Integrated Mobile Access to Heterogeneous Wireless Networks

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informatics

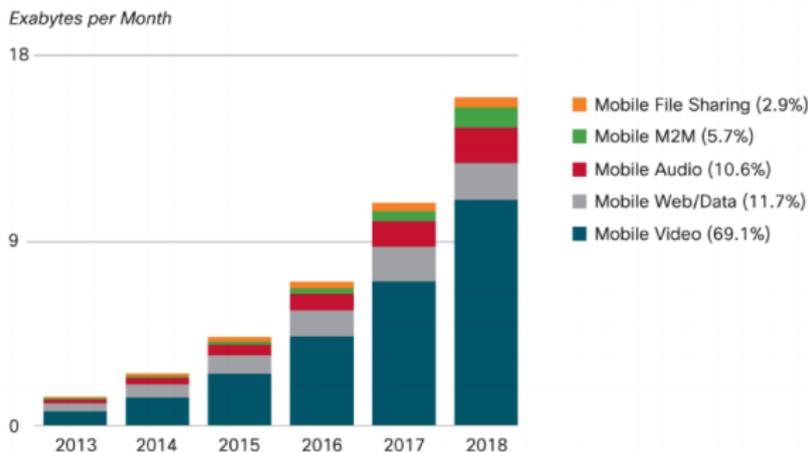icsa | Institute for Computing Systems Architecture

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Mobile data demand to exceed current capacity

"Global mobile data traffic will increase nearly 11-fold between 2013 and 2018"

–Cisco VNI Mobile Forecast, Feb. 2014
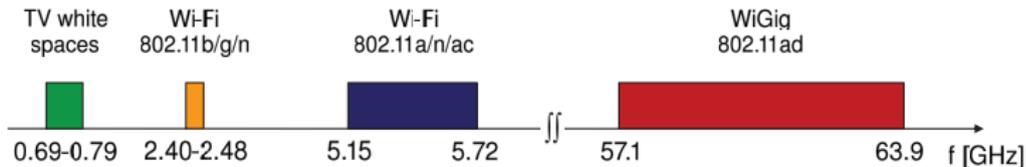
4G rolled out, but connectivity gaps persist

Example: Central Edinburgh, coverage maps for 3 operators

Users locked in the services *only* provided by their operator.

Offloading to networks in unlicensed spectrum

▶ Increasing availability and usage of unlicensed, diverse bands

▶ Vast differences in terms of:
  ▶ Channel quality
  ▶ Transmission range

  ▶ Available airtime (usage)

$f_1 < f_2$

Challenges

1. Enable high-speed mobile services with QoE guarantees over heterogeneous technologies.

2. Design context-aware operator switching mechanisms (leverage ANDSF/HotSpot2.0).

3. Provision resources dynamically and share spectrum efficiently.

Mobile Access to Wide-Spectrum Networks (MAWS)

Effective scheme for accurate & timely evaluation + selection of association options designed for clients of wide-spectrum networks.[*]
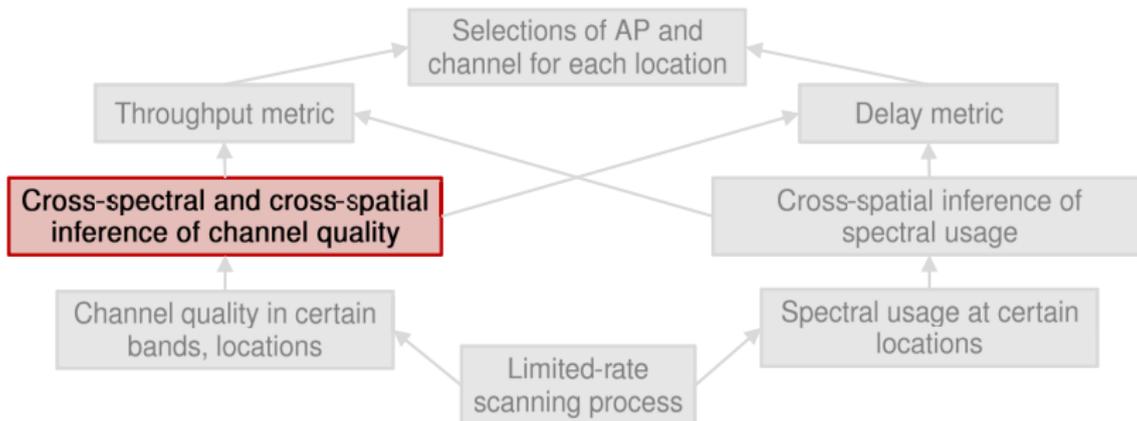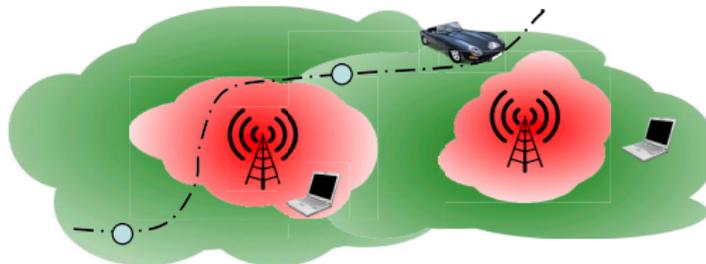
Limitation of current solutions:

▶ Exhaustive scanning & historical data approaches prohibitive.

▶ Fixed band prioritisation oblivious to channel quality/usage.

Our technique: infer channel quality and spectral usage for current location & bands using limited measurements.
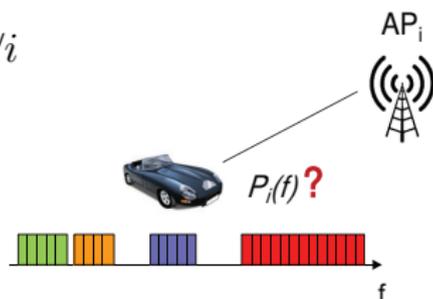
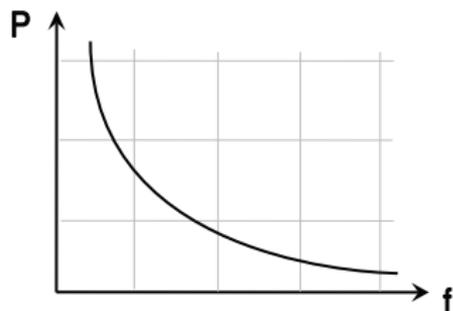[*]A. Giannoulis, P. Patras, E. Knightly, *IEEE INFOCOM* (2013).

Design Overview

Cross-spectral inference of channel quality

▶ Channel quality $P_i(f)$ for link to AP $i, \forall i$

- $P_i(f)$ unknown to mobile clients
- Scanning costs airtime

AP$_i$

$P_i(f)$?

f

▶ Interpolate link quality via models w/ minimum #measurements
▶ Propagation models[*] suggest:

$$P(f) \propto \frac{1}{f^\alpha}, \alpha \approx 2$$

[*]ITU-R Recommendations P.1238-7 and P.1411-6 (2012).

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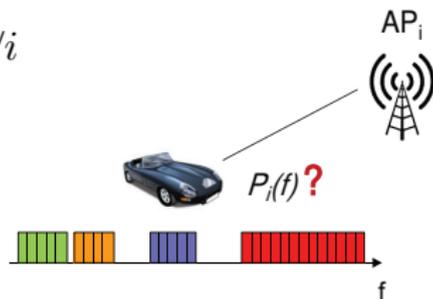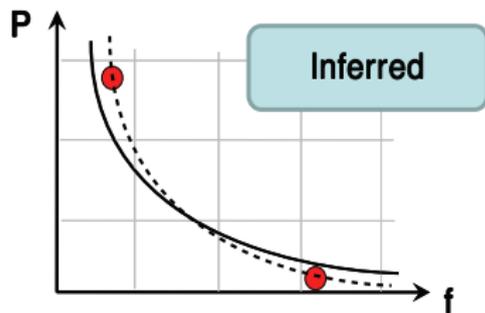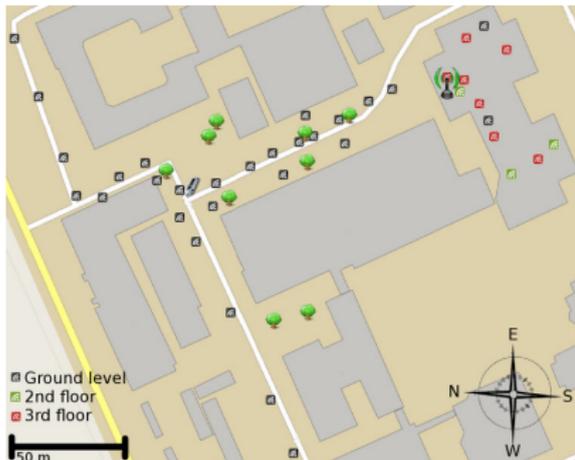- Propagation models[*] suggest:

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Assessing the accuracy of the inference methods

Experiments: Signal strength measurement in multiple bands, locations, environments.


□ Ground level
□ 2nd floor
□ 3rd floor

50 m

Rice University campus, Houston, USA.

▶ Despite sparse sampling, average error of estimated link quality is relatively small.

▶ Insights into effective scanning pattern devisal.

# Gains over existing alternatives for mobile access

▶ Comparison VS. fixed-band prioritisation: time- and space-invariant prioritisation of association options belonging to different bands.
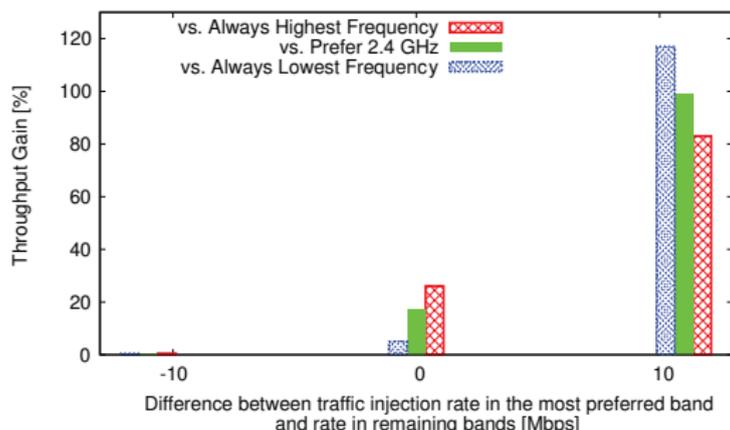
▶ Accounting for actual/inferred channel quality: gains up-to-25%.
▶ Accounting for actual/inferred usage: gains up-to-120%, despite scanning cost and inference errors.

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Next steps*

- ▶ Context-aware inter-operator switching:
    - ▶ Monitor device capabilities, location, and network load.
    - ▶ Account for mobility and application requirements.
    - ▶ Model resource allocation as robust optimisation problems.
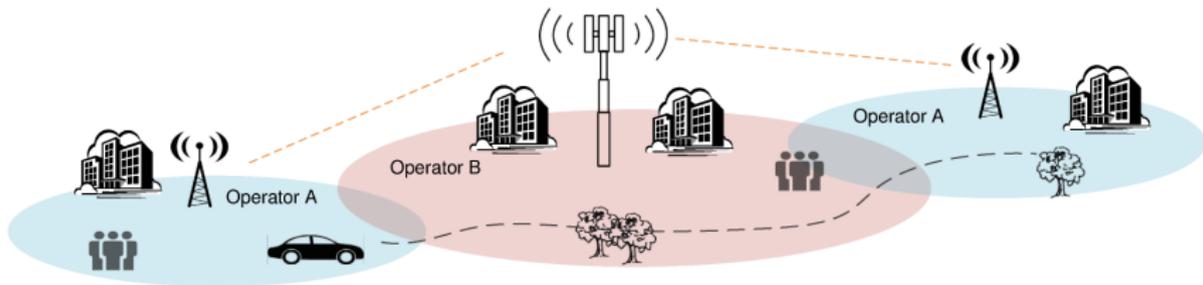
*Joint work with Myungjin Lee at U. Edinburgh.

Next steps[*]

- ► Harness underutilised residential Wi-Fi APs/femto cells:
  - ► Join use of Wi-Fi APs deployed by fixed broadband service providers.
  - ► SDN-based *bandwidth orchestration* → overcome capacity crunch at peak demand times / in popular locations.
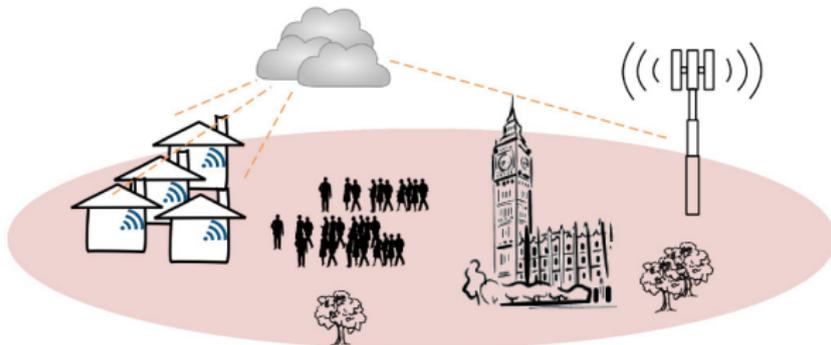
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Thank you

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