Mobile Capacity measurements and estimation

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Developing the Science of Networks

Motivation-state of the mobile internet

- Efficient usage of spectrum is increasingly important.
- Smarter bandwidth allocation can greatly increase the utility of an eNodeB.
- So, we propose a threefold solution:

Lightweight measurement tool

↓

Bandwidth estimation algorithms

↓

Bandwidth optimization algorithms

Data transfer over cellular networks

- Cells transmit symbols not bits.
- A symbol is matched to bits based on a modulation and coding scheme (MCS)

Good channel quality

Efficient MCS

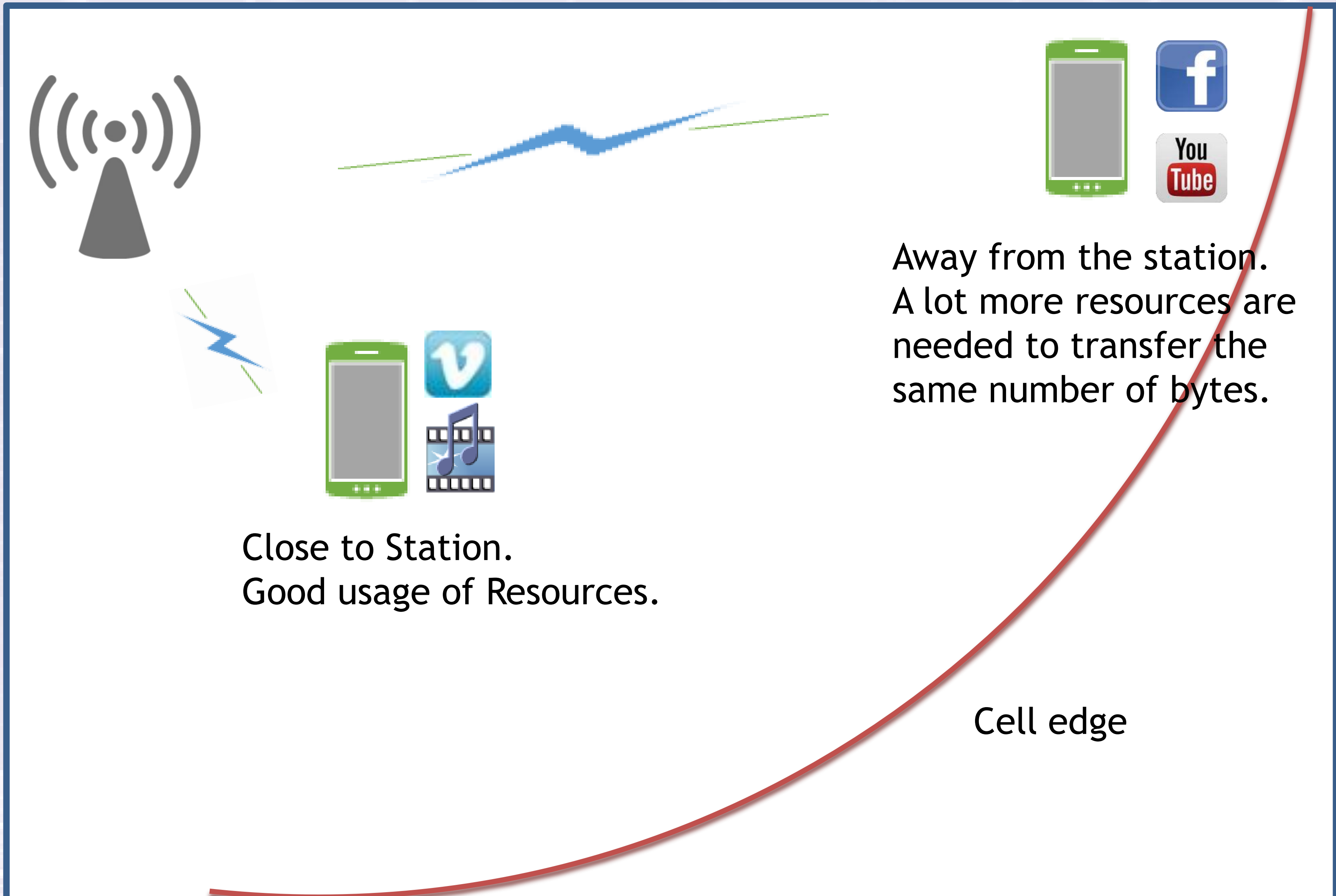
A lot of bits per symbol

Bad channel quality

Robust MCS

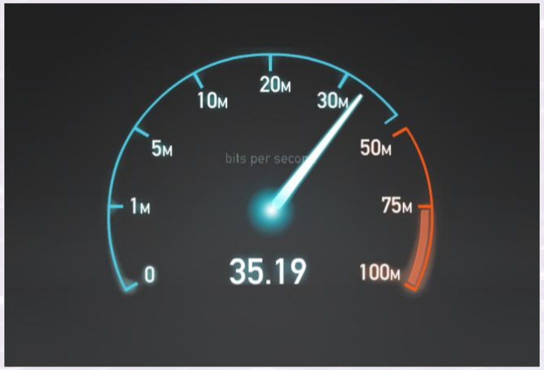
A few bits per symbol

Data transfer over cellular networks

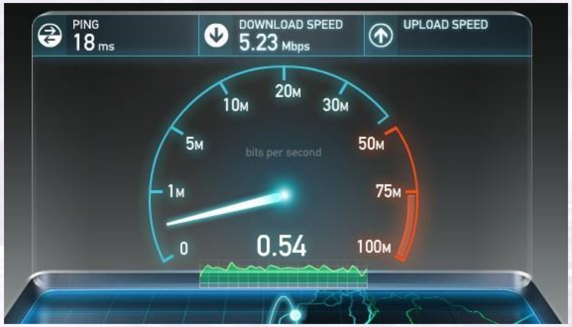


Optimization of Media delivery.

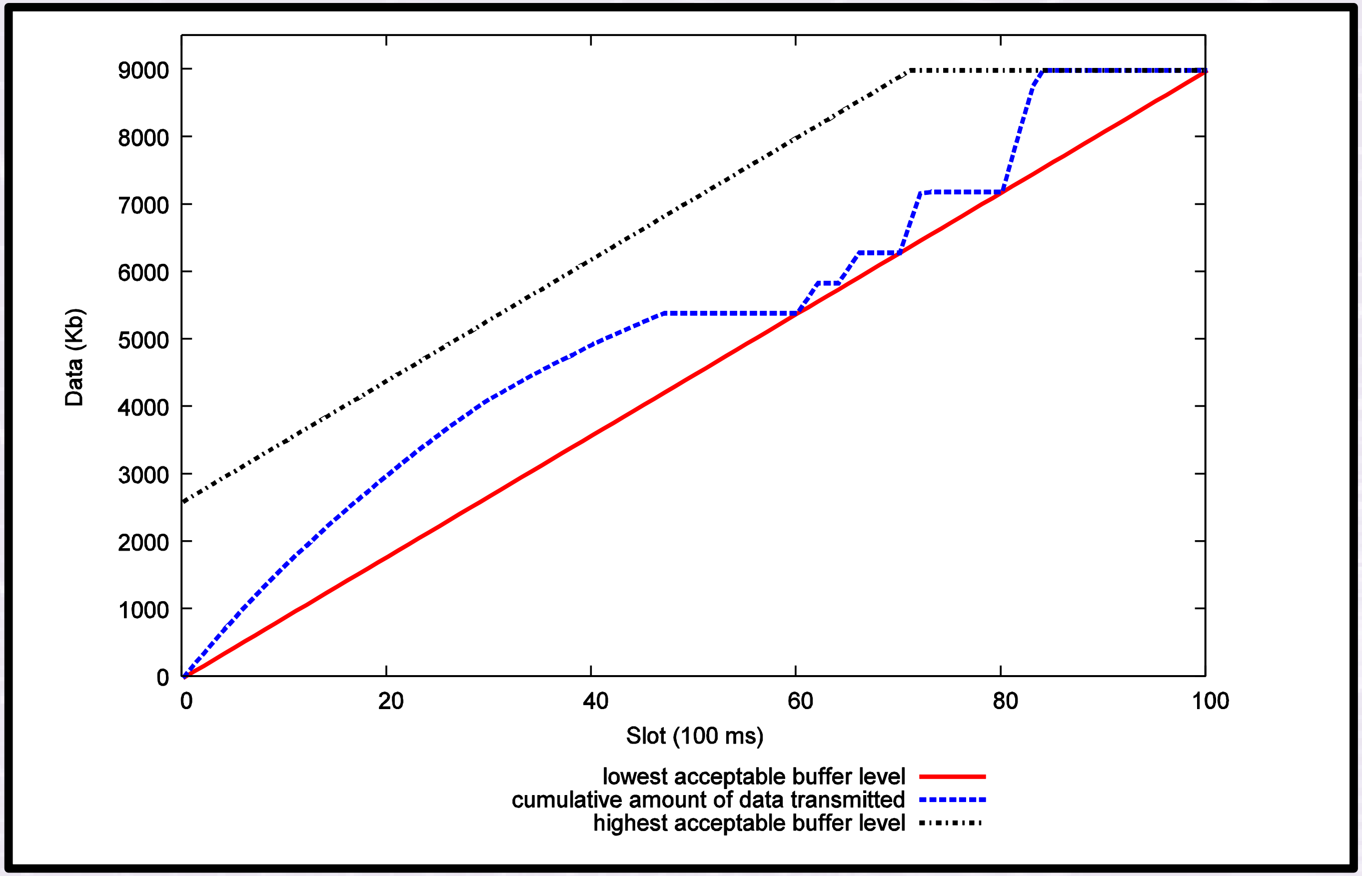
- Use as much capacity as possible when channel conditions are good / there is little competition, in order to build up a buffer



- Avoid using resources when channel conditions are bad / there is competition and rely on the buffer to ensure smooth playback.



Bandwith allocation optimizer-A look a the buffer

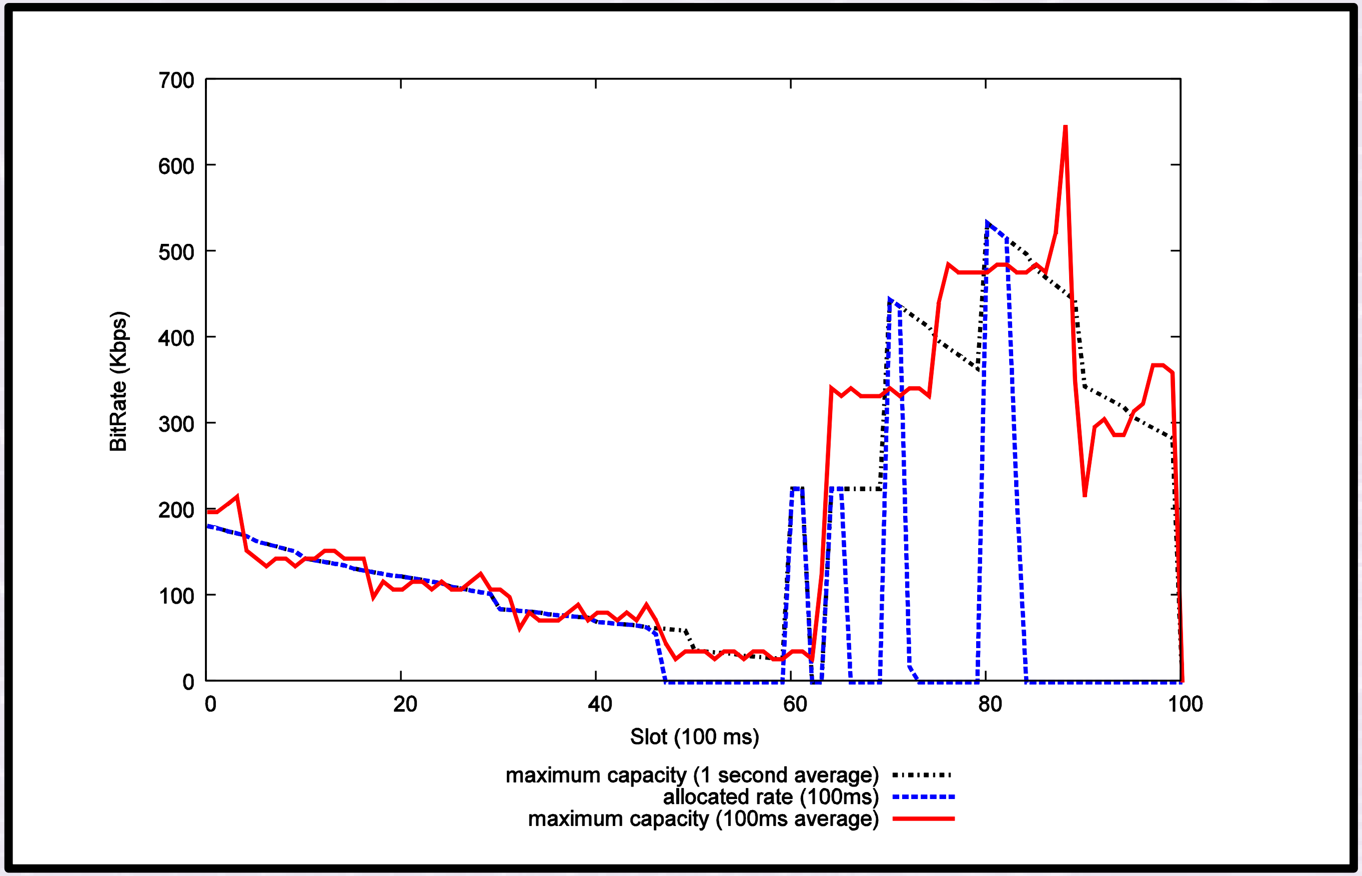


The received data at the client (blue) should be:

•Above the minimum data that need to be received in order to ensure smooth playback (red). If not, rebuffering delays.

•Below the maximum data that the client is able to receive (black). That is data that it has already consumed + buffer size. If not, buffer overflows.

Bandwith allocation optimizer-A look at the capacity



We are not able to have a perfect estimation of the capacity (red). Instead, we assume we have a good enough prediction (black). Based on this information, the optimization criteria, the buffer constraints and some robustness requirements, we transmit at the optimal rate (blue).

Mobile Bandwidth Measurement APP

1 APP 3 Components

- Passive: Creates datapoints by monitoring traffic generated by 3rd party APPS
  - Very small footprint
- Active: Creates datapoints by performing measurements.
- Context: location, time, CQI

Active TCP measurements (1 thread)

A single TCP stream from a well located server.

- Speedtest.net Servers
- Servers that belong to the mobile operator

- Less chance of packet loss or noise caused by the Internet backbone.
- Much easier implementation

Multithreaded TCP Active measurements

3 parallel TCP connections to 3 different servers.

•The measurement is not greatly affected by packet loss or other events that could be interpreted by TCP as congestion.

•Huge bursts of UDP traffic could be potentially Blacklisted by operators.

Active measurements overview

- Used as benchmark for the passive measurements
- Automated version as datapoints

Passive measurement component

- Controls TCPdump instances.
- Keeps track of the amount of data sent and received by all the applications of the phone (1-second interval):
  - Bytes
  - Packets (if supported)
- Based on the active measurement calibration:
  - **“Rate unconstraint” Apps**: maximum bandwidth that can be allocated at that point
  - **Rest of the Apps**: lower limit of the Maximum bandwidth that can be allocated at that point

Passive measurements (on going work)

- a lot of APPs make use of Google cloud messaging
  - ➢Good for battery life and network utilization.
  - ➢Bad for creating passive measurement datapoints.
- Possible solutions
  - ➢TCP slowStart estimation.
  - ➢Speedtest right after a periodic transfer.
  - ➢Study the general characteristics of good and bad connections in regards to slow start packet placement.

Screenshots

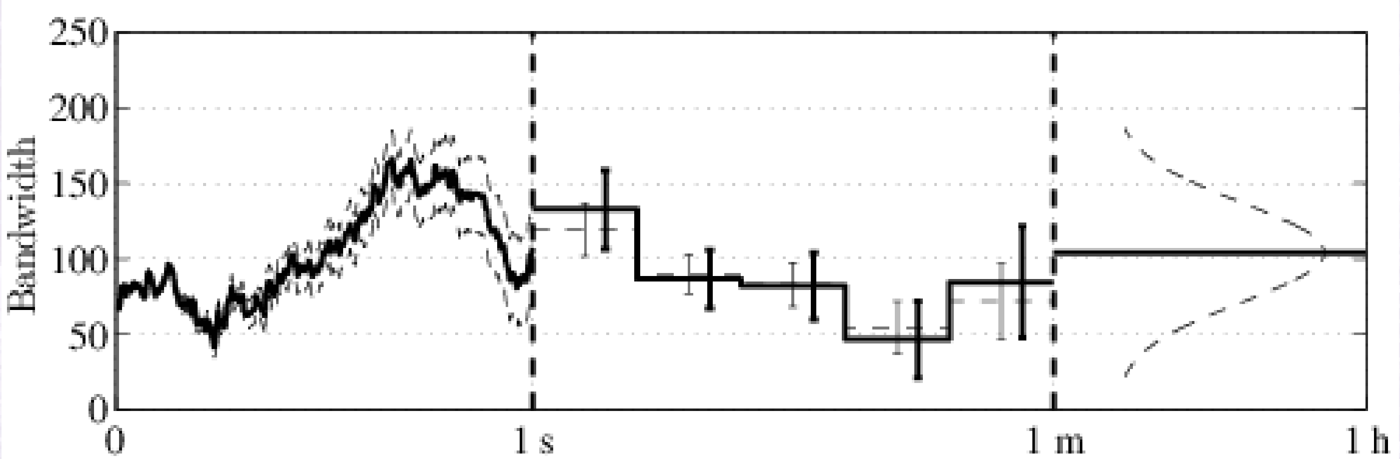
Time-location throughput maps

- We plan to create our own database with:
  - location
  - time of day
  - bandwidth
- Collaboration with Nornet for mobile trace
  - other freely available traces

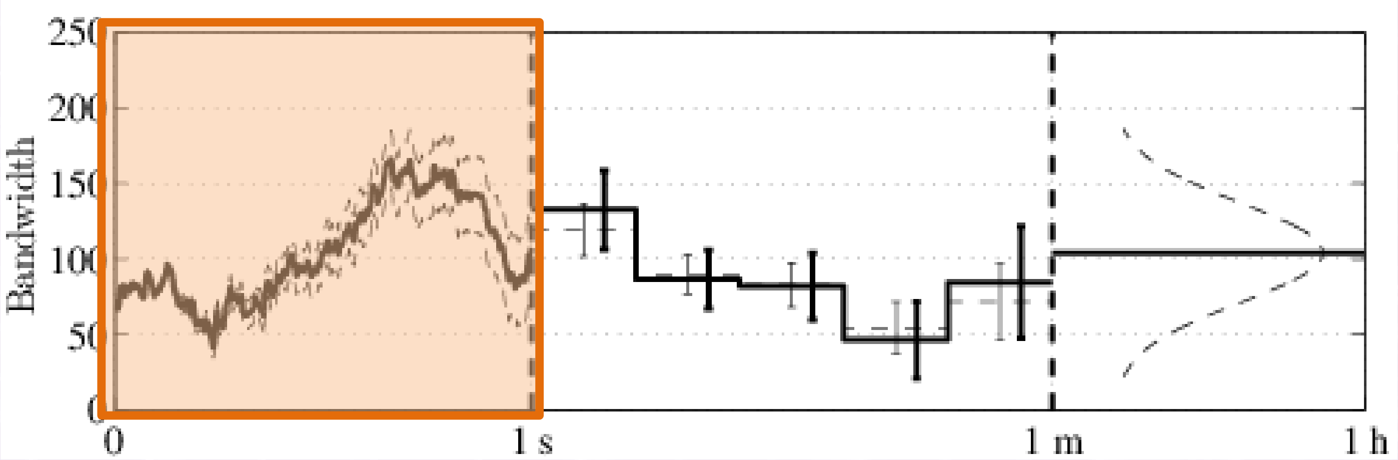
Estimation

Model

- Idea

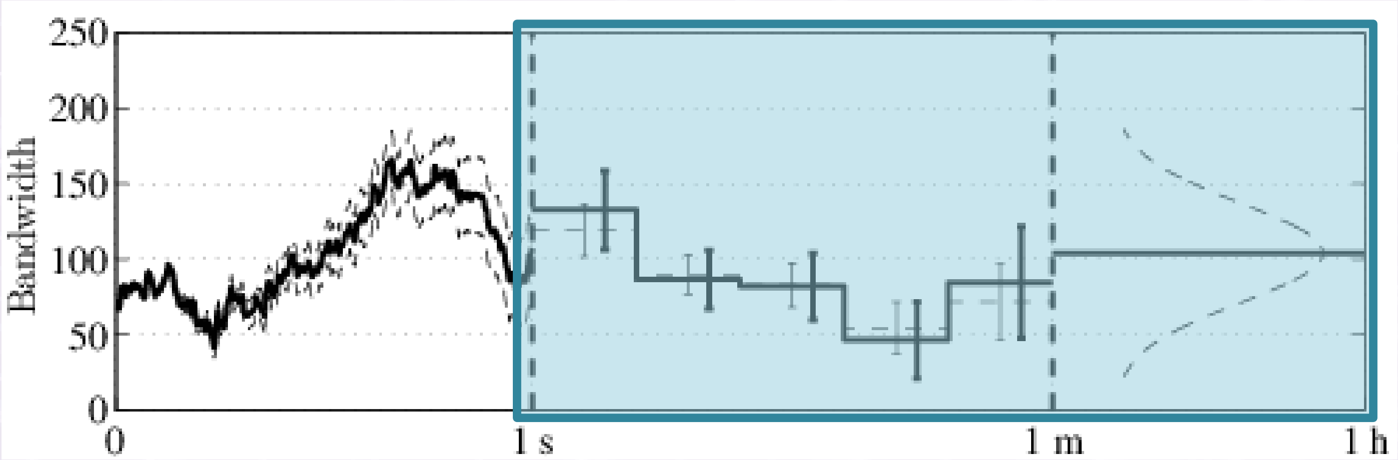


Model



- Idea
  - Short scale: approximate the exact variation of the throughput time series by means of autoregressive filters

Model



- Idea
  - Short scale: approximate the exact variation of the throughput time series by means of autoregressive filters
  - Medium-long scale: approximate the statistic distribution of the throughput accounting for uncertainties (user position, cell congestion, fading, etc.)

The big picture

1. Finalize **passive measurement app**
2. Conduct further **measurement campaigns**
3. **Derive** and **evaluate** bandwidth availability prediction algorithm
4. Content pre-fetching based on network knowledge

Collaboration opportunities

1. Creation of time location throughput maps.
2. Datasets that will allow for the implementation and testing of prediction and optimization algorithms.

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NORNET

CoNEXT 2014 paper (Under submission)

- Packet dispersion technique tuned for mobile Networks.
- Estimates:
  - Per user capacity
  - Asymptotic dispersion rate
- **Lightweight:** Its input is only already existing traffic.
- Is able to provide accurate results with a fraction of the exchanged packets (in some cases just tens of packets).
- Is not affected by the scheduling process of eNodeBs.
- Verified by **a week-long measurement campaign** in two cities.

Contributions

- Monitoring light data exchanges (periodic APP updates) is sufficient to create good estimations of bandwidth.
- May track fast per user capacity variations (at least 20% sampling rate required)
- Dense sampling support makes it ideal for bandwidth prediction / optimization algorithms.