

PerCoSC 2011

Improving Pervasive Positioning through Three-tier Cyber Foraging

**Mads Darø Kristensen,
Mikkel Baun Kjærgaard,
Thomas Toftkjær**

Center for Interactive Spaces
Department of Computer Science
Aarhus University
Denmark

madsk, mikkkelbk, toughcar
@cs.au.dk

**Sourav Bhattacharya,
Petteri Nurmi**

Helsinki Institute for Information Technology HIIT
Department of Computer Science
University of Helsinki
Finland

sourav.bhattacharya, petteri.nurmi
@cs.helsinki.fi

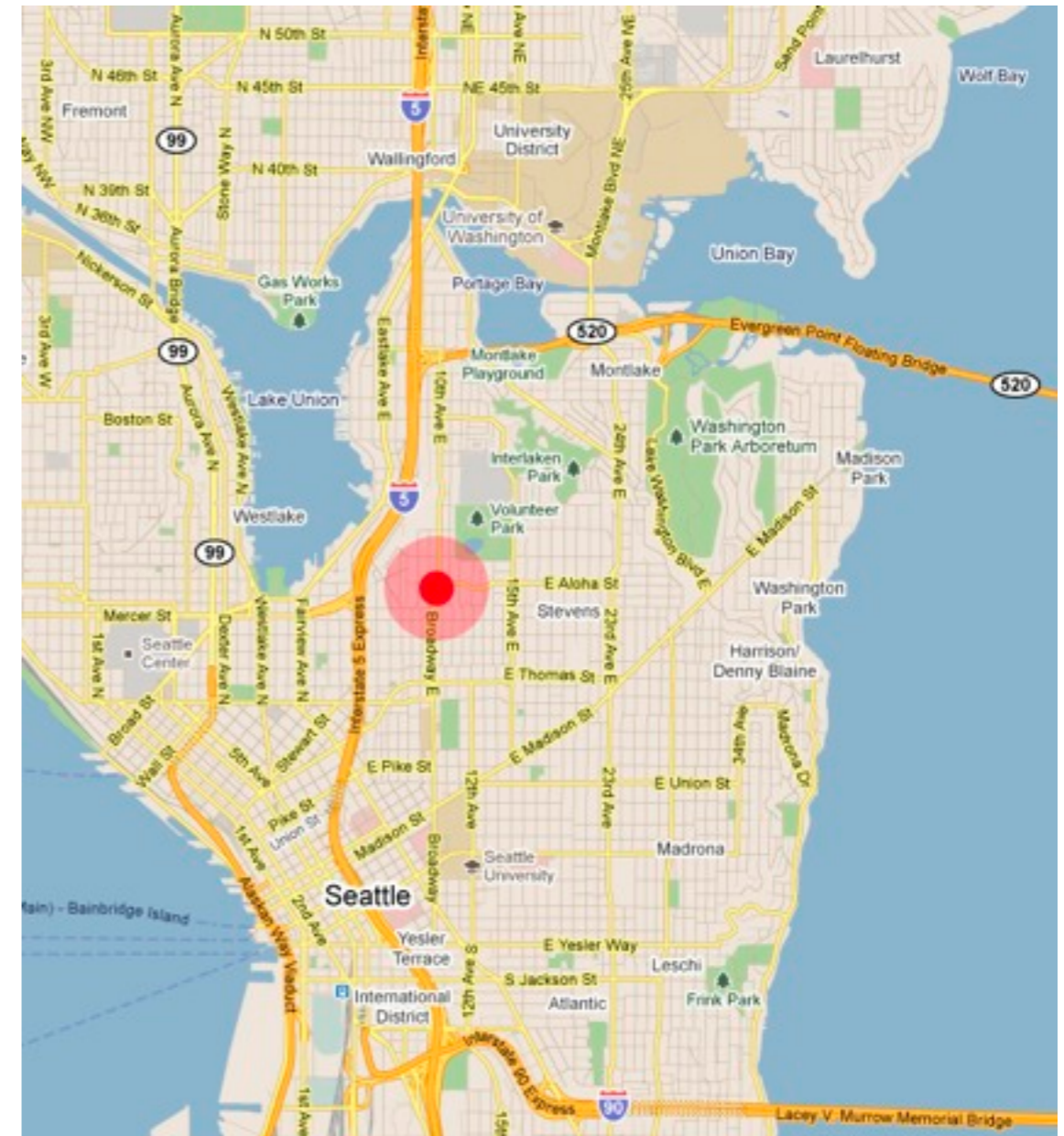
Structure of this talk

- **The use-case: Pervasive positioning**
- **What is Cyber Foraging?**
 - and what are the main challenges...
 - Why not simply use cloud computing?
- **The amalgamation of cyber foraging and cloud computing**



The use-case

- **The pervasive positioning vision is one of adding positioning support to everything.**
- **The use-case here is positioning mobile phones by using GSM signal strength measurements.**
 - This is done using a particle filter based algorithm described by Nurmi et al.



Why use GSM positioning?

- **Not all mobile devices have GPS.**
 - Many common mobile phones still lack GPS.
 - Tablets such as Apple's iPad and many Android tablets lack GPS.
- **GPS receivers use an excessive amount of energy.**
 - The hope is thus, that by using GSM signal strength (which is readily available) precious energy resources may be preserved.



On-device positioning

- **Nurmi et al. describes a positioning algorithm for on-device positioning.**
- **There is one problem with this approach though:**
 - It may save energy because the GPS may be switched off, but...
 - It will **use** energy by utilising the CPU of the mobile device.
 - The mobile device will become unresponsive because of the processing load
- **We have earlier presented results showing that energy may be preserved on mobile devices by offloading CPU intensive tasks.**
 - Even if this means turning on the Wi-Fi interface!

Where to perform the processing?

• On-device

- Is free (no monetary cost).
- It is reliable — the local device is *always* available to do the processing.
- May use a lot of energy.
- Can degrade the overall performance of the device.
- High response latency.



Where to perform the processing?

- **In the cloud**

- Added accuracy (because more particles may be used)
- Uses less energy.
- The CPU of the device is free to do other things.

- May have a monetary cost (use of data, cost of cloud service).
- Data transfer rates are slow = high response latency
- May not always be available.



Where to perform the processing?

- **Using a locally available “surrogate”**

- Added accuracy (because more particles may be used).
- Free?
- The CPU of the device is free to do other things.
- High bandwidth links = low response latency.

- Uses less energy than local processing (but more than using the cloud).
- Surrogates may not always be available.



Do I have to choose only one?

- **The answer is to use all three approaches—when applicable!**
 - What is needed is three-tier cyber foraging.



What is Cyber Foraging?

- **Cyber foraging is construed as “living off the land”**
 - A term coined at Carnegie Mellon University by Mahadev Satyanarayanan ten years ago.
- **More specifically cyber foraging is small, resource poor, mobile devices opportunistically offloading some of their resource intensive work onto stronger, more capable devices.**
 - These stronger devices, called surrogates, are located physically near the mobile device.

Selected cyber foraging challenges

- **Application partitioning**

- An application using remote resources must be divided into code that must be performed locally and (remote) executable tasks.

- **Scheduling**

- Given a number of possible surrogates (and the possibility of using the local CPU) where should the current task be performed?

- **Execution environment**

- Once a surrogate has been chosen, a means of performing *any given task* on that device is needed.



Cyber foraging and cloud computing

- **Many of the challenges within cyber foraging applies equally to mobile devices using cloud computing.**
 - Application partitioning is still an issue.
 - Scheduling w.r.t. choosing between the local device and the cloud is still needed.
 - The need for a flexible, secure execution environment.
- **In some cases, using local surrogates may still be better than pushing everything into the cloud.**



Why not stay in the cloud?

- **For some use-cases cloud computing may indeed replace local surrogates, but...**
 - Not necessarily when working with interactive applications where response time is crucial
 - E.g., augmented reality systems doing face recognition, continuous speech recognition and more.
 - But also simpler applications such as image/video editors etc., where the input data is of a considerable size.
- **The lower latency and (orders of magnitude) higher bandwidth of local Wi-Fi links makes using local surrogates desirable.**

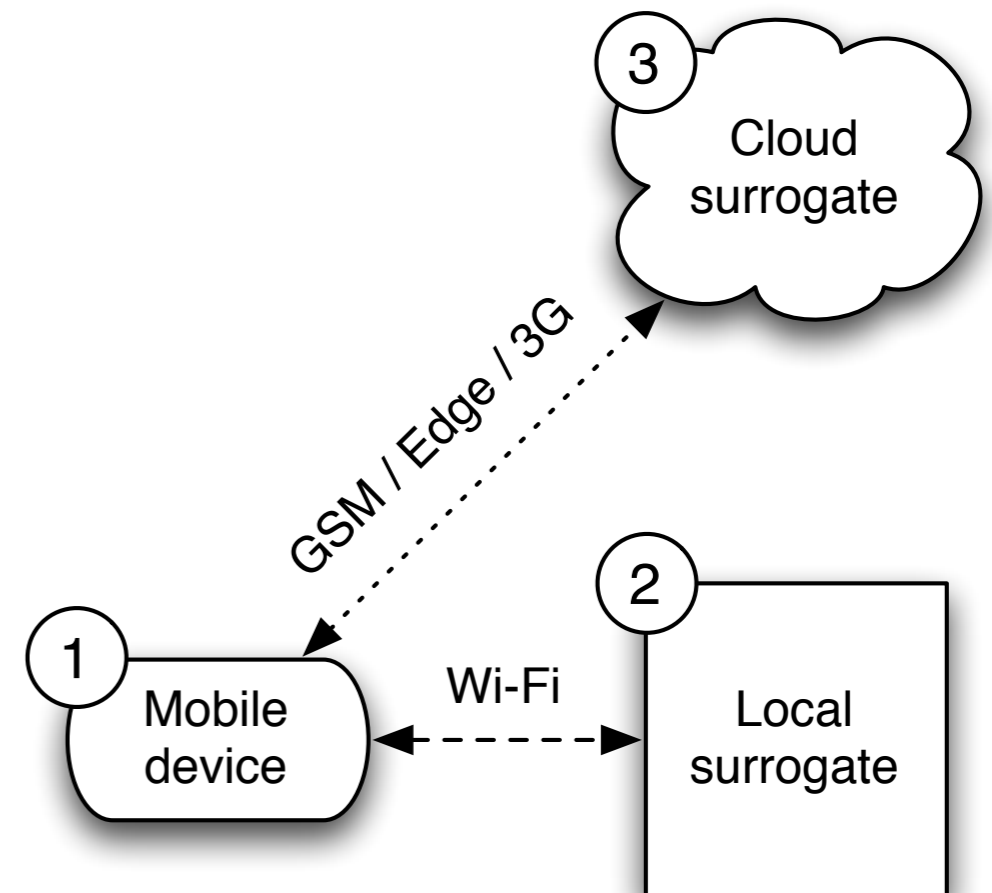
Cyber Foraging in the Cloud

- **What our paper proposes is to add “the cloud” as a third tier in the cyber foraging process.**
 - Scheduling thus becomes the task of choosing between:
 - local execution (slow CPU, no network cost)
 - using a local surrogate (faster CPU, low network cost)
 - using cloud computing (fast CPU, high network cost)
- **Adding the cloud means that:**
 - Remote execution may be performed even when in resource impoverished environments.
 - When in resource rich environments, the lower latency and higher bandwidth of local surrogates may be used to the client’s advantage.



Scheduling over three tiers

- **The following factors must be considered:**
 - Network latency & bandwidth
 - Wi-Fi (b/g/n), 3G, Edge, GSM
 - Task input (and possibly output) size & location.
 - Relative CPU strength
 - of mobile client, local surrogates, and cloud surrogates
 - Task “weight”



Scheduling ~ Scavenger

- **The Scavenger system, which was presented at PerCom last year, presents a simple, approximately linear scheduling algorithm.**
 - This algorithm considers all of the mentioned factors.
 - ... but it does not consider using the cloud.



Adding the cloud to cyber foraging

- **Main challenges of adding the cloud:**
 - Reliably estimating latency and bandwidth of a mobile connection (3G, Edge, GSM).
 - Estimating relative CPU strength of “the cloud”.
 - And of available surrogate machines.
- **Creating schedulers capable of weighing quality (fidelity), energy usage, and response time against each other.**
 - Where multiple energy using devices must be considered:
 - CPU, GSM, and Wi-Fi.

Conclusion

- **The work done within the area of cyber foraging to a large extent applies directly to mobile use of cloud computing.**
 - Researchers working on “mobile cloud” computing should study the work done within cyber foraging.
- **Moving everything to the cloud is not always the best solution!**
 - Mobile devices should keep using locally available resources where applicable.



Questions?

