

Mobile Networks (TDDE48)

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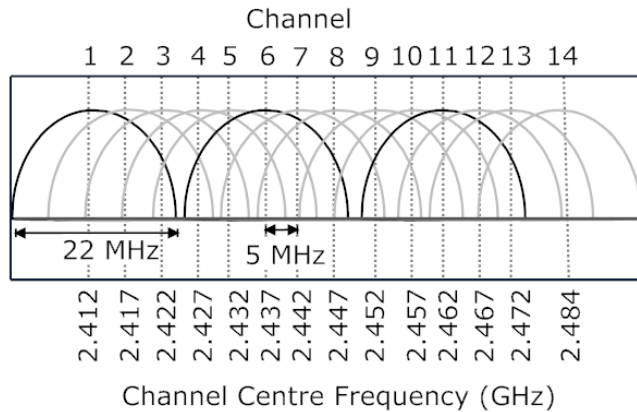
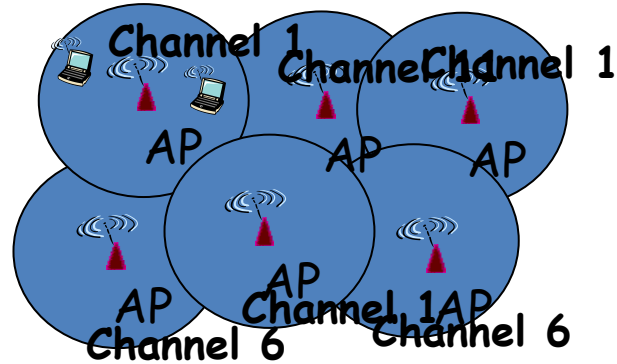
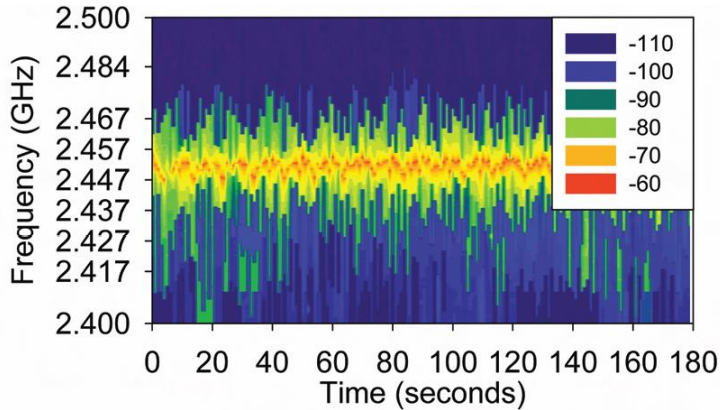
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MN-1

- 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 ...

WiFi speed: Home vs. hotspot



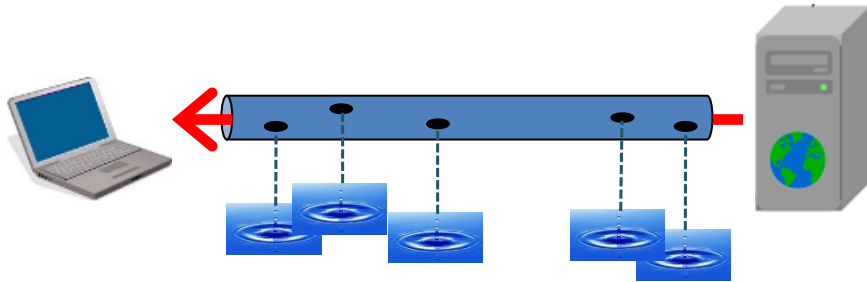
- As you change location, you see different WiFi speed ...
- There is a limited bandwidth spectrum ...
- Among other things, **interference** and **channel selection** affect the efficiency of WiFi channel usage ...

MN-2

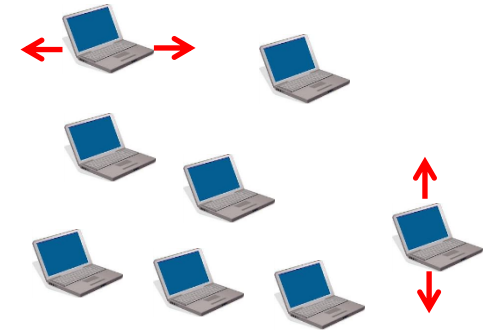
- Tools and evaluation techniques

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



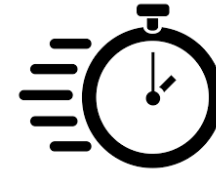
Experiments: e.g., using dummynet (bandwidth, delay, packet losses)



Simulations: e.g., using ns-3 (mobility, bandwidth, energy, packet losses, protocols, ...)



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



vs ...



- **Method selection when evaluating the performance**

- What, when, why ...? Tradeoffs ...
- Example: Consider a new feature that you intend for 3G, 4G, 5G, ...
- How about questions related to your group projects?

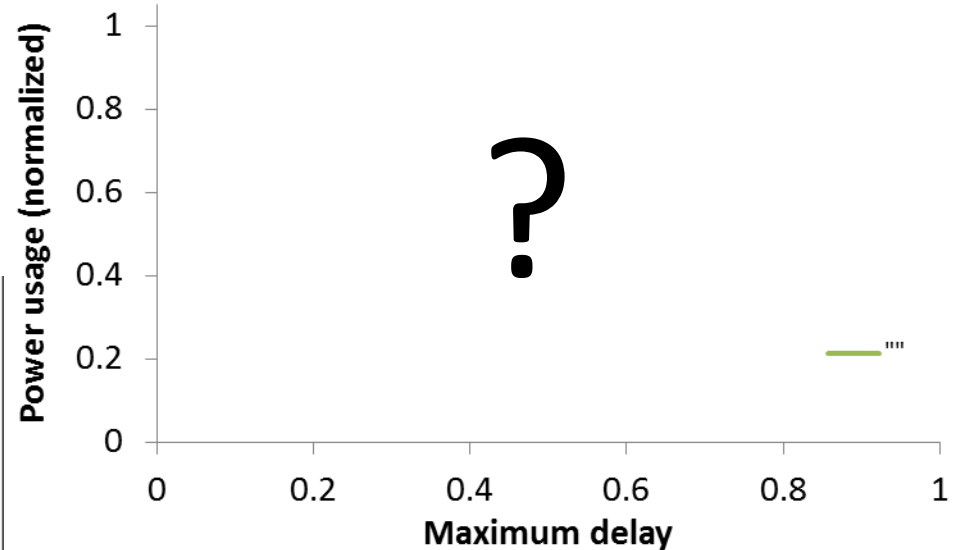
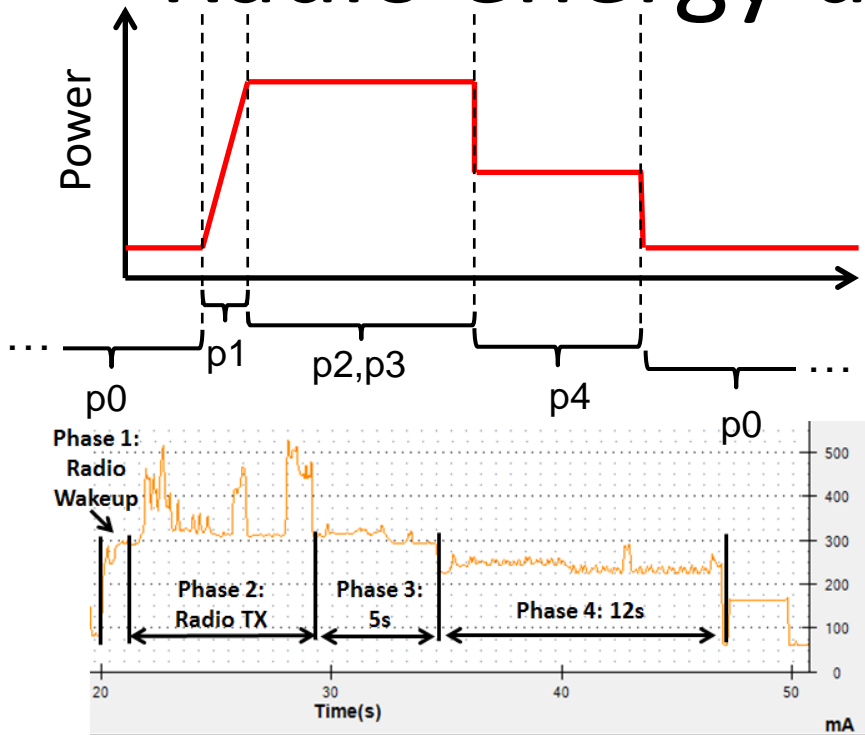
MN-3

- One of the following four
 - 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

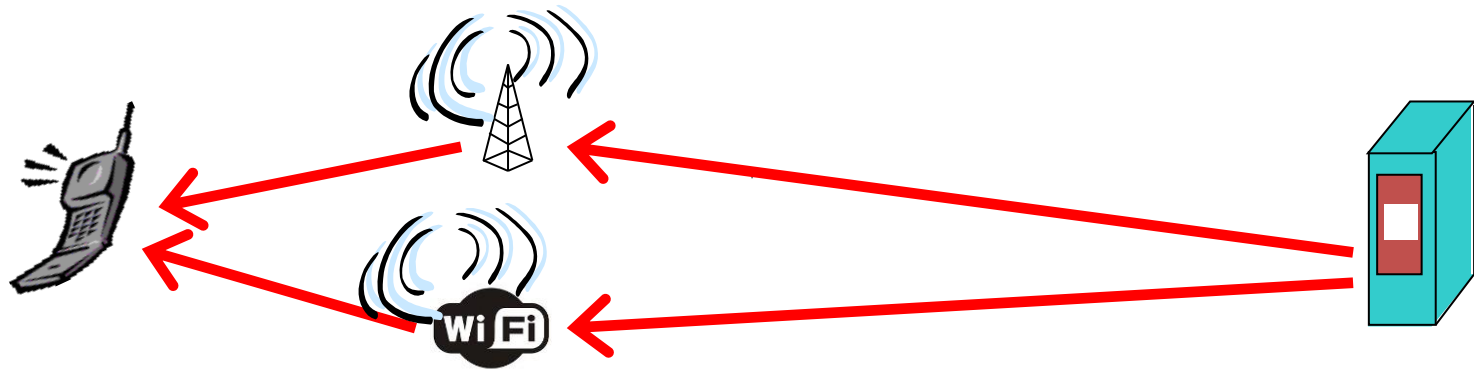
<https://courses.mai.liu.se/GU/IT-termin5/index.html>

Radio energy usage: WiFi or LTE



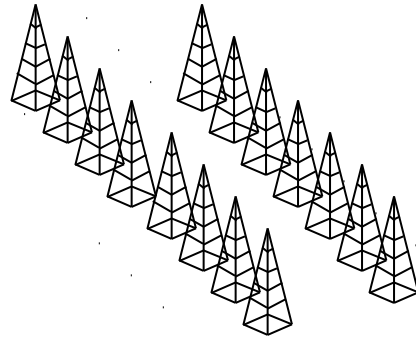
- Phones etc. have limited batteries, with the radio consuming some fraction of the total energy usage ...
- (Optimal) **energy-delay tradeoff** (e.g., delay-tolerant protocol using PSM with multiple power levels)
- Power model (e.g., simple on-off or more complex)
- *Impact of mobility (e.g., when driving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

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



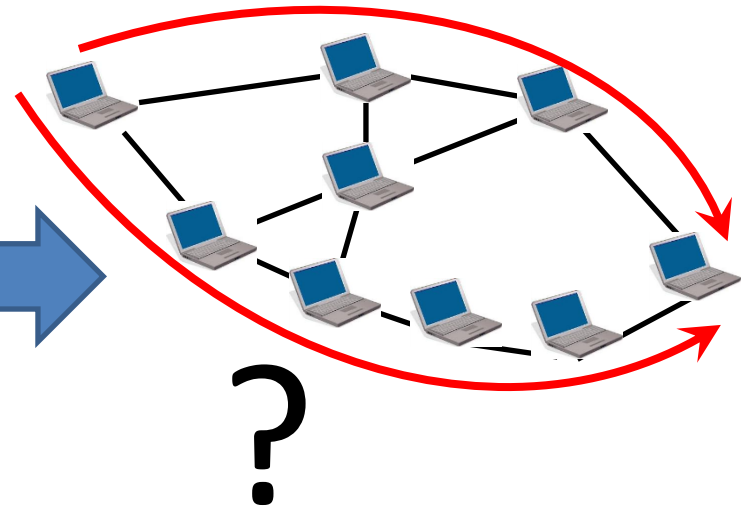
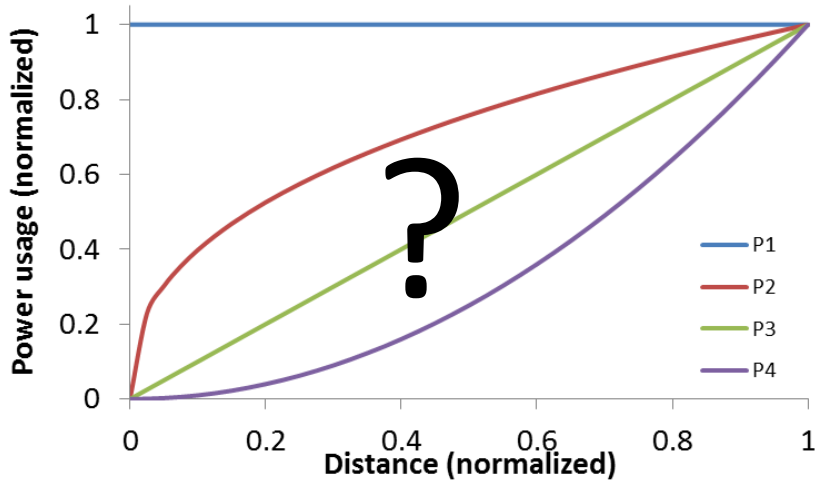
- Smartphones can typically use both WiFi and 3G/4G (each with different characteristics) ...
- Imagine that you are a developer and want to implement a protocol that **minimizes** the energy usage associated with downloading a large file, given access to both technologies and some download time constraint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

Energy optimization in 6G



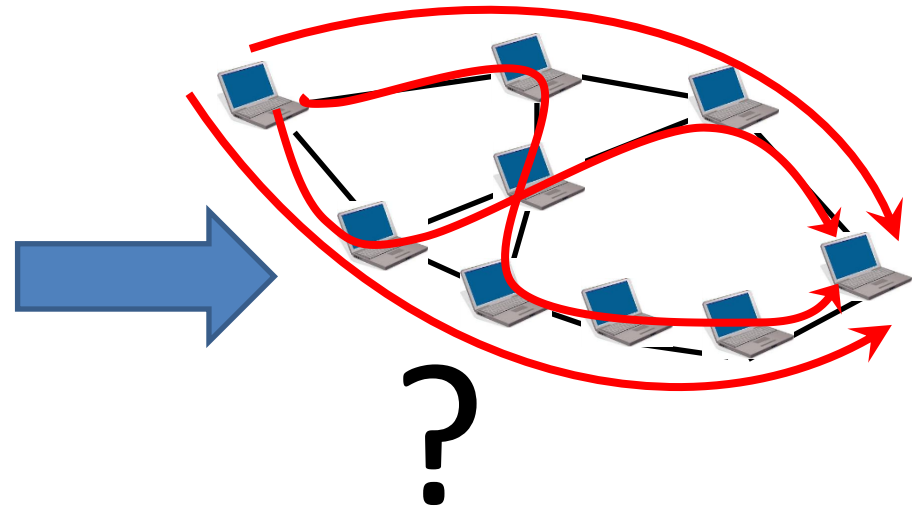
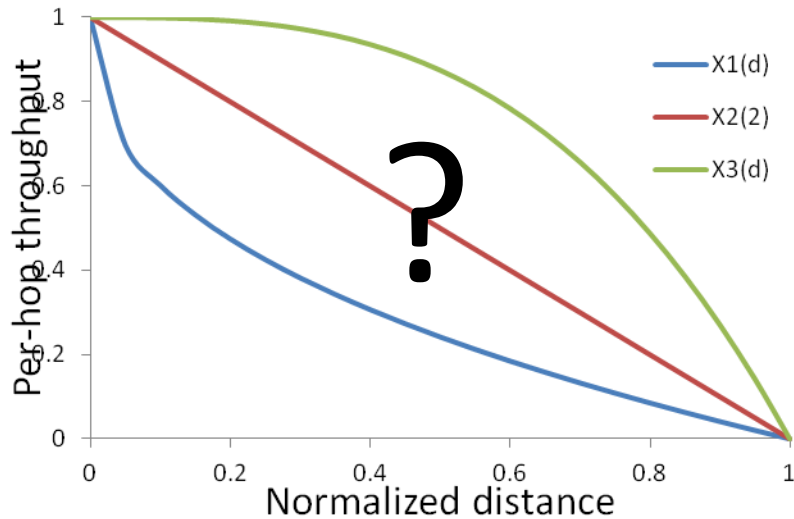
- 6G ? 7G ?
- Use-cases of the future ...
- Optimization objectives of the future?
- Technical challenges and solutions of the future ...
- Who and how can benefit from tomorrow's energy saving solutions?

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



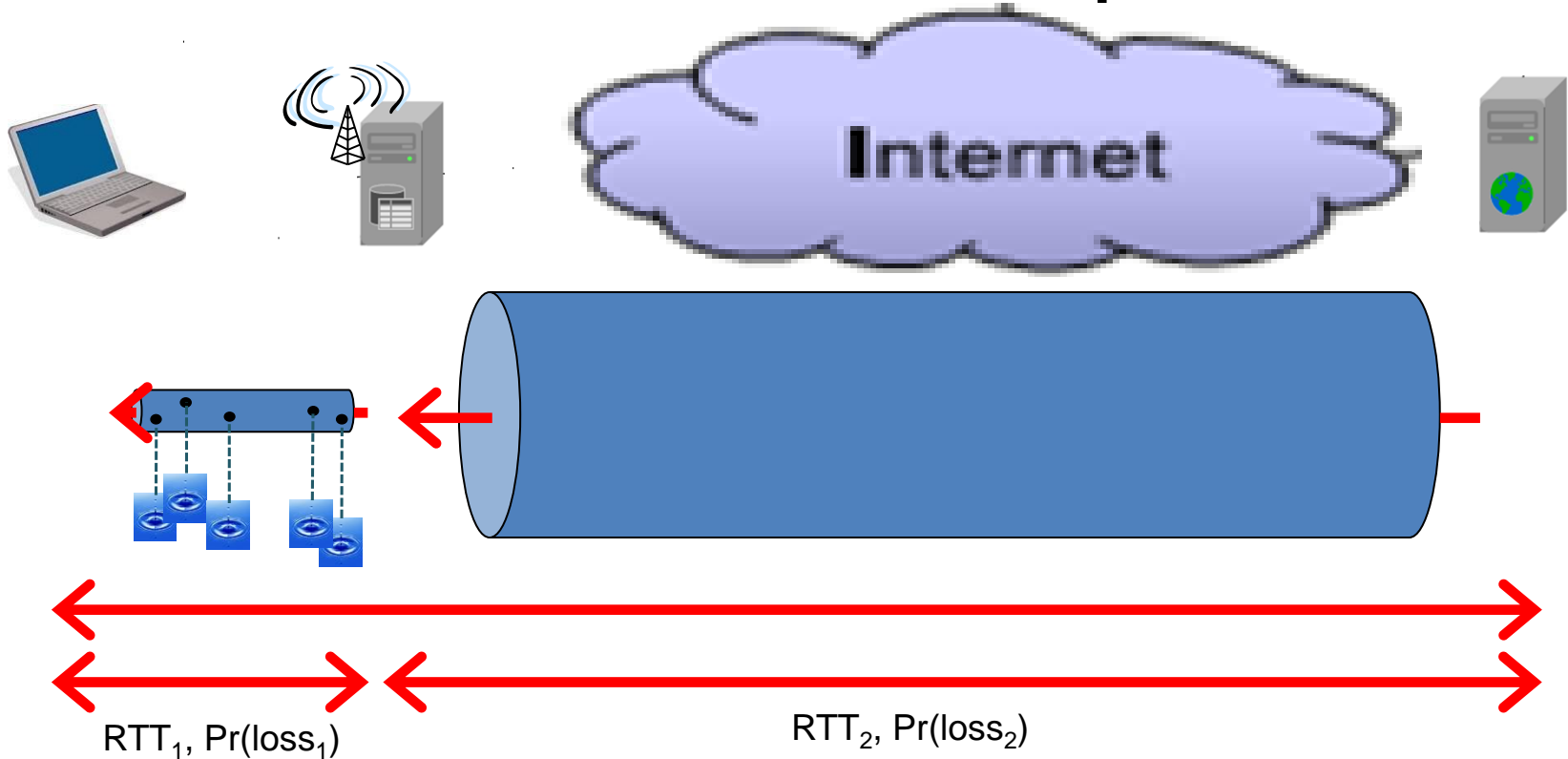
- Reasonable per-node throughput model for information transmission
- (Optimal) multi-path **throughput** for a topology
- Distributed vs. central routing decisions ...

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 ...



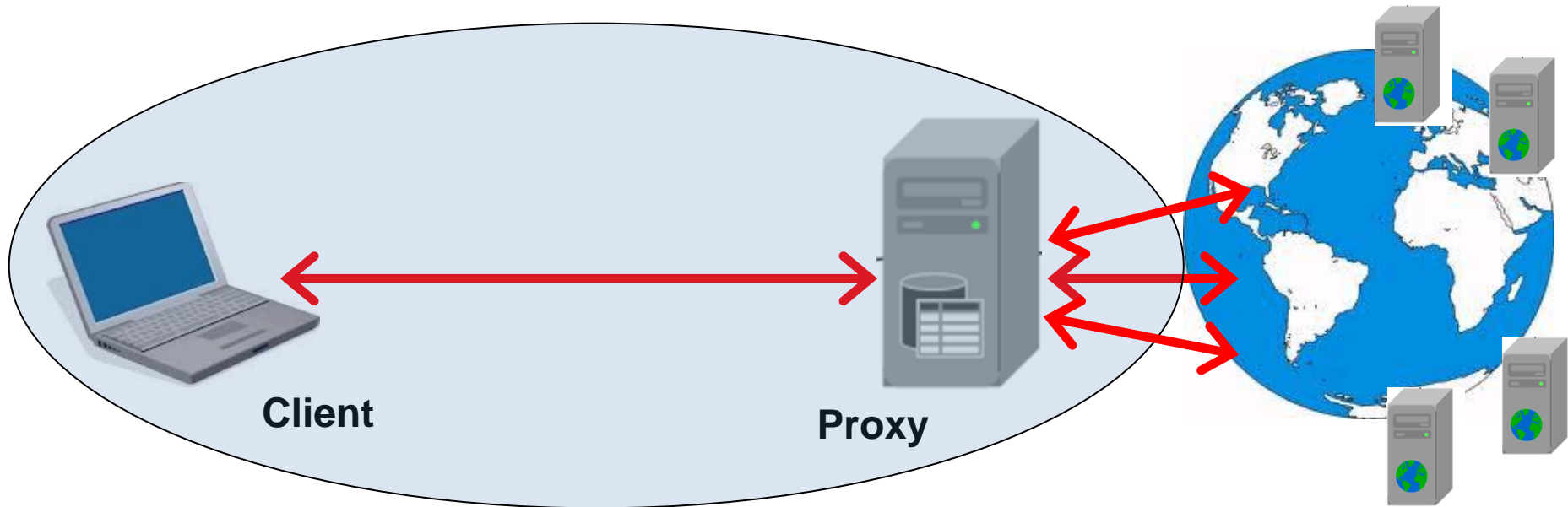
- End-to-end arguments (complexity and end points), middleboxes, channel interfaces, bottlenecks, etc. ...
- (Optimal) theoretic throughput vs measured throughput
- How much can my application(s) fill the end-to-end pipe?

MN-5

- As a group, select one of the following five
 - Cache optimization, prefetching, and resource usage
 - HTTP-based adaptive streaming
 - Multicast using WiFi, LTE, or both
 - 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 ...

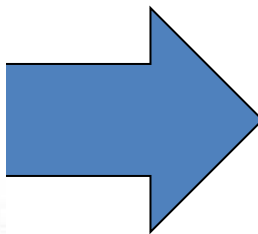
Cache optimization, prefetching, and resource usage



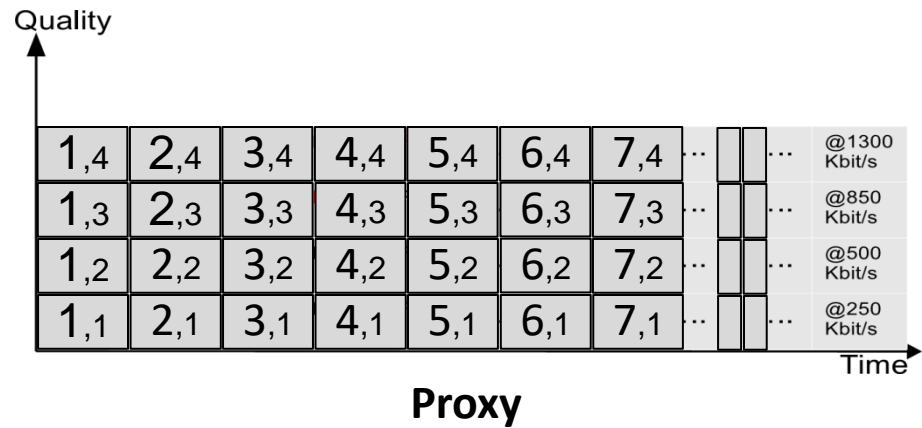
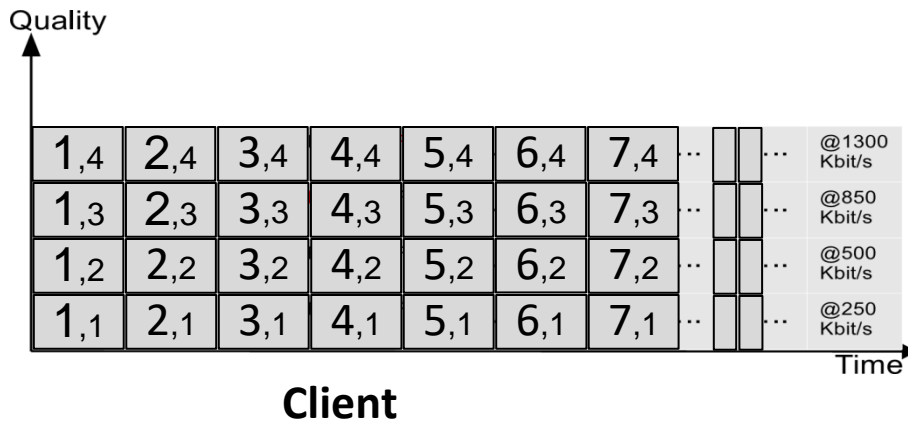
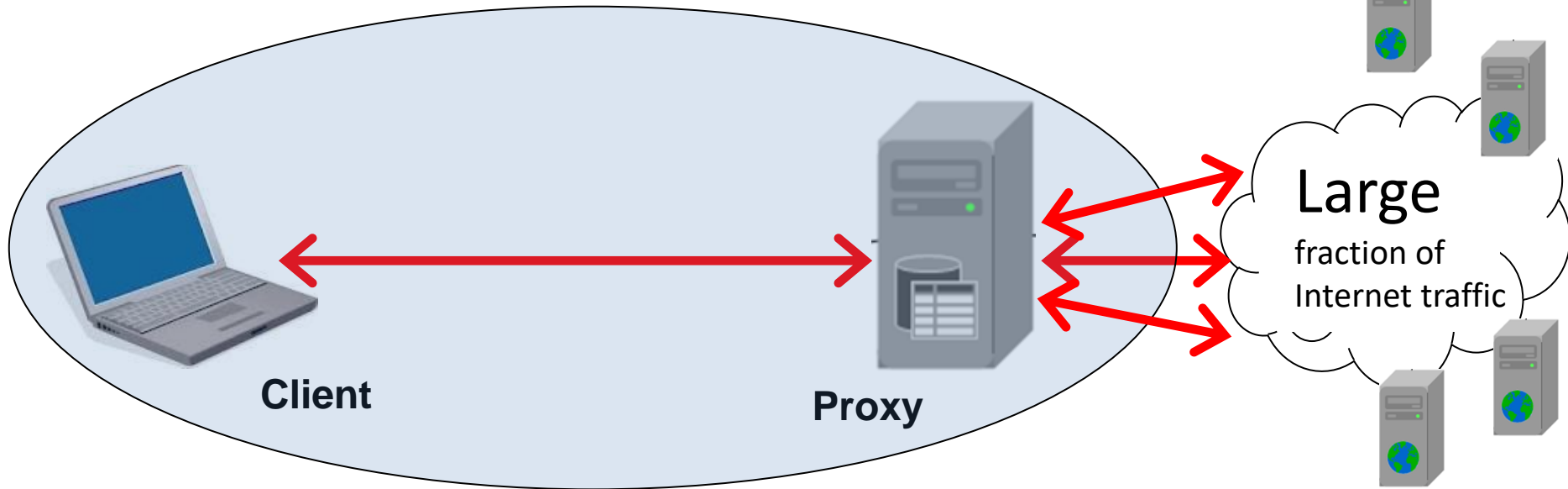
- Heterogeneous clients: PCs, tablets, phones, ...
- Mobile clients ...

Example factors (miss cost and hit rates):

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

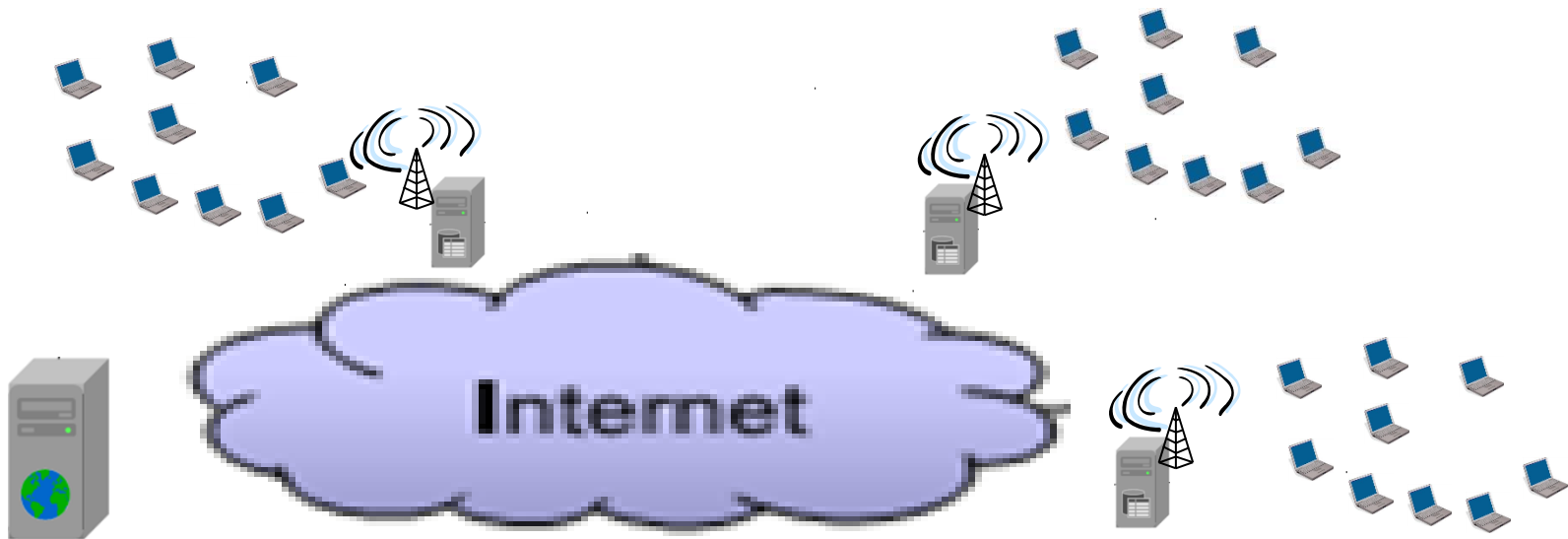


HTTP-based adaptive streaming



- Resource usage, cache hitrate, ...

Multicast using WiFi, LTE, or both



- The **broadcast domain** of wireless networking provide natural opportunity for resource saving: Many users can obtain the same message using a single transmission ...
 - Live events: Super bowl, live soccer, Eurovision song contest
 - Stored content: Highlights, news, ...
- E.g., where, when and how (do we best save bandwidth) ...

Mobile web, personalization, and privacy



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



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