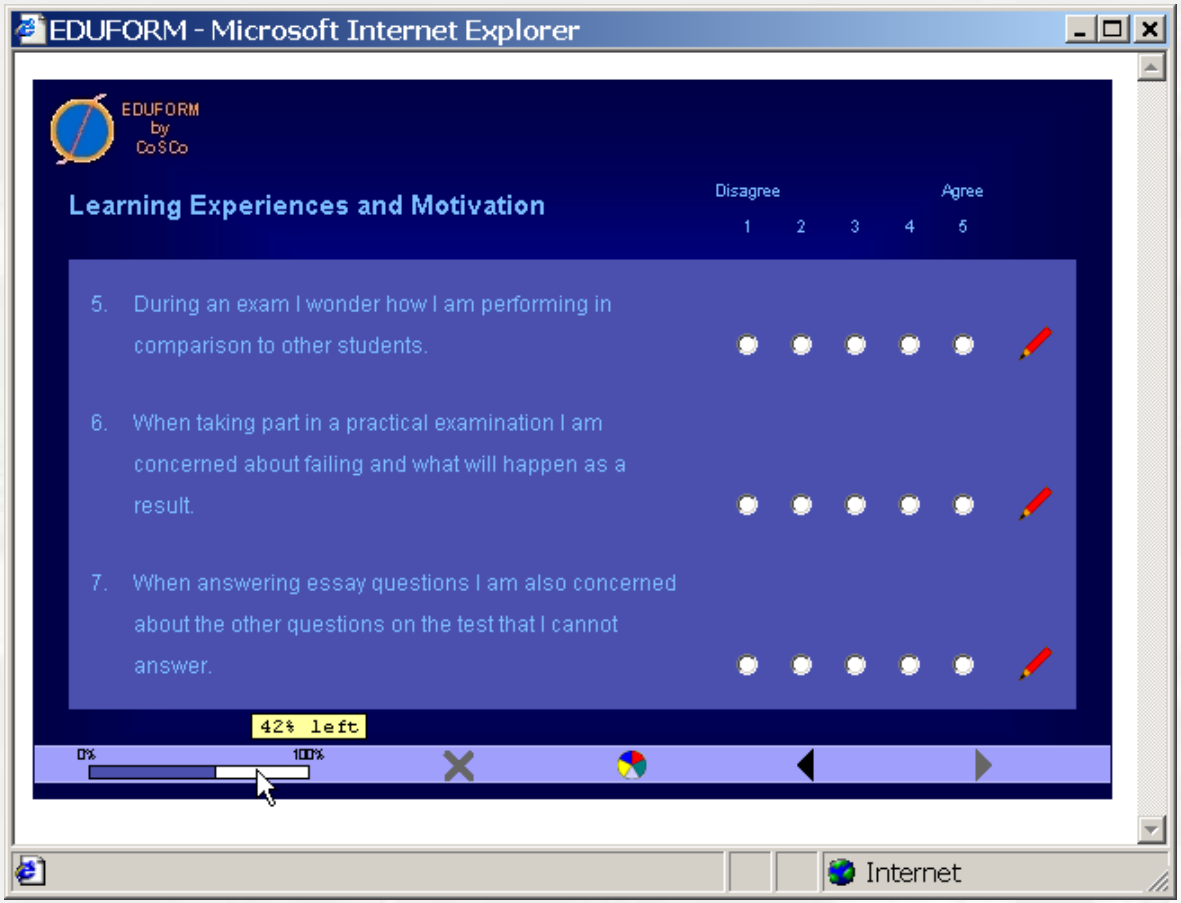

- 30 points
- static; testing done by walking;

# Genaralization: WLAN

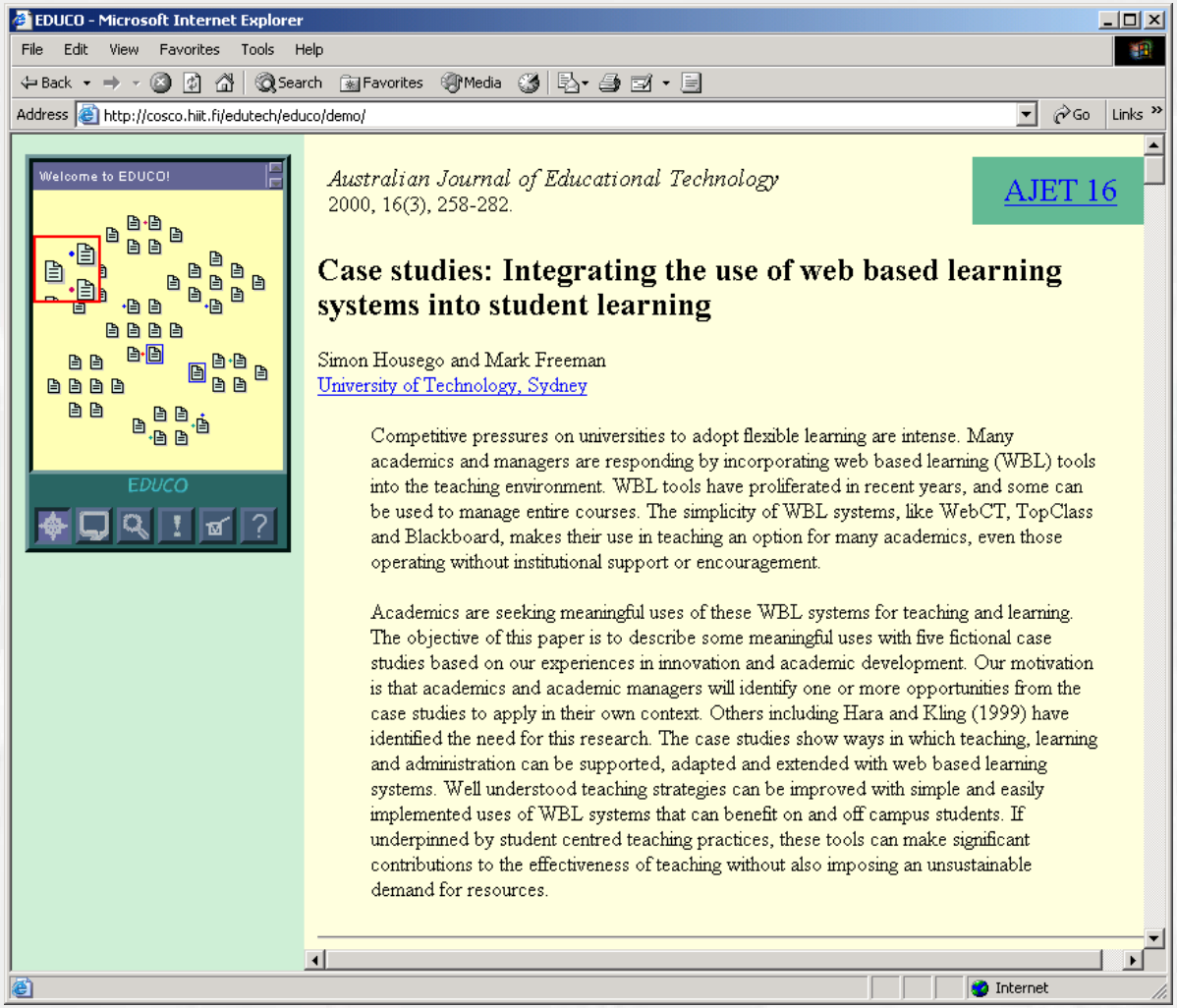



# Intelligent Tools for E-learning

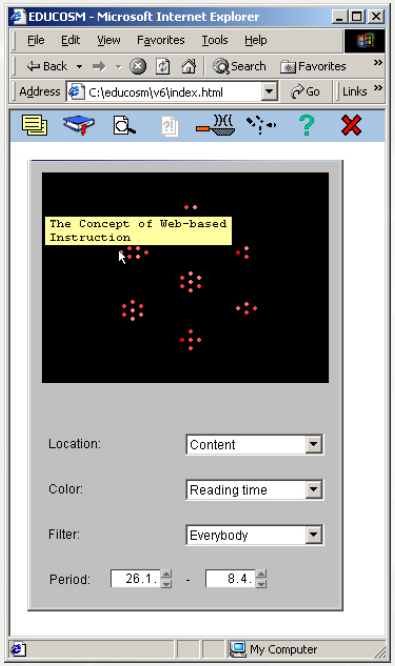
# EDUFORM

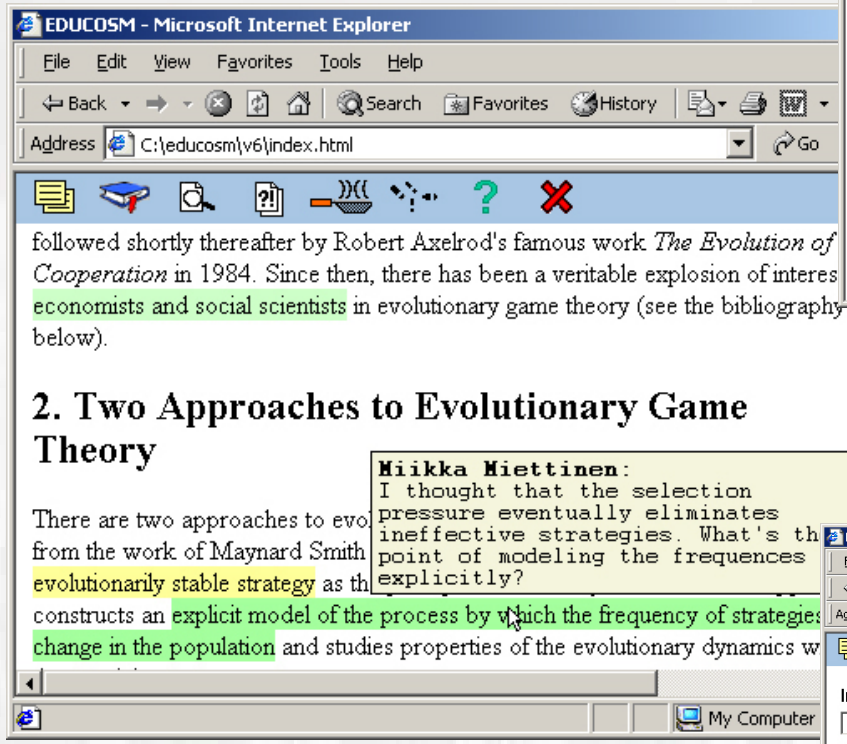


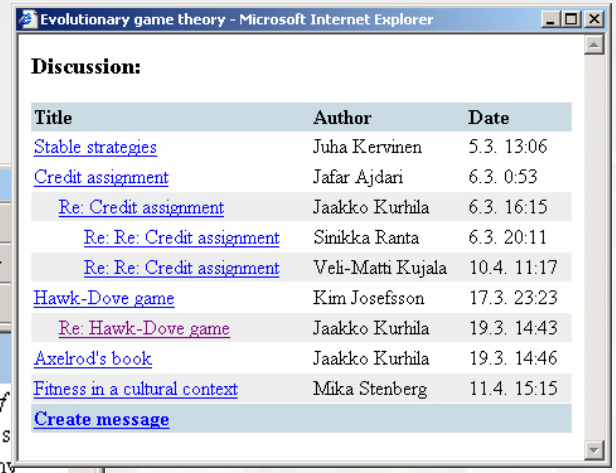
# EDUCO

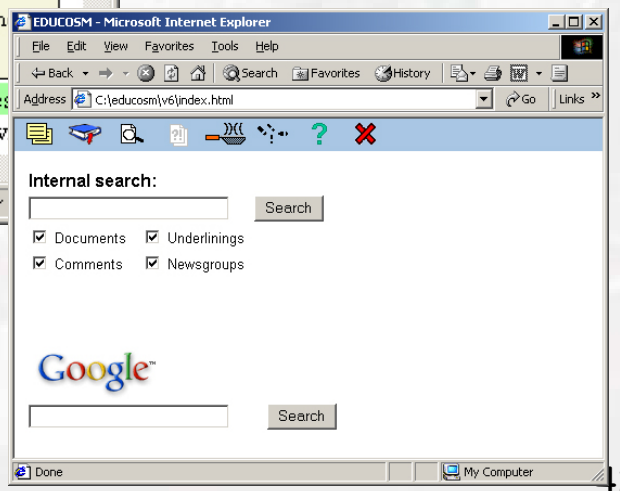


# OurWeb



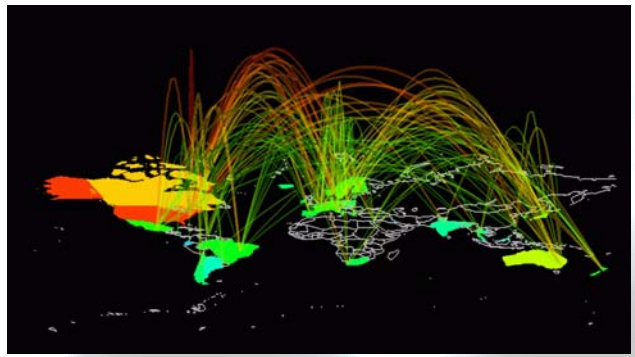



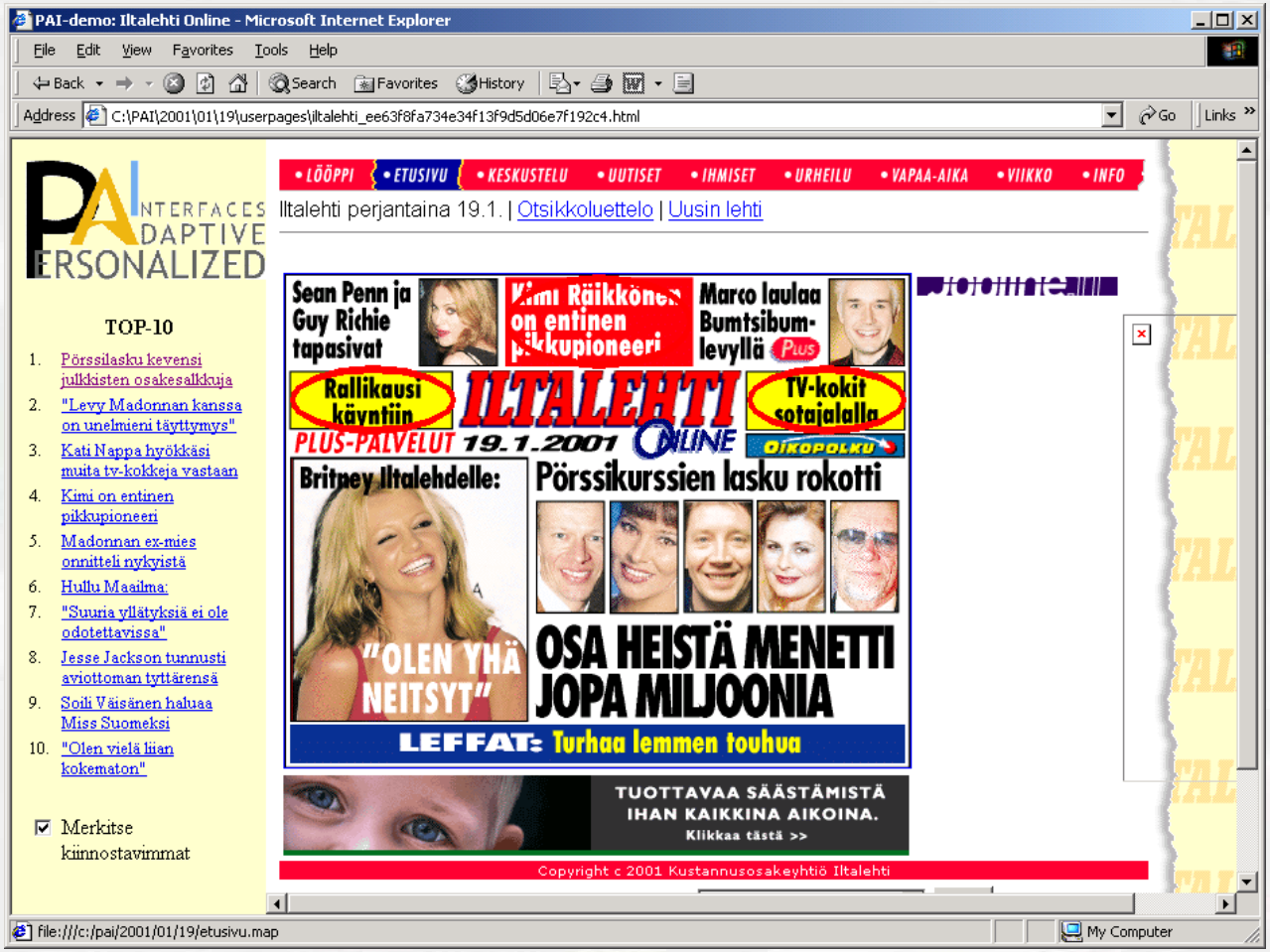



# Personal WEB

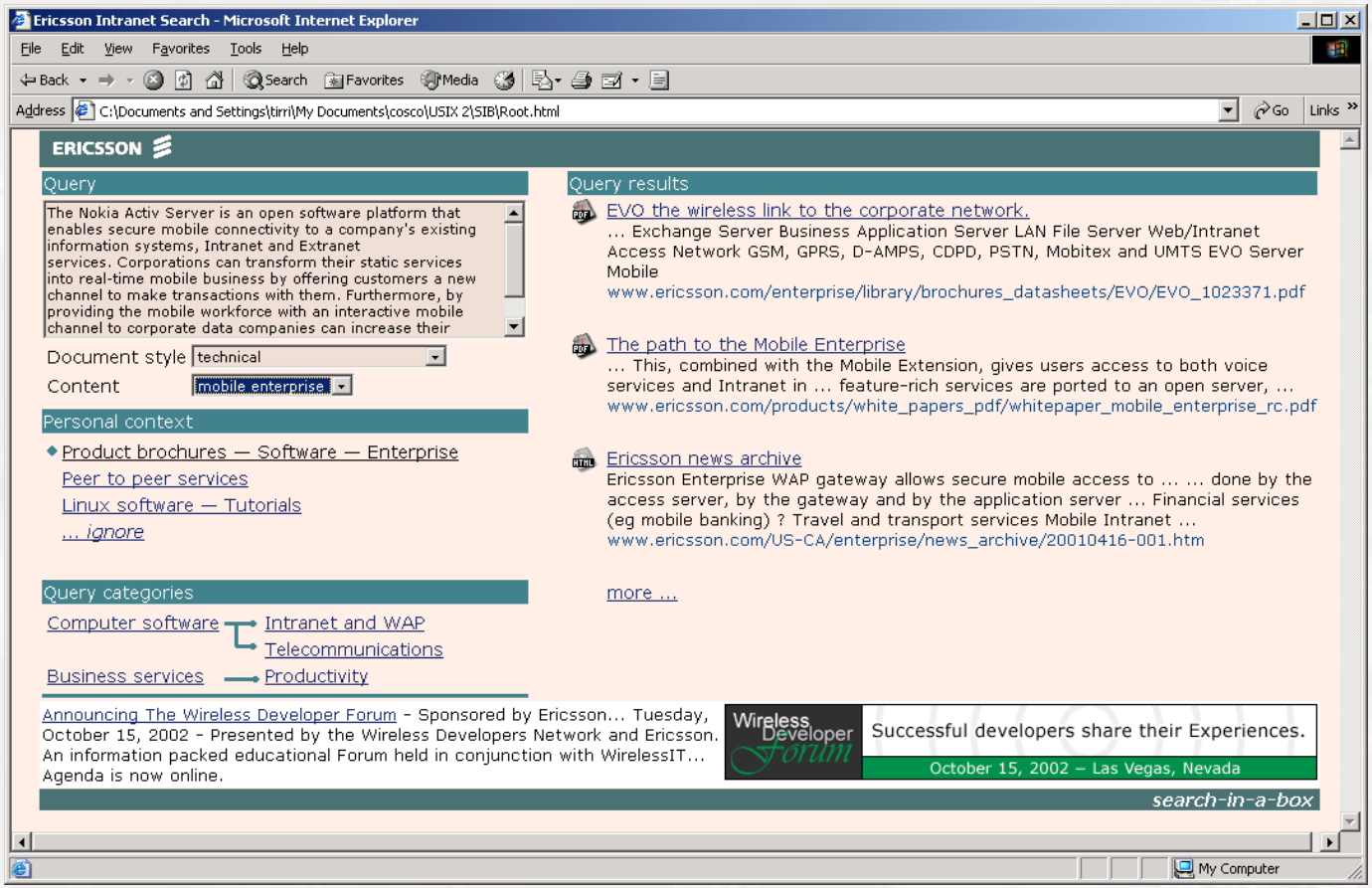
## Personalization and Intelligent Search



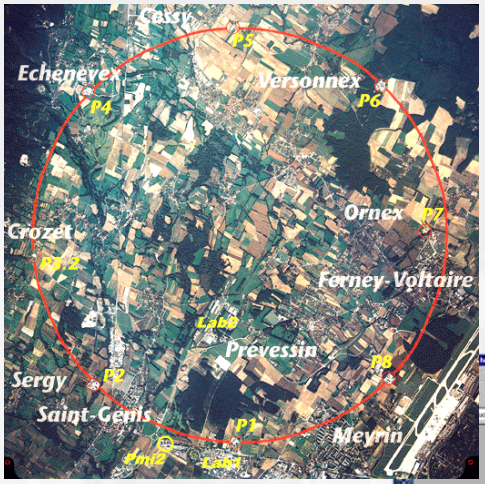
# Personalized, adaptive interface

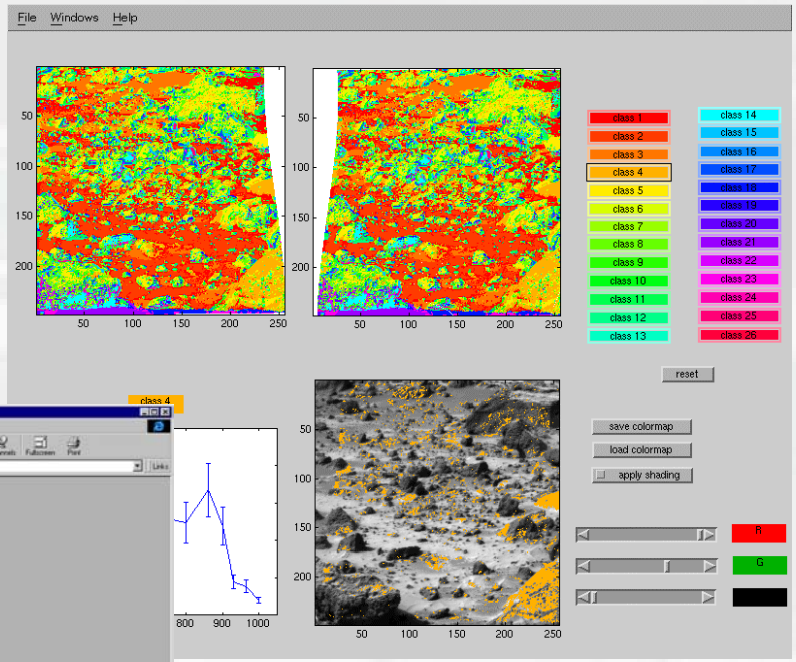


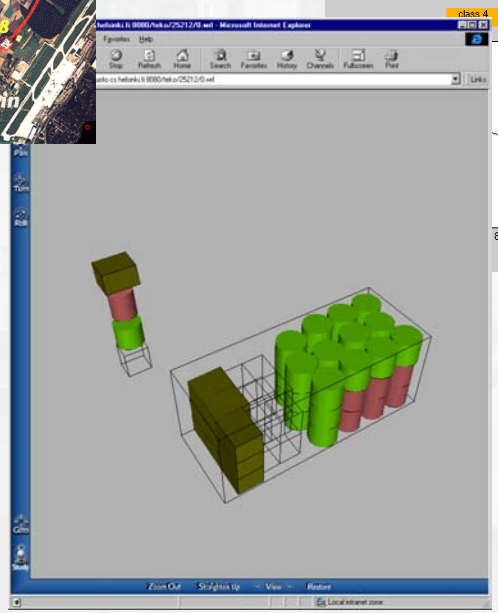
# Search-Ina-Box concept



# and other things



# Termejä

- computational intelligence = laskennallinen älykkyys
- artificial intelligence = tekoäly, artificial life = keinoelämä
- probablistic modeling = probabilistinen mallintaminen
- positioning = paikannus