Wireless Lab (WiSe 2016/17)

Tutorial 3: Tools of the Trade – Data processing, performance evaluation

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Course ID 8501

http://www.inet.tu-berlin.de/menue/teaching0/ws201617/wl_1617/

Outline

- Organization
- Today's assignment
- Wireless Metrics
- Data Processing and Performance Evaluation

Organization

- Oral exams were this week.
- 13 students participated.
- Grading:
  - 12 points for oral exam
  - 8 * 11 points for assignments 03..10
  - Total: 100 points → Final grade
- Points will be on ISIS.

Assignments

- **Only one submission per group!**
- From now on, answers to the assignments **are graded**.
- A few suggestions:
  - Read the questions carefully. **Make sure you answer all of them.**
  - Put all answers (Commands, scripts, plots, explanations) into **one PDF**.
  - **Number your answers** according to the questions.
  - Exception: Scripts of multiple lines go in a separate file.
  - Archive should contain **a directory** with the files
- We **will** deduct points for bad form.

Assignment 3

- You get a large data set
- Process it, make some (read: a lot of) plots
- Evaluate the performance and compare it
  - Which link is better? Why? (Median, CI, ...)
  - Does the result match with your expectations? Why (not)?

- Deadline: Next Wednesday, 16 November, at 11:55 p.m. (23:55)
- Week after the deadline: Debriefing
- **Your submission will be graded after the debriefing**.

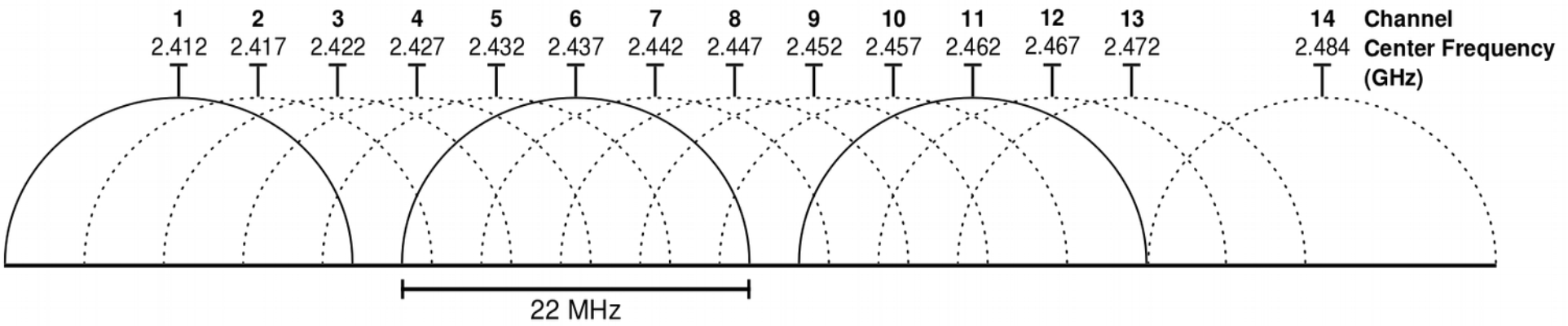
Preparation for Assignments 4..10

- You will get access to your wireless nodes
- Send your SSH public keys (via e-mail) to Mirko
- https://help.github.com/articles/generating-ssh-keys/

Wireless Metrics and Factors

Factor: Transmission Channel

- **2.4 GHz spectrum**
  - Used in 802.11b/g/n
  - Bandwidth: 20 – 22 MHz (802.11 b/g)
  - 14 Channels with different center frequency
  - Channels 1, 6, 11 are “Non-Overlapping”
- Regulated, depending on region



Source: Wikipedia, Michael Gauthier, CC-BY-SA

Factor: Transmission Channel

- **5 GHz spectrum**
  - Used in 802.11a/n/ac
  - Bandwidth: 20 or 40 MHz (802.11a/n), ac up to 160 MHz
  - 23 non-overlapping channels in most countries
  - EU:
    - 36 .. 64 (in steps of 4) only indoors
    - 100 .. 140 (in steps of 4) indoors and outdoors
    - 149 .. 165 (in steps of 2) for Short Range Devices
    - [155 .. 171 (in steps of 4) for Broadband Wireless Access]

→ Is using 5 GHz always better?

Factor: Transmission Power

- Limited by regulations
- EIRP (Equivalent Isotropically Radiated Power)
- Examples for EU:
  - **Up to 20 dBm** (100 mW) for 2.4 GHz
  - **Up to 30 dBm** (1 W) for 5 GHz
- Can be set manually

→ Is high power always good?

Factor: Transmission Power

- Higher power:
  - Longer communication range
  - More interference with others
- Lower power:
  - Shorter communication range
  - Less interference with others

Metric: RSS

- RSS: Received Signal Strength
  - Power level of signal at the receiver
  - In dBm, like the Transmission Power

RSS, Noise Floor

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- Noise floor
  - Lower measurement/detection level
  - Typically around -95 dBm

RSS, Noise Floor, SNR

- RSS: Received Signal Strength
  - Power level of signal at the receiver
  - In dBm, like the Transmission Power
- Noise floor
  - Lower measurement/detection level
  - Typically around -95 dBm
- SNR: Signal-to-Noise-Ratio
  - SNR [dB] ≈ RSS – Noise floor [dBm]
  - Higher = better (easier to detect signal – less errors)

Factor: Transmission Rate

- Influences signal modulation
- Depends on standard
  - 1 .. 11 Mbit/s (802.11b)
  - 6 .. 54 Mbit/s (802.11a/g)
  - 7.2 .. 150 Mbit/s (802.11n)
    depends on Guard Interval and channel bandwidth
  - 7.2 .. 780 Mbit/s (802.11ac)
    depends on Guard Interval and channel bandwidth
- Can be set manually or by Rate Control Algorithm

→ Is high rate always good?

Transmission Rate

- Higher rate:
  - Faster data transfer
  - More sensitive to signal distortion
- Lower rate:
  - Slower data transfer
  - Less sensitive to signal distortion

Metric: Frame Delivery Ratio

- Measure for reliability of a link (Layer 2) in one direction
- N_{Sent} = Number of generated and sent frames
- $N_{Received}$ = Number of successfully received frames
- (Observe MAC sequence numbers in header)
- FDR = N_{Sent} / $N_{Received}$ for each 100 ms

Summary

- Metrics: RSS, SNR, Frame Delivery Ratio
- Factors: Channel, Transmission Power, Rate
- Performance also varies with:
  - Antenna (directional transmission)
  - Distance (devices move, obstacles)
  - Interference (other stations, microwaves...)
- Further reading:
  “Fundamentals of Wireless Communication”
  http://www.eecs.berkeley.edu/~dtse/book.html

Data processing and evaluation

Data sets

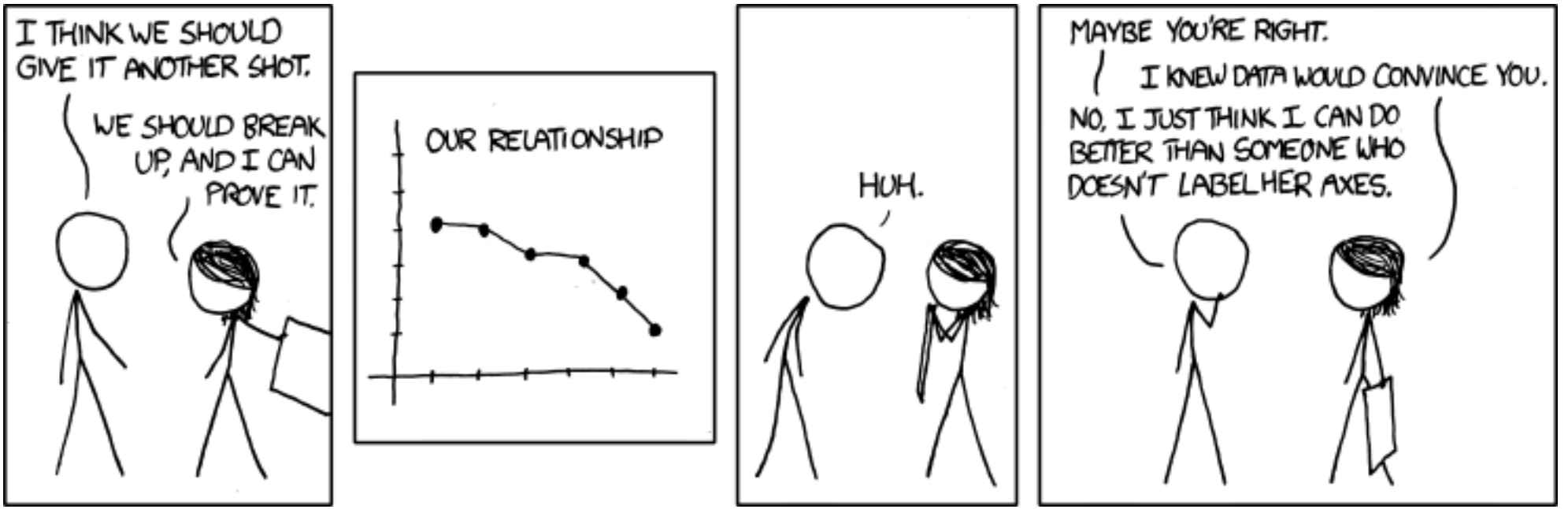
- Typical wireless experiment:
  - Run experiment with different factors (transmission power, channel, transmission rate...)
  - Collect packets (e.g. using tcpdump)
  - Get metric = a list of data points (values) e.g. RSS of every packet
- Data set
  - Can compute median, quantiles...
  - Plot histogram, boxplot...
  - Confidence interval of median RSS (95%)

Plotting

- Use a tool of your choice
  - R, Octave, Matlab, ...
  - ggplot, python-matplotlib
  - Or anything that can produce plots, histograms, boxplots, with confidence intervals
- Make the plot **large enough to read**, but small enough to fit multiple plots on 1 page
- Optimal: Readable in greyscale
- **Label** your plots (transmission power, rate, channel...)

Plotting

- Label your axes!



Source: Randall Munroe, xkcd.com

Performance evaluation

- “How does changing a factor influence the values?”

  → How does transmission power influence RSS here?

- Compare data
  - e.g. the RSS with low transmission power and high transmission power (channel and rate stay the same)
  - Plot two or more data sets next to each other
  - One factor changes, all other stay the same

Comparison of data sets

- Look at median, confidence intervals
- Observe:
  - Absolute values
  - Relative values (in comparison)
  - Dispersion
  - Any extreme cases? Outliers?

Interpretation of results

- What did you expect? (802.11 knowledge)
- Does your observation match your expectation?
- If it does not match...
  - Don't panic :)
  - Double check your scripts and setup
  - Maybe something else influenced performance?
    (Hidden factors = Influences that you did not know about or account for)