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Measurements in the wireless

Lecture slides for S-38.3183

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Contents

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

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

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

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 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

Measurements in layers 1 and 2

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

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

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 relevan information

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

Trace collection methods - Core

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

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

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

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

Packet delay

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

Jitter in wireless

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

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 and type
- (Mobile) session duration
  - And visited APs in that time
- Application profile relation to movement

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 (rendezvouz-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

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

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

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

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