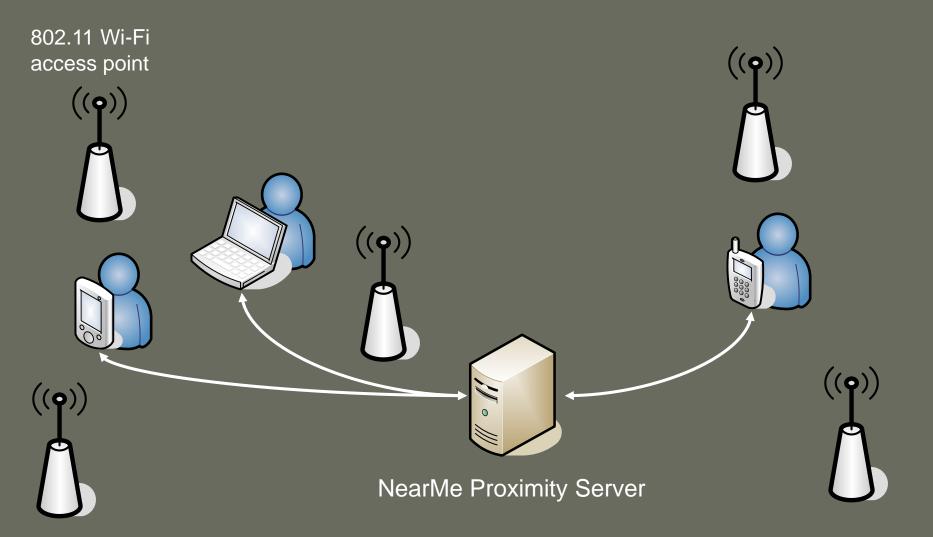
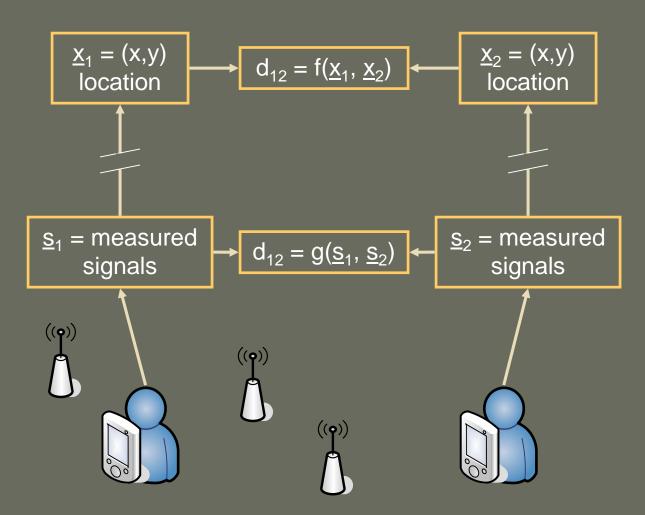
# The NearMe Wireless Proximity Server

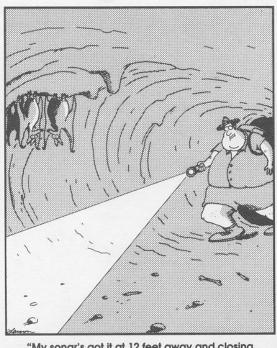
John Krumm and Ken Hinckley Microsoft Research Redmond, WA, USA

### The Basic Idea



# Location vs. Proximity





"My sonar's got it at 12 feet away and closing ....11 feet...10 feet ...God, it's enormous! ... Nine feet..."

### Who Cares?



Schilit, Adams, & Want, "Context-Aware Computing Applications", 1994.

- Which of my friends, colleagues, relatives, or enemies are nearby?
- Who are these strangers with me?
- What are the names of nearby printers?
- What conference rooms are nearby?
- How far away is the nearest receptionist desk?

Other elements of context: velocity, mode of transportation, task, goal, mood ...

# Other Proximity Methods

- Location from
  - Active badges
  - Cameras
  - Wi-Fi
  - GPS
  - Cell Phones
- Conference Devices
  - SpotMe
  - nTAG<sup>™</sup>
  - IntelliBadge<sup>™</sup> NCSA
  - Conference Assistant Georgia Tech
  - Proxy Lady Viktoria Institute
  - Digital Assistant ATR

#### Synchronous Context

- Synchronous Gestures Microsoft
- "Are You With Me?" U. Washington
- SyncTap Sony
- Stitching Microsoft
- Smart-Its Friends Disappearing Computer Initiative



**SpotMe** 

nTAG™

- Services
  - Trepia
  - iChat Apple
- Short Range Networking
  - Infrared
  - Bluetooth

### NearMe Client

😫 NearMe		
Test Connections Register	Wi-Fi Report│Nea	arMe
Choose Type		Enter New or Choose Previous
person demo person conference room printer cafeteria reception desk stitchable	New Name: Previous Name: Email (optional): URL (optional):	John Desktop John Laptop
	Expire:	1 <u>÷</u> hour(s) Register

File Zoom	Tools Help
🄊 John Pocke	at PC 🖳 🗱 🔫 4:27 🛛 🕸
Туре	
person conference ro printer elevator stairs cafeteria kitchen mail room reception desł bathroom stitchable demo person	Previous Name (none of this type ▼ Register Previous New Name John Pocket PC Expire Hours 10 ▲ ▼ Register New
Register Report	Near Me

PocketPC 2003

Windows XP

Requirements:

- Windows XP
- WWW access
- Microsoft .NET Framework

### NearMe Client – Test Connections

😫 NearMe		
Test Connections Re	egister   Wi-Fi Report   NearMe	
NearMe Service	Sep 2 2004 6:01PM in Redmond, Washington, USA Live status message from NearMe Service: This is a test version of the NearMe web service. If you can see this message, you have successfully connected to the service.	(( <b>°</b> ))
Wi-Fi Hardware	ORiNOCO USB Card 00:40:96:31:c7:0d -70 00:40:96:31:87:78 -90 00:40:96:31:6c:34 -92	

# NearMe Client – Register

🐏 NearMe	
Test Connections Regist Choose Type person demo person	Wi-Fi Report NearMe Enter New or Choose Previous New John Desktop
conference room printer cafeteria reception desk stitchable	Previous Name: Person Nearby Person Farther Away Person Even Farther Away
	Email (optional):
	URL (optional):
	Expire: 1 + hour(s) Register

Register with:

- Name
- Email (optional)
- URL (optional)
- Expiration interval

# NearMe Client – Report Wi-Fi

😫 NearMe - Registered as "John Des	sktop" (ID 364)		
Test Connections Register Wi-Fi F	Report NearMe		
Report		E Beep on Report	
ORiNOCO USB Card 00:40:96:31:c7:0d -77 00:40:96:31:87:78 -92	Periodic O Start O Stop	Interval          1 minute         2 minutes         5 minutes         10 minutes         20 minutes	

- List of detectable Wi-Fi access points
  - Access points used only as beacons
- Periodic reports for mobility

# NearMe Client -- Query

😫 NearMe - Registered as "John Desktop" (ID 364)			
Test Connections Register W	i-Fi Report NearMe		
Choose Type	Overlapping Access Point		
person demo person conference room printer cafeteria	Person Nearby Person Farther Away		
reception desk stitchable	Access Point Hops Person Even Farther Away (2)		
	Query Look back: 20 ÷ minute(s)		

#### Adjustable "Look back" time to filter outdated reports

# NearMe Client – Nearby Things

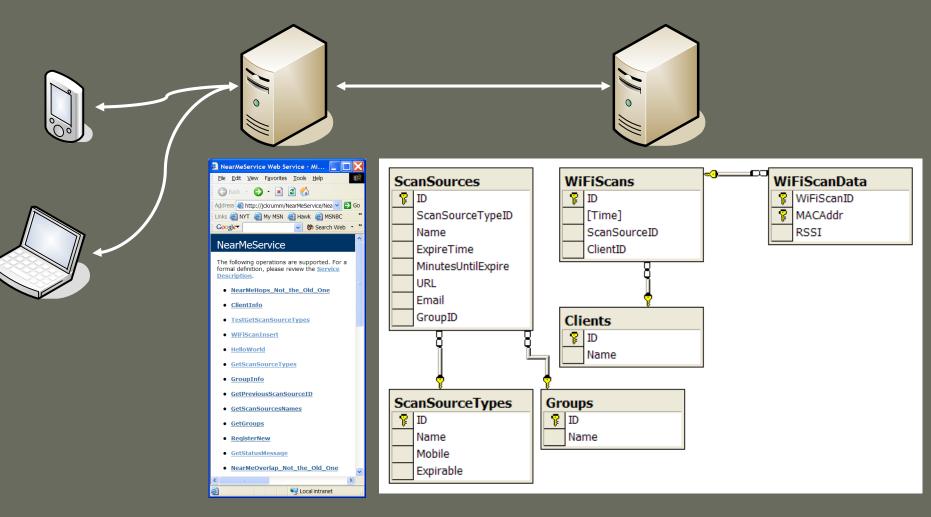
NearMe					
NearMe         Test Connections       Register       W         Choose Type       Person       demo person         conference room       printer       cafeteria         reception desk       stitchable	NearMe - Registered as "MS 113/3:           Test Connections         Register         Wi-Fi I           Report         Image: Constant of the second sec	Choose Ty person demo person	• Registered as "John ections Register W ype son e room	n Desktop" (ID 364	Me ccess Point Hops (2) (2)
Register as thing	Report sig	nal stre	ngths	Query fo	or things
person	elevator		kitchen		bathroom
conference roo	om stairs		mail room	)	stitchable device
printer	cafeteria		reception	desk	demo person

### NearMe Server

Clients

.NET Web Service

SQL Server

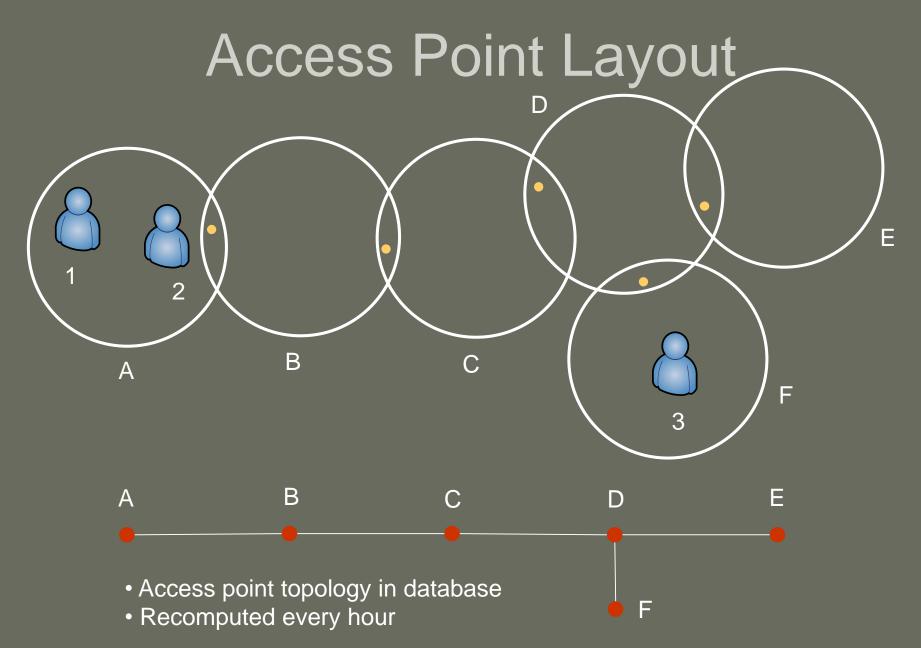


### NearMe Server Data

		Minutes	Time Sta	amp	Access Point 1		Access Point	2	
Name	Туре	Until Expire	Date	Time	MAC	RSSI	MAC	RSSI	
			1-Sep-2004	16:13:04	00:40:96:31:c7:0d	-78	00:45:cf:1e:7a:d0	-67	
Bob480	person	128	1-Sep-2004	16:14:04	00:40:96:31:c7:0d	-81	00:45:cf:1e:7a:d0	-65	
			1-Sep-2004	16:15:04	00:40:96:31:c7:0d	-75	00:45:cf:1e:7a:d0	-70	
Maryoza	person		1-Sep-2004	16:18:25	00:45:cf:1e:7a:d0	-79			
Ivial 1	person		1-Sep-2004	16:21:25	00:40:96:31:c7:0d	-65			
B113-3-N	printer	N/A	5-Mar-2004	12:04:32	00:0f:34:ab:0c:a0	-82	00:02:dd:34:44:e5	-63	
B42/231	conference	N/A	12-May-2004	20:12:31	00:0f:34:ab:0c:a0	-60			

#### Expiration deletes source of Wi-Fi data, but not Wi-Fi data itself



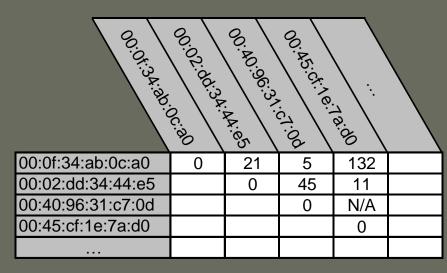


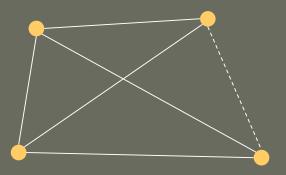
# Hops = Distance Estimate

😫 NearMe - Registered as "Joh	n Desktop" (ID 364)		
Test Connections Register W	i-Fi Report NearMe	👥 NearMe - Registered as "John	Desktop" (ID 364)
person demo person conference room printer cafeteria	Overlapping Access Point Person Nearby Person Farther Away Access Point Hops	Test Connections Register Wi- Choose Type person demo person conference room printer cafeteria	-Fi Report NearMe Overlapping Access Point MS 113/3209 MS 113/3379 MS 113/3377
	Person Even Farther Awa (2) Query Look back:	reception desk stitchable	Access Point Hops MS 113/3181 (2) MS 113/3005 (2) MS 113/3001 (2) Query Look back: 20 - minute(s)

Extends proximity range beyond radio range

### Access Point Travel Times

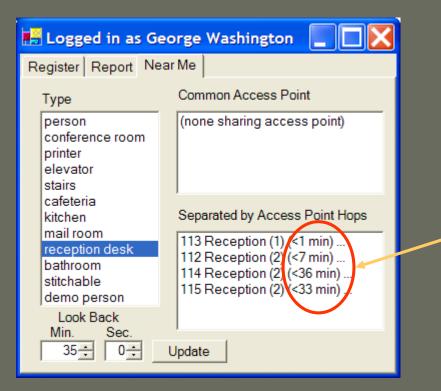




Minimum observed client travel time between access points

- Recomputed every hour
- Could be computed from other "wardriving" data, e.g.
  - Intel Research Place Lab
  - NetStumbler
- To Do
  - Path plan,  $e.g. A \rightarrow C = A \rightarrow B + B \rightarrow C$
  - Cluster times, e.g. times for walk, bike, drive

### Travel Times = Distance Estimate



Observed lower bound on travel time

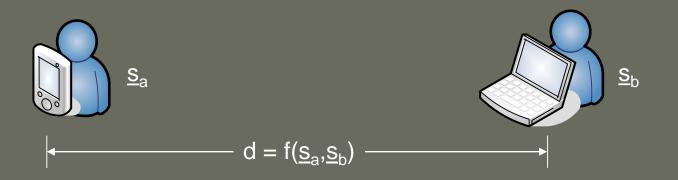
### **Distance** Estimation

魓 NearMe - Registered as "Joh	nn Desktop" (ID 364)
Test Connections Register W	Vi-Fi Report NearMe
Choose Type	Overlapping Access Point
person demo person conference room printer cafeteria	Person Nearby Person Farther Away
reception desk stitchable	Access Point Hops Person Even Farther Away (2)
	Query Look back: 20 ÷ minute(s)

How to estimate distance between things?

### **Distance Functions**

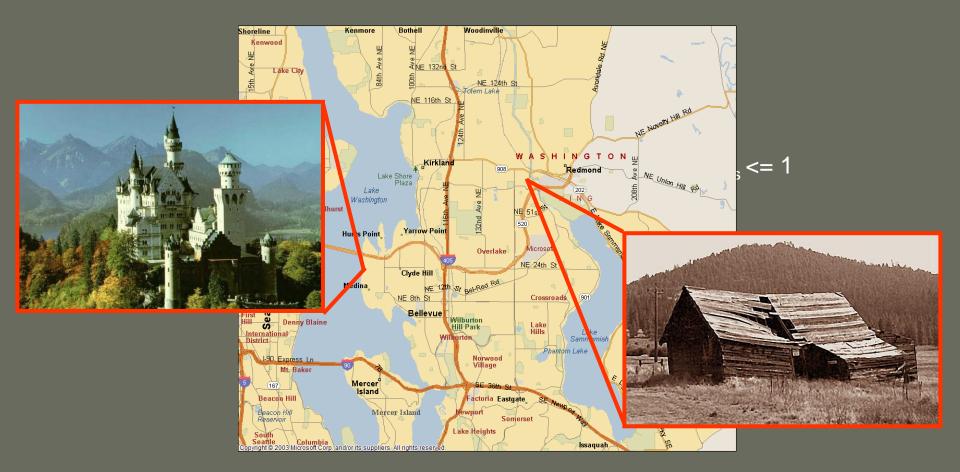
Wi-Fi Signature =  $\underline{s} = \{ (mac_1, rssi_1), (mac_2, rssi_2), \dots, \{ (mac_n, rssi_n) \} \}$ 



Candidate Distance Features:

- 1.  $n_{\cap}$  = number of access points in common
- 2.  $ssd_{\cap} = sum of squared differences of rssi in common$
- 3.  $n_u =$  number of access points *not* in common
- 4.  $\rho_s$  = Spearman rank coefficient of access points in common

### **Compare Ranked Signal Strengths**



### **Distance Functions**

 $d = f(\underline{s}_a, \underline{s}_b)$ 

 $d = f(n_{\cap}, \, ssd_{\cap}, \, n_u, \, \rho_s)$ 

Example:  $d = a \cdot n_0^2 + b \cdot ssd_0 + c \cdot n_u^3 + d \cdot \rho_s$ 

4 features + polynomials to  $3^{rd}$  degree = 45 different test functions

### Test Data

#### 🖶 Log RSSI

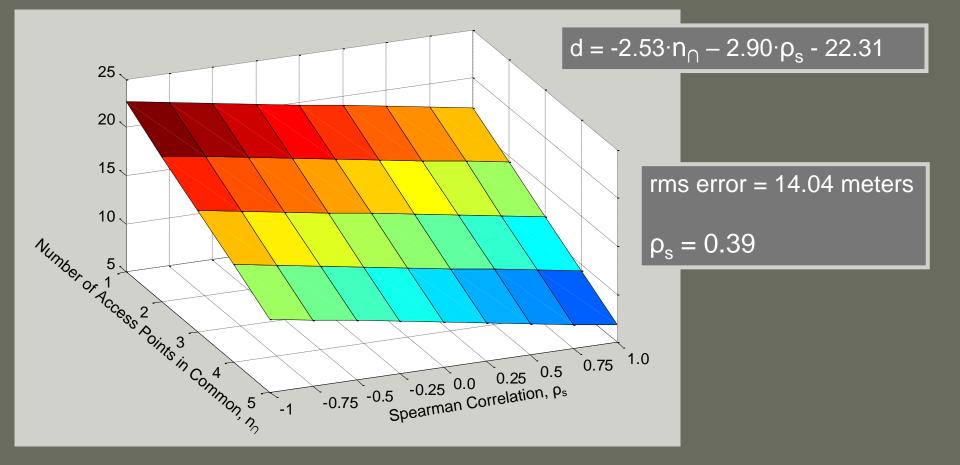
E EOS KODI		
		Floor Plan          Open       Unselect         Current       Selected         X (m)       4.67         Y (m)       91.91         Wi-Fi Scans       Scan Interval (sec)         Scan Interval (sec)       Log         3 ±       Beep on Log         Log File       Detected NICs         ORiNOCO USB Card       ORiNOCO USB Card - Packet Schedu         Max RSSI       100         -100       0         Access Pts       0         0       10
		Notes 1) Must select log file with "Log File" button before logging is enabled. 2) Indicate unspecified location by unselecting location. 3) Can unselect location by double- clicking in map.

#### Wi-Fi Cards

- 1. Dell built-in laptop
- 2. Microsoft Wireless USB
- 3. ORiNOCO PC Card
- 4. Actiontec USB
- 5. Cisco Aironet PC Card
- 6. Linksys USB

Office Building:1,441,739pairsCafeteria:572,027pairs

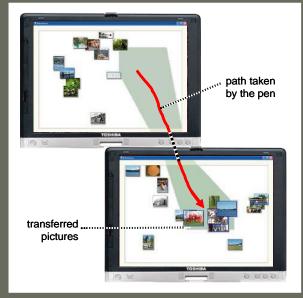
### Simple Distance Function



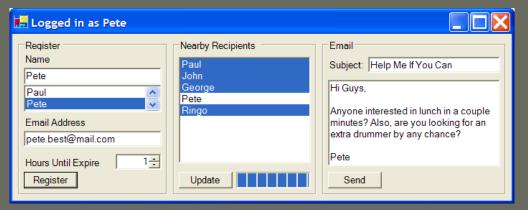
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Ele Edit View Favorites Ic » 🧗	Ele Edit View Favorites
🕞 Back 🕤 🕤 🔹 📓 🏠	🕒 Back 👻 🕥 🐇 🙀
Address 截 http://jckrumm/Net 💌 🛃 Go	Address 🚳 http://research.mic
Links 🖲 NYT 📢 My MSN 🍓 Hawk 🏾 🎽	🗄 Links 👸 NYT 🤘 My MSN 🧃
i Geoglet 💗 🔍 🗸 💗 🚽 💓 🎽	Geogle- 📦 🔍 🗸 💗
NearMe Wi-Fi Web Service People John Desktop V Go Conference Rooms 113/3/3209 V Go	
Printers 113-3-3312 v Go	
Demo People Homer Simpson 🗸 Go	Homer Simpson
🧃 🧐 Local intranet 🦽	🎒 🔹 Internet

#### Look up URLs of nearby people

### Applications



#### Stitching



>

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📢 My MSN 👸 Hawk 👻 💓

#### Send email to people nearby

# What Makes NearMe Different?

- Works on existing Wi-Fi devices
- Minimal setup
  - "Out of the box" for nearby people
  - Capability grows with use
- Short range proximity
  - Accounts for different Wi-Fi hardware
  - Sorted by distance
- Long range proximity
  - Hop distances via adjacency analysis
  - Travel times via timestamp analysis

#### Demo