

Parasitic radio frequency tracking

Leveraging existing infrastructure for location aware computing

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Introduction

- Ubiquitous Tracking
 - How to track in the wild?
 - Isolated islands of high precision
 - Economic considerations \leftrightarrow User desires
- Not all applications require high precision
 - Navigation
 - Initialization of primary sensor systems

Closer Look at the Environment

- Ubiquitous Tracking infrastructure
 - Economically infeasible
 - Coordination / Maintenance problems
- Continuous growth of information society
 - Communication / Networking pervasive
 - Integrated into end-user gizmos
 - Diffusion of personal information displays and interaction
- Non-Tracking related infrastructure readily available

Parasitic Tracking

- General idea of Parasitic Tracking
 - Derive as much information as possible from existing infrastructure
 - No need for actual participation
 - No dedicated infrastructure
- Strategies
 - Exploits known characteristics of infrastructure
 - Semantic characteristics
 - Technical characteristics

Parasitic Tracking

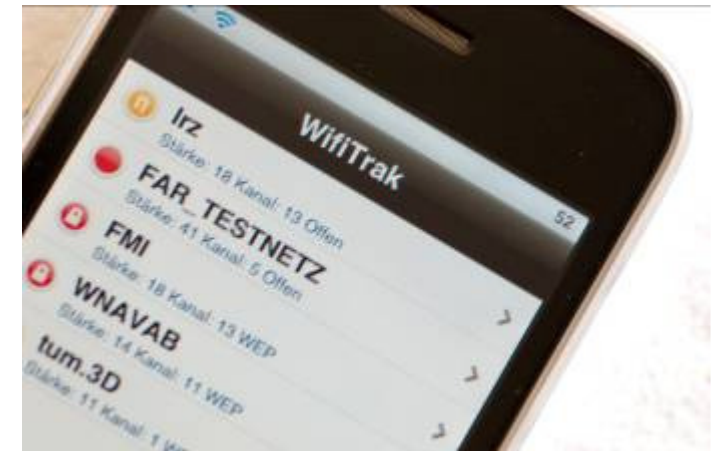
- Each parasitic tracking method inherently unreliable
 - May not be available at all
 - Cannot be trusted
 - May be modified
- Parasitic Tracking
 - Needs to integrate different services
 - Dynamic reconfigurability mandatory
- All parasitic tracking techniques implemented as Ubitrack components
 - Management using trackman
 - Fusion of different methods
 - Propagation of location estimates

Radio Frequency tracking methods

- Quality dependent on accessibility of exploitable characteristics
 - No direct support from off-the-shelf products
 - Hidden internal mechanisms may influence measurements
- Relevant characteristics currently hidden / distorted
- **Software Defined Radio**
 - Moves complexity from hardware to software
 - „Move the computer as close to the antenna as possible“
- Access to Over-the-Air data cheaper / Reception process more explicit
 - Better exploitability

1. Scenario: 802.11 Wifi Tracking

- Prime candidate for parasitic tracking
 - Fastest growing information infrastructure
 - Indoors reception of multiple base stations
- Different Approaches
 - Fingerprinting
 - Has to be learned for each environment
 - Ranging based on radio characteristics
 - Can be described abstract by non-application-specific data
- Characteristics
 - Received Signal Strength Indicator (RSSI)
 - Round-Trip-Time



802.11 Tracking: Testbed Setup

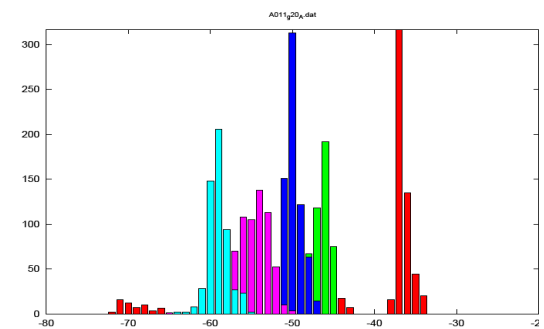
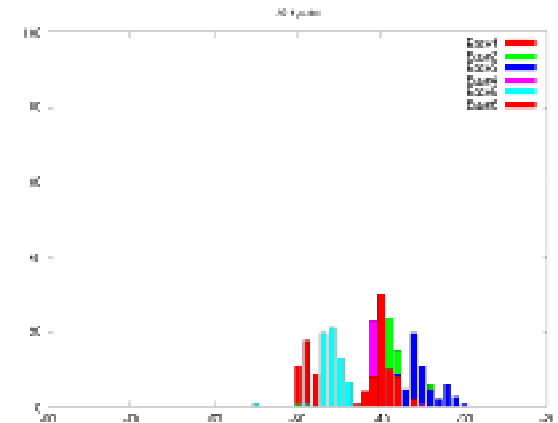
- Testbed scenario
 - Distributed several access points
 - User equipped with SDR 802.11 software receiver (USRPv1)
 - Comparison with 2 OTS wifi receivers
 - Registered with Tachymeter
 - Implemented / Managed with Trackman



802.11 Tracking: Improvements / Results

- Data gathered by SDR is more expressive
 - Signal strength much more consistent with distance
 - Higher update rate
 - More differentiated values
 - Better control against drowning of far away stations

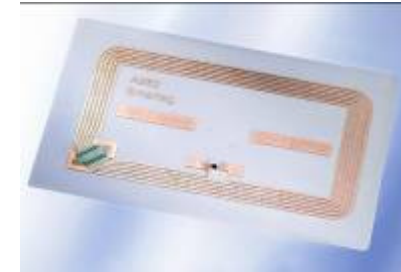
| Data excerpt | OTS RSSI | SDR Signal Strength |
|----------------|----------|---------------------|
| Station 1 (1m) | -41dBm | -35dBm |
| Station 3 (3m) | -37dBm | -51dBm |
| Station 6 (6m) | -49dBm | -70dBm |



- Distance estimation based location with 0.5m accuracy in 5m x 15m setup

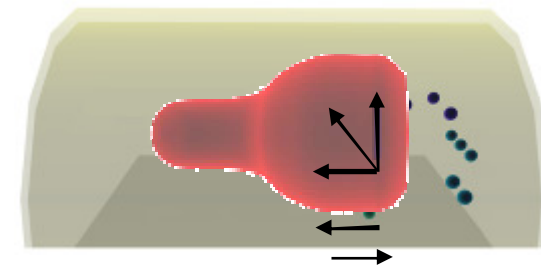
2. Scenario: RFID-Tracking

- Contactless / Long-Range Identification
 - Gains importance
 - e.g. Supply Chain / Inventory Management
- Complex assembled devices
 - Consist of many, individually tagged parts
 - Locations known from CAD/PDM/PLM
- Exploitable Infrastructure
 - RFID tag cloud
 - Location annotated tag database



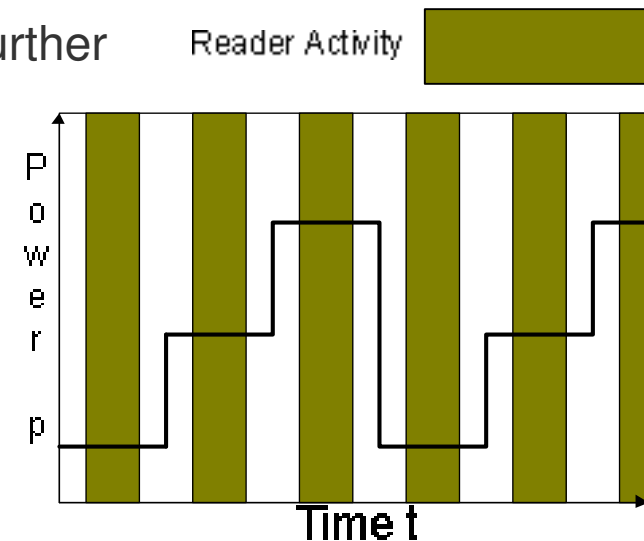
RFID-Tracking: Basic Approach

- Test scenario: Aircraft cabin
 - Mockup equipped with long-range UHF tags
 - User equipped with RFID reader
 - Setup managed with Trackman
- Required: Radio communications characterization
 - Estimate reading volume of antenna
 - Profile tag response behavior
- Location process
 - Read tags
 - Fit antenna model to read tag cloud
 - Antenna model rotated with gyroscope orientation



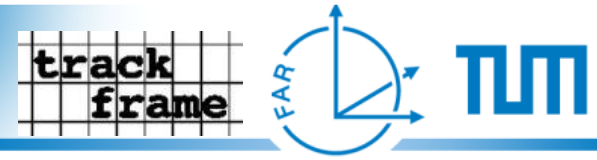
RFID-Tracking: Results / Challenges

- No vendor support for device „misuse“
 - No RF data available
 - Binary detection decision
- Use power modulation to differentiate distances further
 - Actively cycle radio settings rapidly
 - Only possible due to SDR receiver
- Probabilistic distance estimation to each tag
- ML position estimation
- Initial results: Position error < 0.5m achievable



Outlook

- Many open problems
- More precise characterization of communications channels necessary
 - Characterization of timing behaviour
 - Characterization of RFID communications
- Probabilistic position estimation
- Applicable to many tracking methodologies
 - GSM
 - Radio-Fingerprinting
 - Bluetooth
 - Etc.



Thank You