
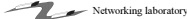


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Measurements in the wireless

Lecture slides for S-38.3183
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Contents

- Motivation
- Wireless environment specifics
- Wireless trace collection
- Wireless measurement methods
- Mobility measurements





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Goals of this lecture

- After this lecture you should
 - Know how to characterize the wireless environment in regards to measurements
 - Know why measurements in the wireless are hard and how the gathering of measurement information is distributed
 - Know where the wireline and wireless measurements and analysis are the same and where they differ




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Why measure?

- Wireless networks differ from the "usual" Internet access
 - The access is (slightly) spatially dynamic
 - Ad-hoc networking is easier
 - Lack of wiring (=wireless) can create very highly populated networks
 - Medium (the air interface) access is more complex and dynamic
 - Clients and applications may show much more diversity



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The same ol' same ol'

- Wireless networks contain the same users with same applications as networks in the wireline
 - However, there might also be (a significant amount of) legacy customers from "mobile voice networks" (GSM).
 - Same measurements and analysis apply on layers 3 and above
 - Same results definitely do not!
 - Due to access layer being slightly different also the results may turn out to be slightly different
 - Network traffic properties as a function of layer 2?!

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What is different?

- A network is a network
 - However, WLAN performance is influenced
 1. Mobility
 - Handoff, handover
 2. Channel noise
 - 2,4/5GHz area is unlicensed, noise may be a problem with increased distance
 3. Multiple access contention
 - Access quality decreases as user count increases

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Measurements in layers 1 and 2

- Transmission rates, retransmissions, signal strength
- Collision avoidance, detection
- RTS/CTS
- Traffic in different channels

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Wireless traces

- Incomplete
 - Different depending on the measurement point
 - Design is distributed, control points do not exist
- Inaccurate due to more probable configuration errors
- Subject to layer 2 features
- Contention very much dependent on where the measurement point is located and how it is moving (mobility)
 - Channel usage and contention is location-dependent

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Trace collection methods - nodes

- Wireless monitors
 - Monitor all activity in the channels
 - Event-triggered logs
 - Memory and storage requirements
 - Form a view (analysis!) of the network status and notify
 - Other nodes in the WLAN
 - Access point(s)
 - Information/state distribution uses up bandwidth
 - Careful planning and management of the measurement arrangements
 - Do not overload production networks
 - Do not lose relevant information

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Trace collection methods - BS

- Network trace dumps at the base station
 - Poll access points with SNMP-protocol
 - Gather info on amounts of connected users, transmission errors, and transmitted traffic

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Trace collection methods - Core

- Network trace dumps at aggregating routers
 - Where traffic from several access points is aggregated
 - Capture also traffic directed to WLANs
 - Additional monitoring and capturing load
 - Determine traffic mix, network service profile etc.
 - Normal traffic analysis
- Packet loss
 - Two sources for packet loss
 - Competing transmissions
 - Miscalculation in power management
 - Insufficient signal strength

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Probing for bandwidth


- Available BW depends on
 - Amount of users in the coverage area
 - Overall traffic load
- Available BW varies a lot
 - Actively probing for BW introduces additional traffic and interferes with other traffic


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Unintrusive bandwidth probing


- **Configure dedicated queues for probe packets**
 - Forward probe packets only if no other traffic exists
 - Larger packets/lower bandwidth still cause some interference to other traffic
 - Egress router measures the packet arrivals and sends the info back to the sender





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Losses in wireless


- **High error/loss rates**
 - Competing transmissions
 - Signal strength related losses
- **Adaptive transmission rates result in busier medium**
 - A lot of time data is sent at 1Mbps -> medium is reserved and contented and more losses/errors occur
- **Multi-path fading produces a lot of (bit) errors**
 - Packets/bits received multiple times





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Packet delay


- **WLANs produce larger transport delays**
 - Signal propagation (not that large contributor)
 - Aggregating signal propagation results is significant delay
 - Handovers
 - Retransmissions
 - Inference




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Jitter in wireless

- **Due to medium dynamics jitter is much more pronounced in wireless**
 - Handovers
 - Inferences, shadowing
 - Link Layer Scheduling
 - RTS/CTS



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Measuring for mobility

- How often and how much a user moves while on line
 - Physical movements are hard to measure
 - RFIDs, but way-y in the future ☺
 - Detect roaming patterns from APs
 - With dense AP placement, the node may change APs even if it is not moving
 - Group APs into location clusters (per building, for instance)

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Mobility measures

- Time spent in one AP (location cluster)
- Movement speed
- (Mobile) session duration
 - And visited APs in that time
- Application profile relation to movement

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Handoff measurements

- Handoff is performed when a mobile node transfers from one AP to another.
- Hand-off time is divided into two components
 - Inter-cell time (rendezvous-time), the time elapsed moving from one APs range to another
 - In a well planned network this time should be negligible
 - Hand-off setup time
 - The time required to restore traffic flow when APs have changed

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Routing measurements in wireless

- Wireless environments are dynamic
 - Especially ad-hoc networks
 - Dynamic/Adaptive routing is mandatory
 - Routing table sizes
 - Rate of changes in the routing table
 - Modeling
 - Convergence times / dynamism of the network
 - Modeling

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Results from previous measurements


- High overhead
 - Results show that only 40% of traffic is original data packets
 - Retransmissions, acknowledgements, management traffic
 - Retransmission rates are high (28% of data, 46% of data transmission time)
- Design for location access, not complete coverage
 - Make sure you have APs where the users are, but not necessarily on the way to get there
 - Users seem not to be moving when using WLANs



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Open&interesting issues

- User mobility modeling
 - How do users move and how to model it?
- Inference studies with varying network topology
- More studies in wireless environments needed
 - Application behavior in WLAN, 3G environments
 - Overall traffic profiling and analysis
 - This lecturer has no knowledge of analysis performed, for instance, in Aalto-network at TKK.
 - Sell the idea, secure funding and get a summer/M.Sc. Thesis job!!
- Ad Hoc –networks will produce interesting analysis targets



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Summary of wireless/mobility measurements

- Several methods of gathering the traces
 - No single method provides complete overview of the network status
- User profiling and characterization is twice as hard
 - In addition to application usage there is also user mobility to account for
- Networks are also dynamic
 - Mobile nodes, dynamic routing
- Distributed network status
 - In nodes, APs and aggregate routers
- Several factors in various layers effect the network status
- Wireless network analysis is challenging
 - No easy conclusions, no easy analysis

