



Applications of Communication Technologies beyond Communication

Distributed Systems Seminar
FS09, ETH Zurich

Simon Mayer

Contents

- Introduction & Motivation
- Communication Technologies
- Example: The *Redpin* indoor localization system
- Summary & Outlook



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Introduction & Motivation

- Pervasiveness of wireless communication technologies
 - GSM Association: 4 billion subscribers (as of 11th of February 2009)
 - ABI Research: 550 million Bluetooth devices shipped in 2006

Mobile World Celebrates Four Billion Connections --Sustained Innovation Expected to Generate Six Billion by 2013 --Mobile Broadband users near 100 million

By: PR Newswire | 11 Feb 2009 | 04:00 AM ET

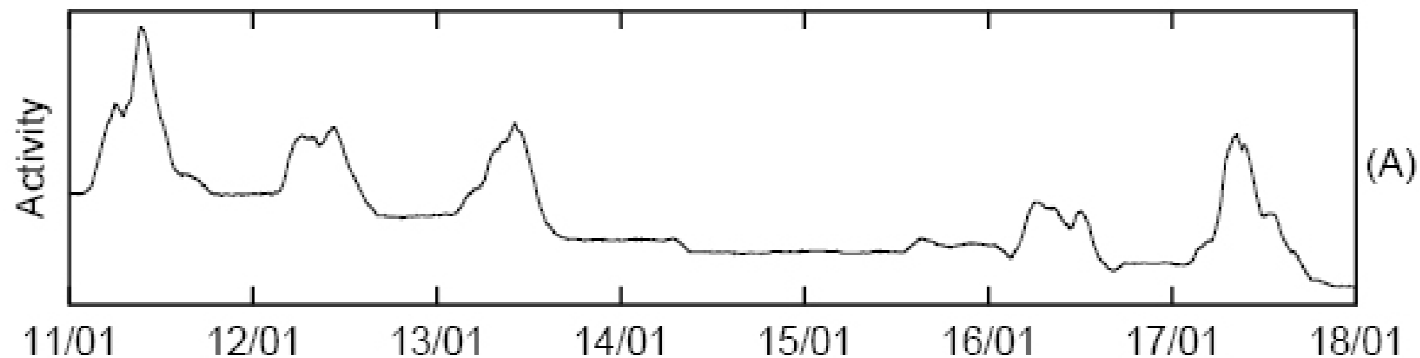
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LONDON, Feb 11, 2009 /PRNewswire via COMTEX/ -- The GSMA today announced that the mobile world has celebrated its four billionth connection, according to Wireless Intelligence, the GSMA's market intelligence unit. This milestone underscores the continued strong growth of the mobile industry and puts the global market on the path to reach a staggering six billion connections by 2013.

Source: cnbc.com

Introduction & Motivation

- Personal handheld devices as personal identifiers
 - Nokia Research Center, Finland
 - Explore the potential of rich Bluetooth environments
 - 1299 *individual* BT-devices

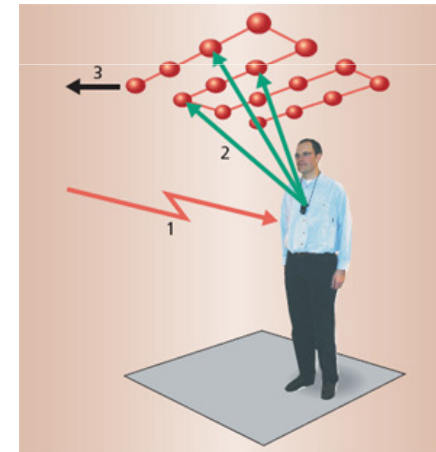


Source: Hermersdorf et al., Sensing in Rich Bluetooth Environments

Introduction & Motivation

- Localization
 - Bolliger (2008): “Key missing technology”
 - Global Positioning System (GPS) for outdoor localization

- Specialized localization systems
 - Require special hardware
 - Ultrasound (“Bat”)



Source: Addelee et al., Implementing a Sentient Computing System”

- “Exotic” localization systems relying on existing infrastructures

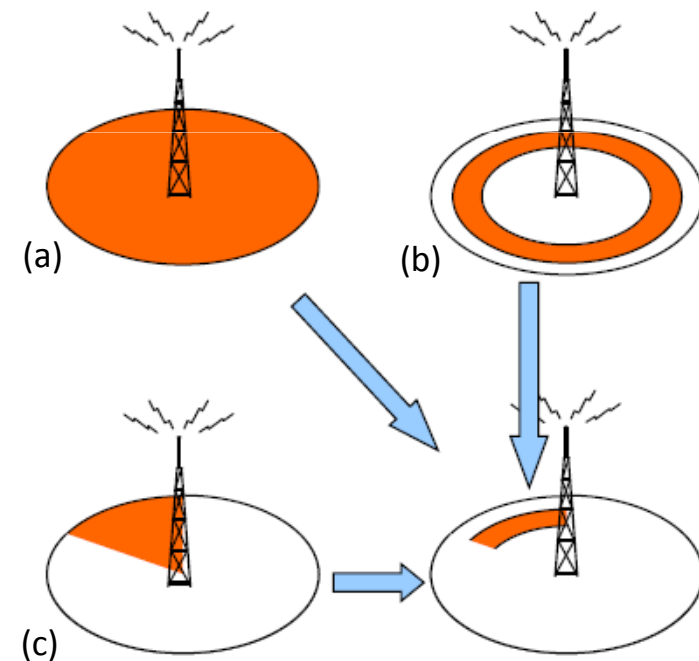


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The Global System for Mobile Communication (GSM)

- Prevailing standard for mobile telephony
- Localization using GSM features
 - Cell Identification (a)
 - Enhanced Cell Identification (b)
 - Cell Sector (c)
- Localization using fingerprinting
 - Very stable network



Source: F. Mattern, Lecture Notes, "Ubiquitous Computing", FS08, ETH Zurich

Wireless Fidelity (WiFi)

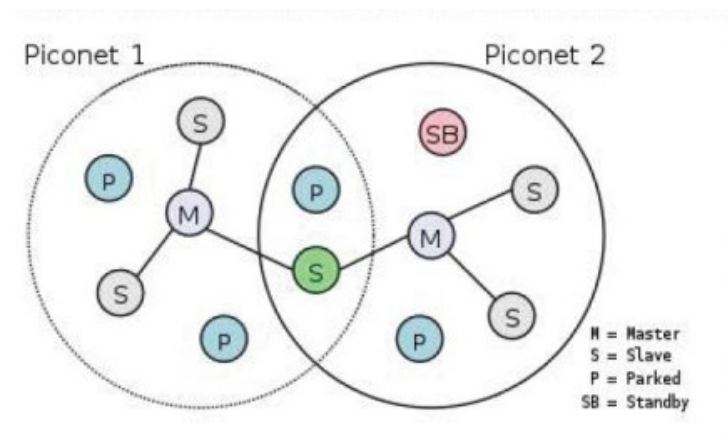
- Most important standard for wireless local area networking
 - Interoperability certification for IEEE 802.11a/b/g devices
- Limited range
 - Limited coverage
 - Better accuracy
- Temporal Dynamics
 - Fluctuation of more than 50% within one hour
 - People in line of sight, doors, humidity



Source: Wikipedia

IEEE 802.15.1 Bluetooth

- Main standard for wireless personal area networks (WPANs)
- Extremely unstable
 - Bluetooth radios in *mobile* devices
 - Compensated by abundance in certain environments (Hermersdorf et al. (2006))
- Tedious coupling process
 - Sometimes 30s for setting up a topology
 - Slow detection & high power consumption



Source: Techtree.com

IEEE 802.15.4 ZigBee

- Low-power, low-bandwidth standard for WPANs
 - Simple wireless connectivity (e.g., remote controlling)
- Very long battery lifetimes
 - 100-1000 days (compared to 1-7 days for Bluetooth/GSM)
- Specification includes Link Quality Indicator
 - Can be used to estimate distance between nodes
 - Simplifies implementation process



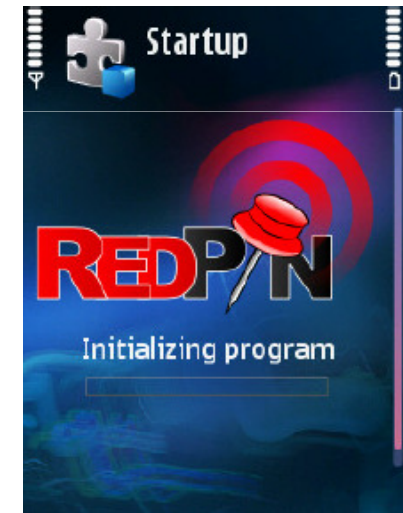
Source: ZigBee Alliance

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The *Redpin* Indoor Localization System

- Developed at ETH Zurich by Philipp Bolliger (2008)
 - “Adaptive, Zero-Configuration Indoor Localization through User Collaboration”
 - Room-level accuracy
- Fingerprinting:
 - Signal strengths of **all WiFi access points** in range
 - **Bluetooth identifiers** of all non-portable Bluetooth devices
 - **Cell ID** of the currently active GSM cell
- Zero-Configuration and Adaptability
 - No explicit training phase
 - Users create, manage and correct (!) locations collaboratively



Source: Bolliger (2008)

Redpin in Action

1. Calculate fingerprint at current location (“sniffing”)
2. Send measurement data to a central server
 - Success: Plan of current floor and device’s location is returned
 - Failure: Unknown location / Wrong location



Redpin – Evaluation



Source: Bolliger (2008)

1. How good is the localization?
 - Correct in 90% of the cases
 - Remaining 10% can be explained by the simplicity of the locator algorithm
2. How long does it take until every room can be identified?
 - Map had been completed after one day (10 participants)

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Summary & Outlook

- Wireless communication technologies can be applied in the context of mobile sensing
 - Extraction of behavioral patterns
 - Indoor localization
- Merging of multiple technologies successful
- (Location) Privacy
 - Important aspect of mobile sensing
 - “Implications of ubiquitous sensing” (7th of April 2009)



Source: www.owenbloggers.com/



Thank you for your attention!

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