Mobile Networks (TDDE48)
Fall 2024

Niklas Carlsson

niklas.carlsson@liu.se

www.ida.liu.se/~nikca89/

Note re. purpose + expectations

These scenarios are intentionally (and as intended with PBL) designed to be open ended and give you lots of freedom to practice (1) identifying, (2) exploring, and (3) learning about problems related to each scenario.

For some weeks, there are several choices of scenarios. In some cases, you may select a scenario where some person/people in your group has/have the scenario as their group project and in other cases this will not be the case. Different groups are therefore likely to explore different aspects, as well as cover the topics in both different breadth and depth.

While the scenarios and the problems that you identify are intended to be open ended, if you run short of ideas, the general "theme" is performance in and for mobile systems. You are therefore expected to be able to identify, explore, and learn about performance tradeoffs and optimization aspects related to each of the different scenarios and/or the specific protocols identified relevant to the scenarios.

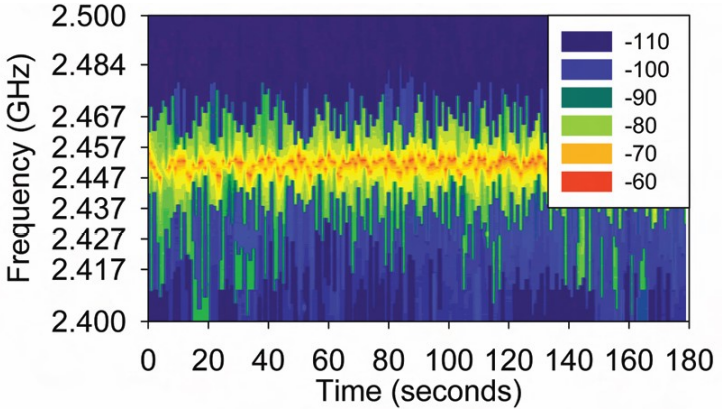
Finally, please use the meetings to explore these scenarios (which is what you do get credits for here) and practice the mentioned skills (which will help you in the longer term), NOT studying for exams (which you get other credits for). (Side note: Yet, some tweaks have been made to provide more opportunities for scenarios to build depth and breadth knowledge useful for the exam.)

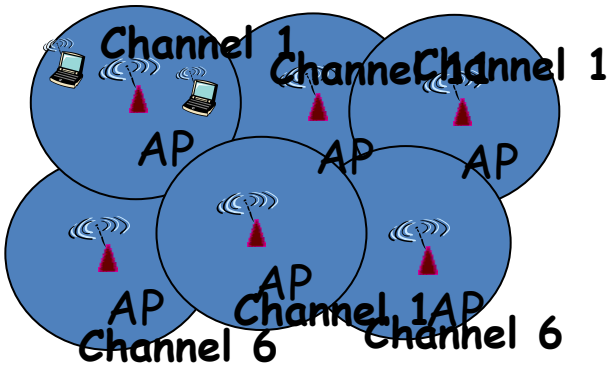
MN-1

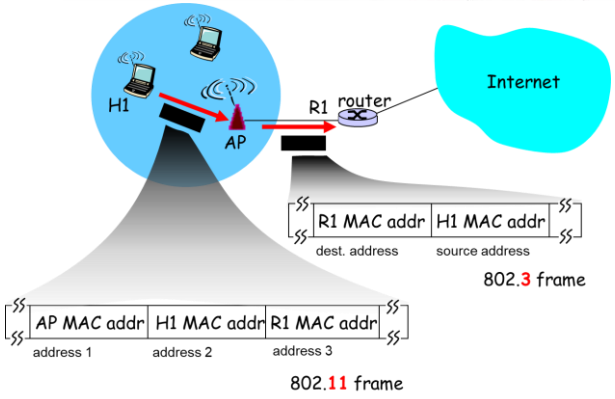
- WiFi speed: Home vs hotspot

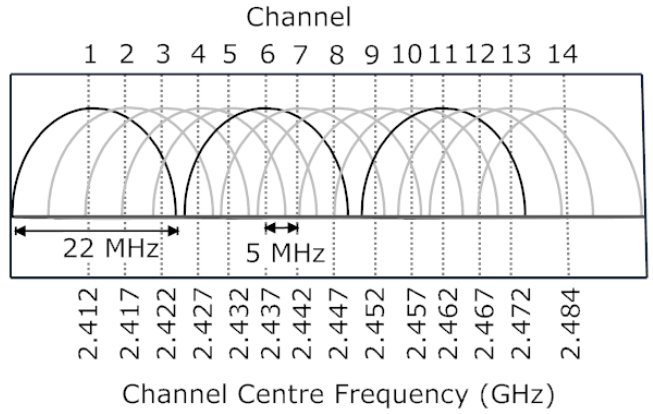
Desired focus: Let us start with a scenario we are all very familiar with and the issues that may arise in this context ...

E2E WiFi speed: Home vs. hotspot









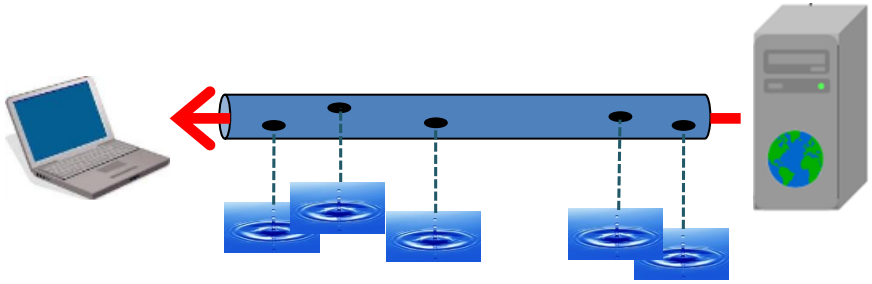
- As you change location, you see different WiFi speed …
- There is a limited bandwidth spectrum ...
- Among other things, **interference** and **channel selection** affect the efficiency of WiFi channel usage …

MN-2

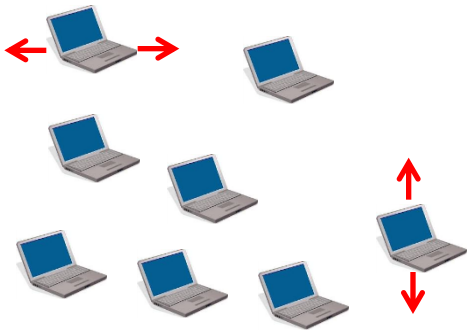
- Tools and evaluation techniques

Desired focus: Help build some understanding for example methodologies that may be useful when studying mobile networks (or doing course projects on the topic) ...

Tools and evaluation techniques

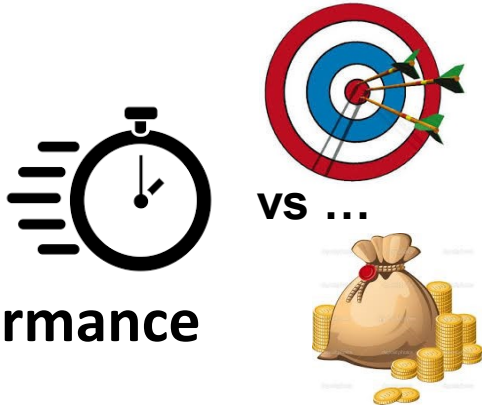


Experiments: e.g., setup and configure connections, bandwidth constraints, delays, packet losses, etc.



Simulations: e.g., using existing or build own simulator that captures mobility, bandwidth, energy, packet losses, protocols, …

Analytic: e.g., using mathematical and statistical tools that you know and/or can learn



- **Method selection when evaluating the performance**
  - Tools? What, when, why ...? Tradeoffs …
  - Example: Consider a new feature that you intend for 3G, 4G, 5G, ...
  - Performance questions related to your group projects?

MN-3

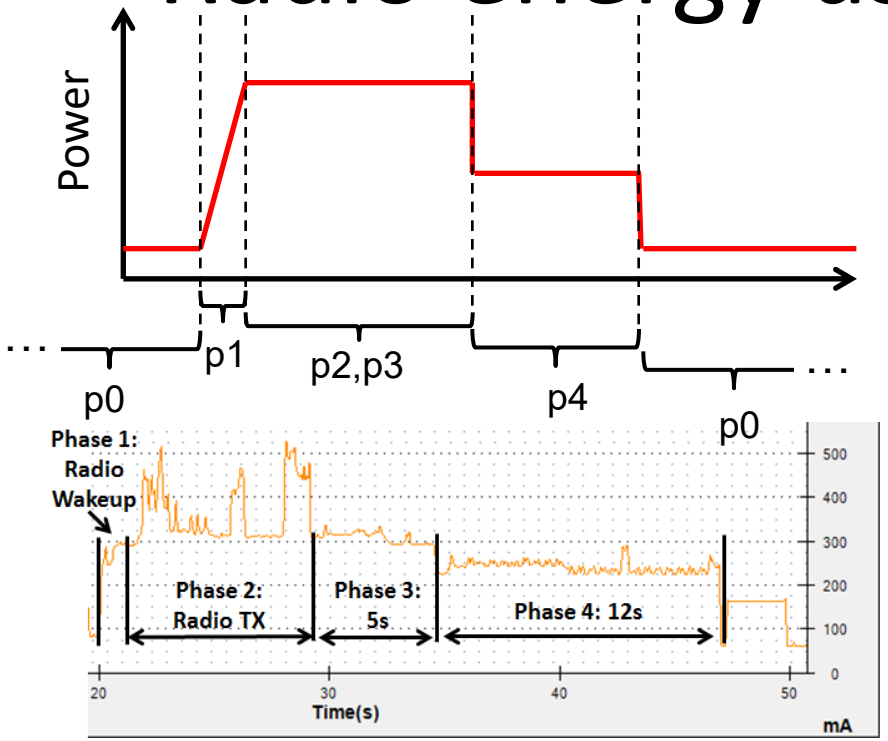
- One of the following five
  - BG1: Radio energy usage
  - BG2: Energy optimization: WiFi vs 3G/4G/5G
  - BG3: Energy optimization in 6G
  - BG4: Power-aware routing
  - BG5: Multi-path throughput optimization

  Desired focus: Please place particular focus on example (sub)problems that may be important to optimize ...

  BGx groups, defined as per this website

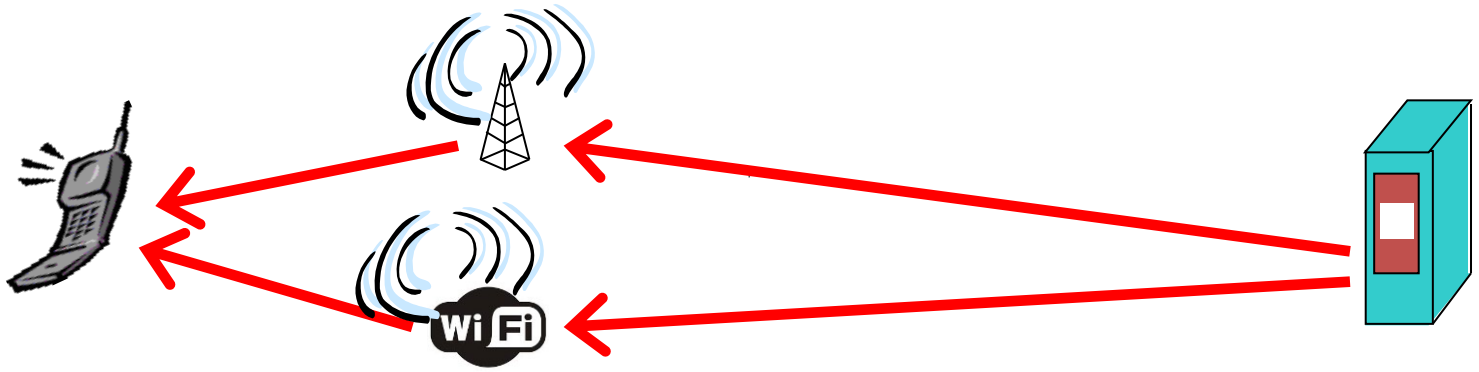
  https://courses.mai.liu.se/GU/IT-termin5/index.html

Radio energy usage: WiFi or LTE



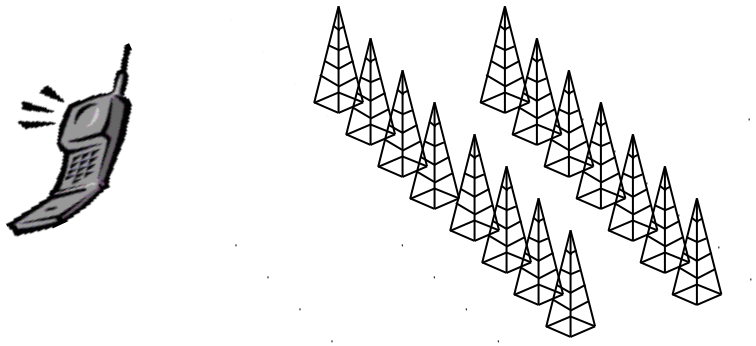
- Phones etc. have limited batteries, with the radio consuming some fraction of the total energy usage ...
- (Optimal) **energy-delay tradeoff** (e.g., delay-tolerant protocol using PSM with multiple power levels)
- Power model (e.g., simple on-off or more complex)
- *Impact of mobility (e.g., when driving your hybrid low-power car)*

Energy optimization: WiFi vs 3G/4G/5G



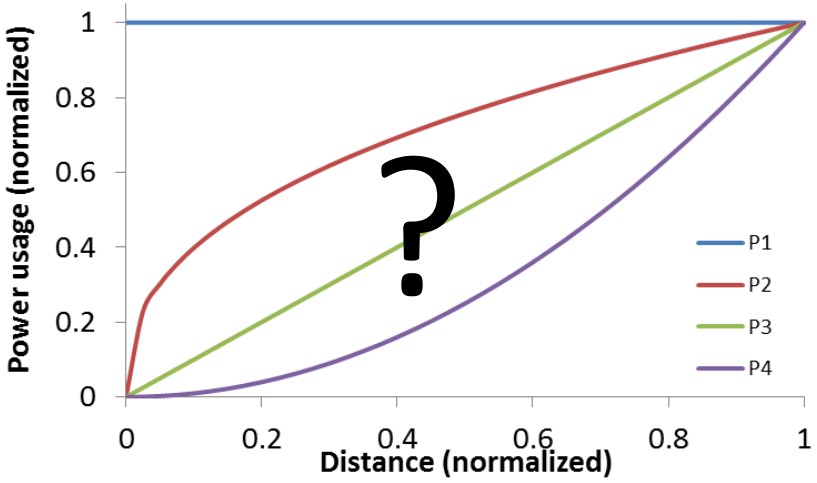
- Smartphones can typically use both WiFi and 3G/4G (each with different characteristics) …
- Imagine that you are a developer and want to implement a protocol that **minimizes** the energy usage associated with downloading a large file, given access to both technologies and some download time constraint …
- Impact and opportunities associated with mobility (e.g., when driving your hybrid low-power car), use of MPTCP, or ...

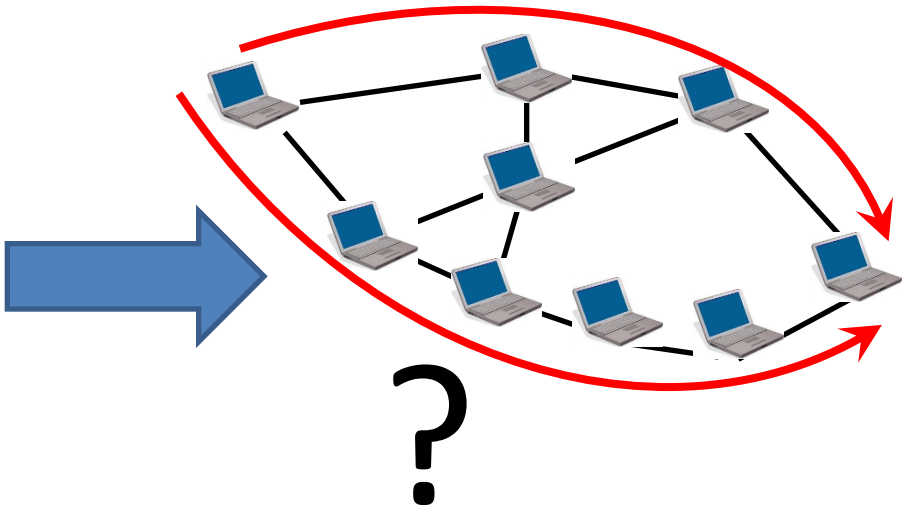
Energy optimization in 6G



- 6G ? 7G ?
- Use-cases of the future …
- Optimization objectives of the future?
- Technical challenges and solutions of the future …
- Who and how can benefit from tomorrow’s energy saving solutions?

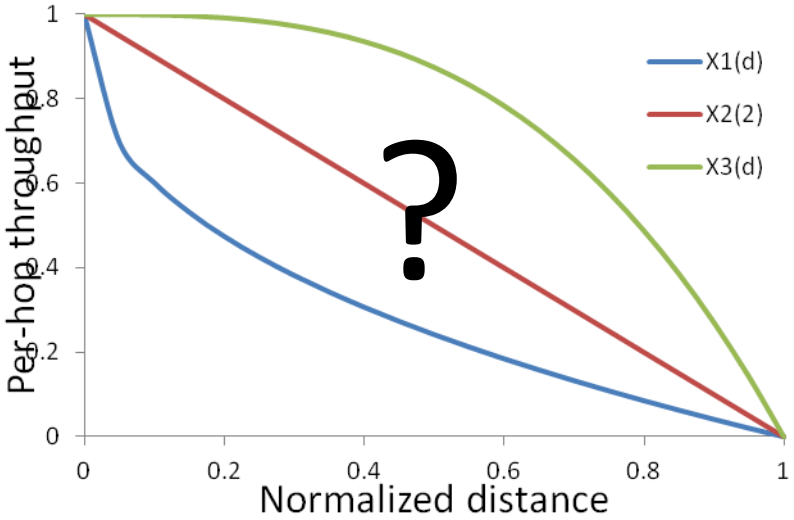
Power-aware routing

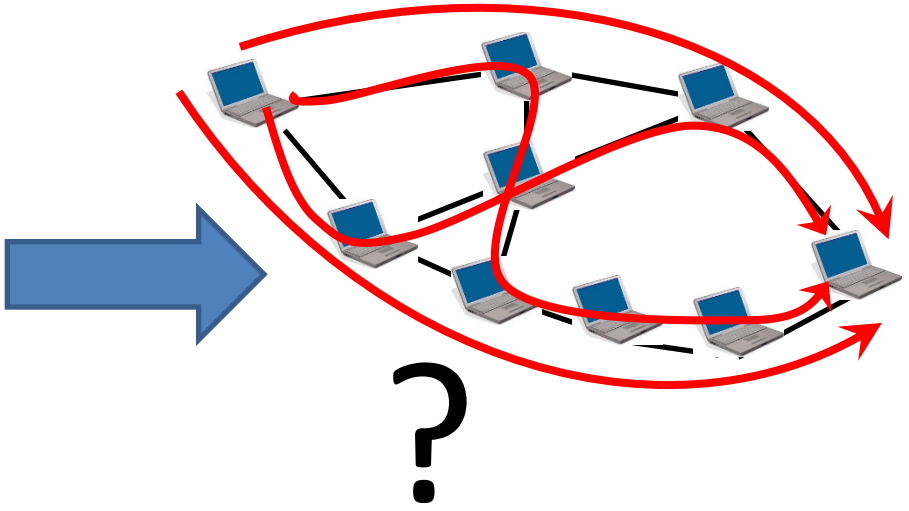




- Reasonable per-node power model for information transmission
- (Optimal) **energy-efficient path** for a topology
- Distributed vs central routing decisions ...

Multi-path throughput optimization





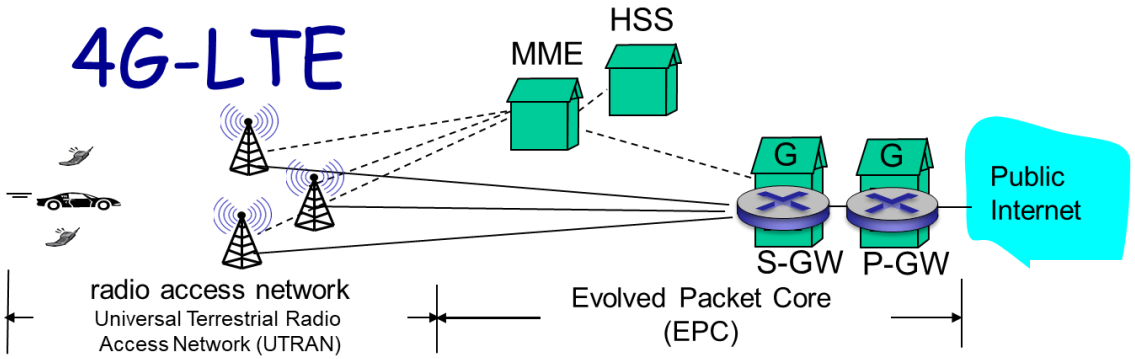
- Reasonable per-node throughput model for information transmission
- (Optimal) multi-path **throughput** for a topology
- Distributed vs. central routing decisions ...

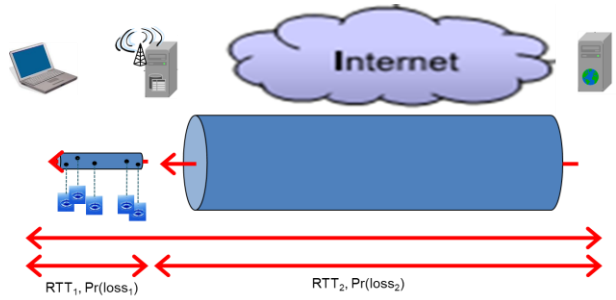
MN-4

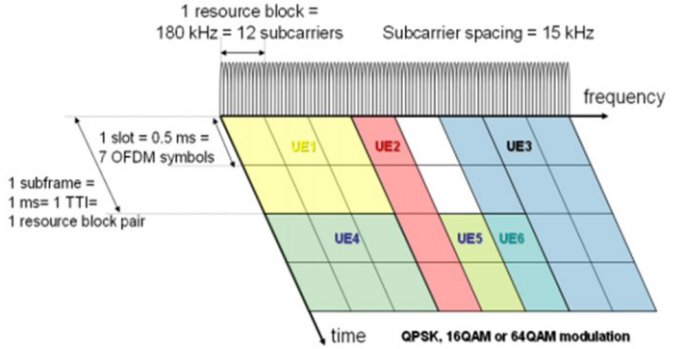
- Why I only get a small fraction of the advertised 4G speed …

Desired focus: Differences between theory and practice (e.g., how close to the theoretic optimal schedule we expect to achieve, and can we always expect it) ... the world is complex.

Why I only get a small fraction of the advertised 4G speed …







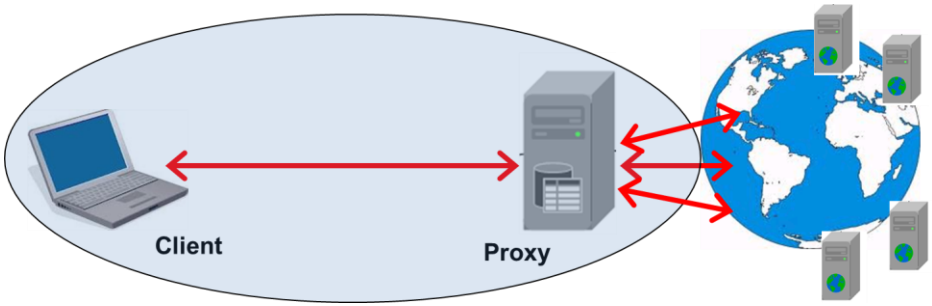
- End-to-end arguments (complexity and end points), middleboxes, channel interfaces, bottlenecks, etc. …
- (Optimal) theoretic throughput vs measured throughput
- How much can my application(s) fill the end-to-end pipe?

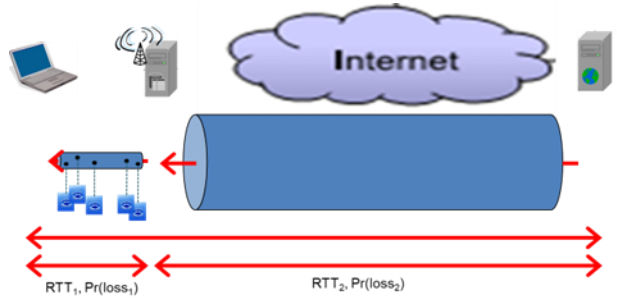
MN-5

- As a group, select one of the following five
  - Cache optimization, prefetching, and resource usage
  - HTTP-based adaptive streaming
  - Traffic analysis and privacy
  - Mobile web, personalization, and privacy
  - VR, AR, MR, gaming and interactive streaming over LTE

Desired focus: Finally, let us consider the mobile networks in the context of some example applications and services ...

Cache optimization, prefetching, and resource usage

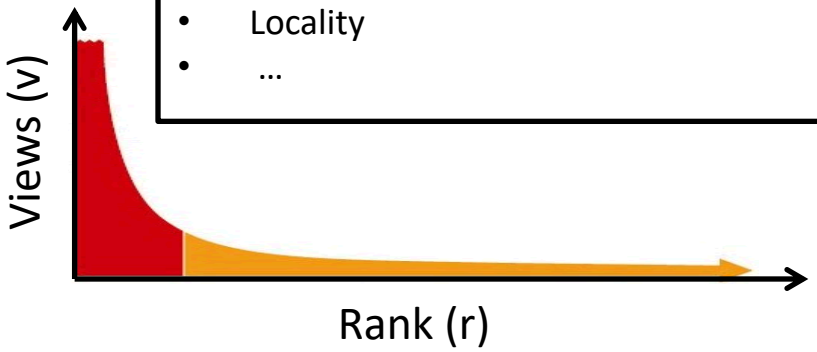




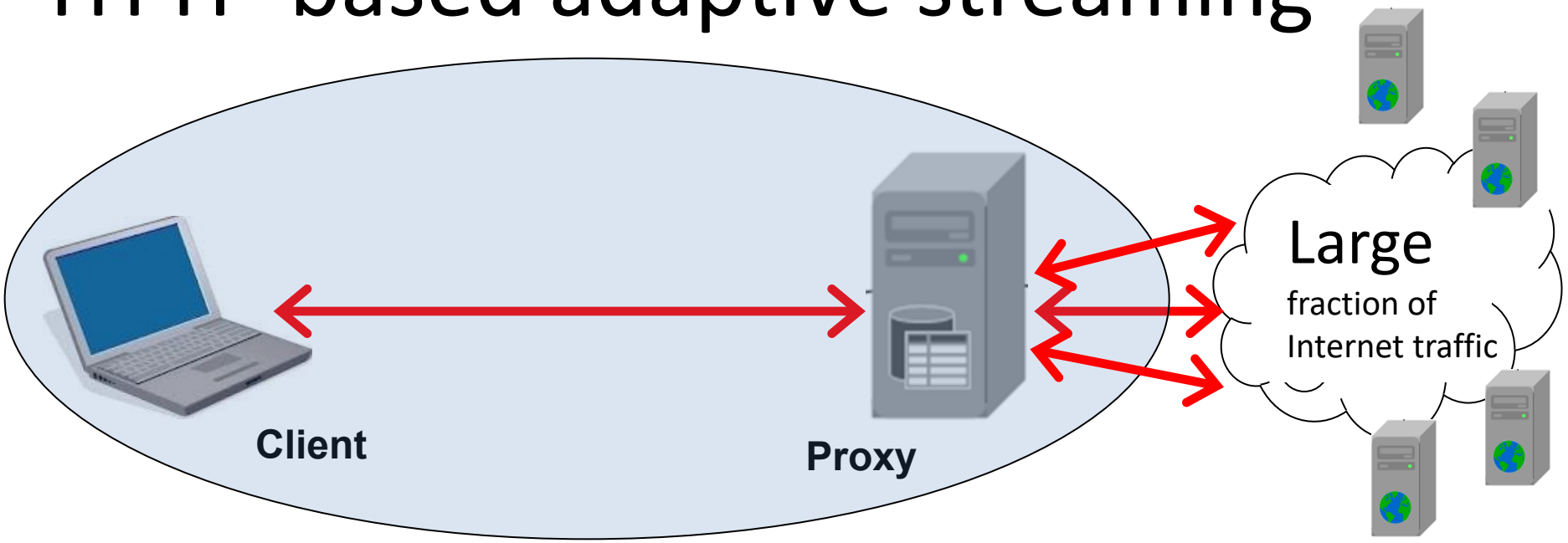
- Heterogeneous clients: PCs, tablets, phones, ...
- Mobile clients ...

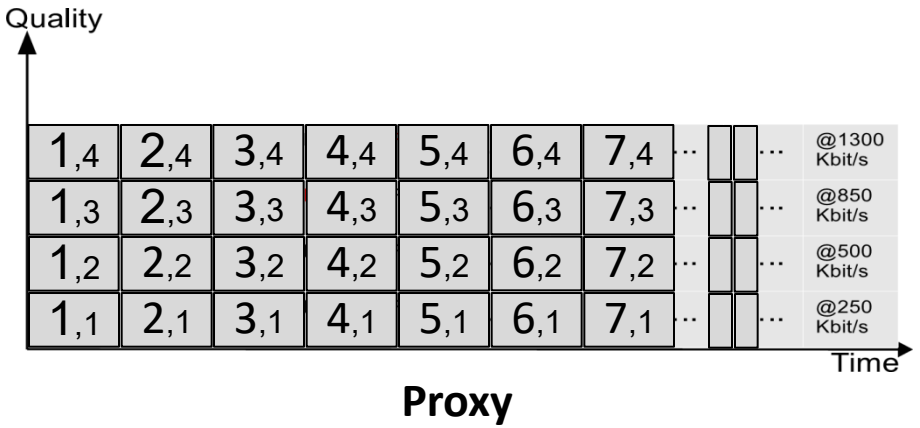
Example factors (miss cost and hit rates):

- Cache size
- Content type
- Content size
- Popularity
- Locality
- ...



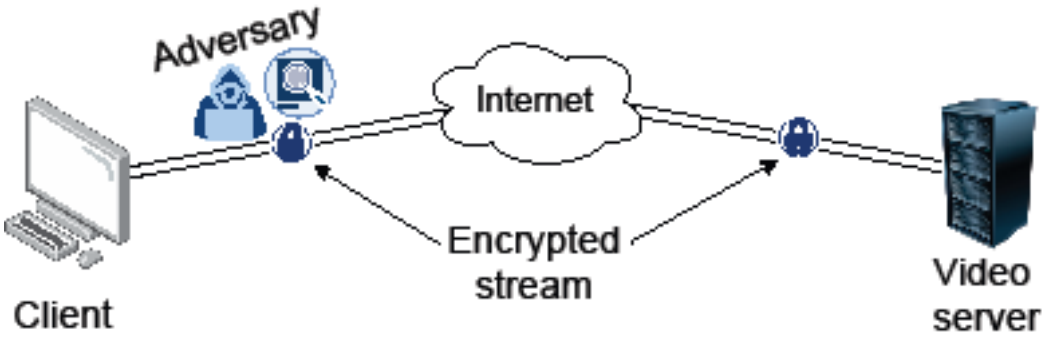
HTTP-based adaptive streaming

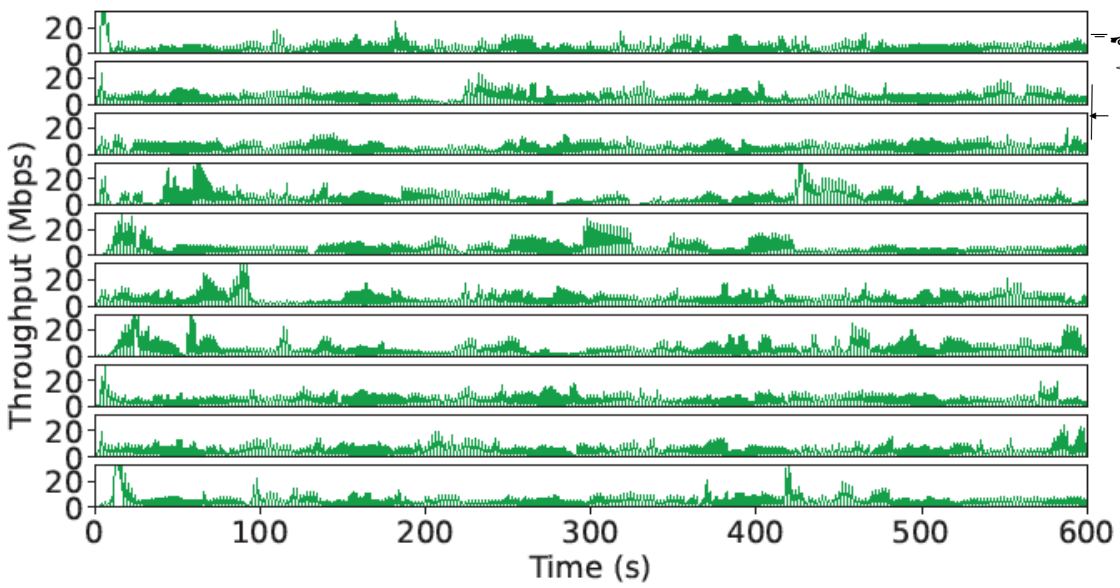


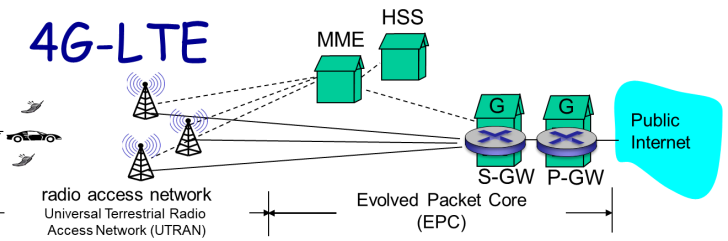


- Resource usage, cache hitrate, ...

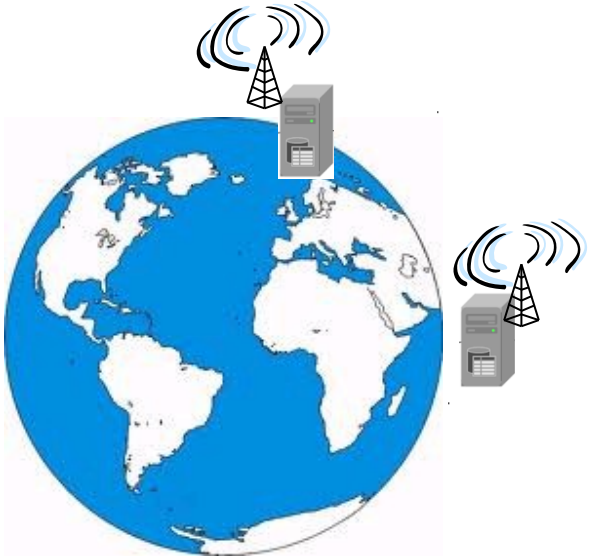
Traffic analysis and privacy







Mobile web, personalization, and privacy



VR, AR, MR, gaming, and “interactive” streaming (e.g., 360 or branched) over LTE

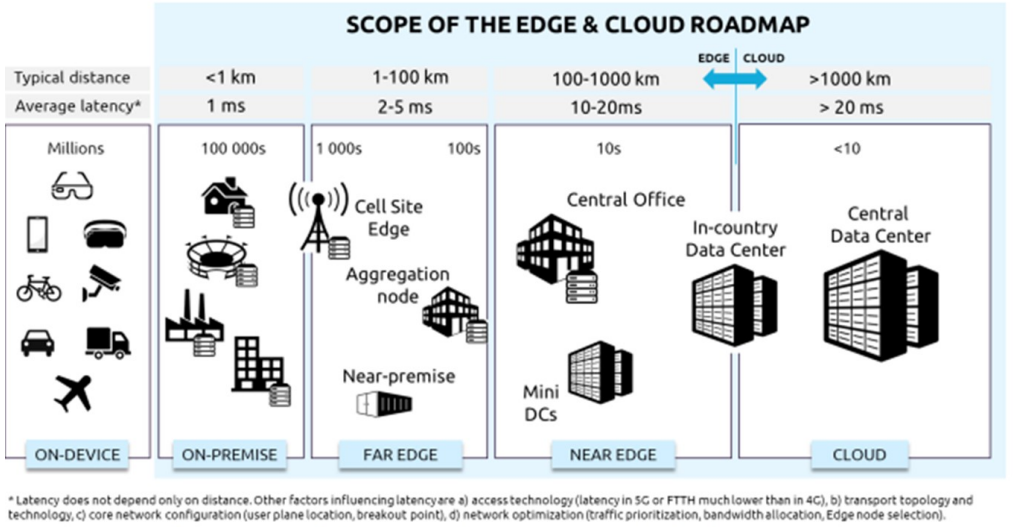


Figure: *Scope of the Industrial Roadmap in the cloud-edge continuum*

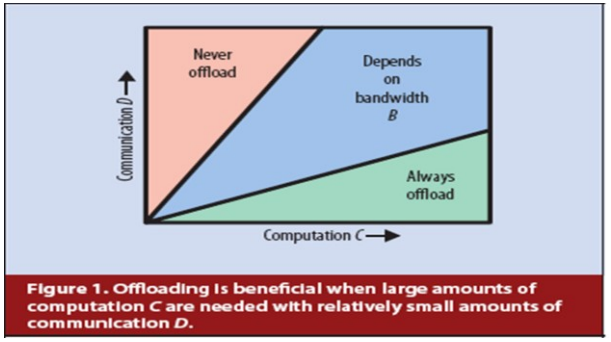


Figure 1. Offloading is beneficial when large amounts of computation *C* are needed with relatively small amounts of communication *D*.

- Requirements
- Delays and packet losses
- Location of processing
- Edge servers, third-party clouds, end-devices, mobile phones, headsets, tablets, PCs, ...