Saving Mobile Internet.

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In this paper I will point out a number of very serious principal objections on the idea of a Mobile Internet, and why it will not work. At least not as currently planned.

Then, I will show how some of the objections – the most serious ones – can be solved by taking a radically different path to the future. A path that is so different that most people hesitate to think about it since it may mean that the role of mobile operators disappears.

The resulting project, called ***The RadioSphere****, is run at the Centre for Distance-spanning Technology, CDT, in Sweden.*

When discussing concrete examples and general market situations I will use Sweden because of its very high penetration of broadband Internet to homes, PC's & mobile phones. It therefore has especially good prerequisites for pioneering the RadioSphere approach.

Why Mobile Internet Does Not Work

Many of us hear the distant sound of alarm-clocks concerning the somewhat unreflected enthusiasm concerning mobile Internet. In any case, I am not convinced. Yet. And I am writing this paper to find some help.

The objections can be summarized in the following points:

1. Radio bandwidth will always be low, compared to wired.

2. Radio bandwidth will always be expensive, compared to wired.

3. The requirement for small, light and low-power terminals creates and almost (?) hopeless case for decent user interaction.

4. There are few, if any, obvious applications beyond "talking" that feels natural when on-the-move.

The current state of affairs in an area is less important if there is an observable and steady change going on, (such as the inevitable price/performance improvement of electronics according to Moore's law). However, concerning point 1 and 2 above it seems like mother nature has decided once and for all on this relationship, and no change is in sight. There is hope for point 3 and there is reason to keep on searching under point 4.

Few would object to point 1. However, the recent reports on GPRS and UMTS actual capacity makes it urgent. The GPRS packet radio seems to provide marginally higher capacity than GSM, and will probably never even approach the ISDN level which we dumped already 10 years ago as "too little too late". The nominal top capacity of UMTS of 2 mbit/s will be available only if standing alone under the antenna mast, and probably not even then. When actually moving, capacity drops dramatically to at best a few hundred mbit/s. What are the great benefits we get for accepting such a terrible straight-jacket?

As a direct consequence of point 1 we arrive at point 2 and the depressing fact that radio bandwidth will always be priced high. Goods in limited supply just have that property. I loved the brand new world of fibre, WDM and giga-ethernet where we with confidence could say that "bandwidth is plenty and almost for free". This turned things upside down and truly represented a revolution, (much more so than the somewhat desperate current commercials claiming revolutionary properties for mobile internet). It was fun, and realistic, to think about brand new applications of electronic communications. In the radio-world, bandwidth costs 2 – 5 Euro per mbyte transported, 2 – 10 Euro per minute even for below-ISDN capacities. A Euro is gone even before you have worked over the tedious log-in of the WAP-portal. Downloading a typical MP3 tune will cost you 10-30 Euro in just bit transport.

This is not "Internet"! At least not as I have come to know it over the last 15 years. Nevertheless, there might be enough radio available for doing very useful things, but let me express the core observation in a different way: Wired bandwidth sets a standard for what to expect that always threatens to make us disappointed when going wireless. Concerning price as well as performance.

Little hope is seen for lowered costs, basically because radio spectrum is a fixed natural resource. We cannot manufacture more, as we can with fibre. Higher capacity means either higher frequency or less users per cell, which in both cases means smaller cells and more basestations. All these need to be connected. By wire! It is said

that more than 10 thousand basestations are needed to cover the country of Sweden, and each of the four new operators need, in principle, their own coverage. The costs have been projected to two digit Billon Euros, requiring every Swedish customer to spend in the order of 1.000 Euro on UMTS bit-transport a year over up to a decade. Anyone gets a feeling of Iridium?

If there is to be any point with mobility, the terminal needs to be small. You are actually supposed to carry it with you. The meager progress in wireless power supply also makes us dependent on batteries of limited lifetime. All this creates a very hard case for any designer of user interfaces, so hard that I have a feeling that everybody except the most hard-core enthusiasts naturally prefer to wait until sitting down by a real computer rather than fiddling with a phony user interface that makes the seventies Teletype shine in comparison.The little thing called a phone, (PDA or PocketPC), is convenient for talking. Period, sort of. Having used the then most advanced Pocket PC for a longer time I suddenly woke up one morning, looked at it and said to myself: "it is actually a lousy PC". Magic was gone.

Let us think about the most basic of services, like email: First of all you sure want to have access to your full email environment, otherwise your mobile service is degraded to a special case variant of SMS. Most of us get rather large mails, because of the widespread use of attachments in various formats, each requiring a special reader program, (word, excel, powerpoint, Netscape, Acrobat, etc, etc). This means that your mobile device must be able to run those programs, which in practice means essentially all the capacity of a full PC, (powerful CPU and lots of memory, and probably a small rotating hard-disk). Those programs furthermore have rather "rich" user interfaces, which makes the UI issue even more pressing. In any case, while low power electronics is progressing, the need for much, much more of it works in the other direction. Wireless operation time is therefore likely to stay limited.

What is the hope, then, concerning the UI case? An obvious approach is glasses, which have also decreased in price. For example, the Sony Glasstron, (http://www.sonystyle.com/vaio_direct/76/33/942.default.html), is said to "reproduce a 52-inch TV screen as seen from 6 1/2 feet away", for a list price of currently 499 dollars. Why haven't we seen such in wider use for replacing screens? In general, I see a need for much more activity on drastically new computer interaction approaches if the mobile dilemma is going to be solved. We also need mobility-convenient input devices, where speech recognition is starting to be an off-the-shelf technology which works reasonably well for limited vocabulary command sets. However, many of us think it is somewhat embarassing talking in this way in public settings, about potentially confidential things, (who you mail, for example, and the descriptive name of files, etc, etc). Furthermore, background noise plays funny games with the speech recognizer similar to the often irritating handwriting recognition. Anybody has good new idea for mobile-suitable replacement for the keyboard and mouse?

Now, applications. When being in the negative mood I feel convinced that we already have picked the only genuinely mobile application: talking. It requires very little bandwidth and has an extremely simple user interface. Surprisingly many people can even walk and talk simultaneously. Almost all other applications I think about fail in at least one of those respects.

Concerning advertisements sent to your mobile device I doubt that those will make you any more happy than the ones you currently get in you wired mailbox. What do you think about those today? And what would you think about getting them into your resource scarce mobile device?

Positioning has recently popped up as a mobile application with a good potential. The UI issue is however still unsolved, and to do something with a coordinate you need to combine it with lots of mapping information. Any tourist or traveller knows how good it is to study the map. Where is that coming from? A CD in your mobile device or downloaded for 1 – 5 Euro per mbyte?

GPS works well today, at least outdoors, and inexpensive GPS receievers have been on the market for many years. You can even have a GPS wrist-watch, (http://www.casio.com/gps/). Mobile net based positioning can however never get even close to that precision for obvious reasons. Measuring signal-strength to approximate distance is full of errors and gives no direction information unless either new direction sensitive antennas are installed or you can find an intersection between at least two basestations. What may be a bit irritating is however the suspicion that current attempts to provide positioning services through basestation intersectioning is driven by operators desire to generate marginal income from their existing infrastructure and a suspect desire to lock users into their particular services.

Concerning bandwidth capacity and pricing I see hope, though, in hotspot technology like Radio LAN's where basestations are very inexpensive, (now abot 300 Euro), bandwidth decent, (many mbit/s), and traffic costs very low, (view them as simple extensions of the flat-price and inexpensive wired IP network). The current large scale deployment of wired broadband in Swedish society makes this realistic, since all you need is nearby connection point where too hook up the Radio LAN basestation.

That will work in most places where I want to stay connected. When going wilderness I care less. However, this also means that operators should stop dreaming about huge cash flows.

How Mobile Internet Could Work.

We all love the freedom that lies in wireless. We all want the freedom there is to take contact, get information, and participate, wherever we are using our own private dedicated terminal. In a wider sense we want to be able to be everywhere, but without tiring and unproductive journeys. We all want to choose freely among newspapers, seminars, courses and meetings independently of where those are “produced”.
We all want to have access to The Net, independently of where we happen to be right now.

The goal of The RadioSphere project is to give you all this. “Mobile Internet”, but with a price/performance ratio that revolutionizes usage.

The basic idea is to utilize and combine four trends, where the effects of especially the first two are in fact stunning:

1. Inexpensive and ubiquitous wired Internet access.
2. Inexpensive equipment for short range radio access.
3. Portable but very powerful computers and PDA's.
4. The advent of terrestrial DVB/DAB.

Wired Internet access is today available, or is quickly deployed, in most of western society, and in Scandinavia in particular, for low end-user price. In Sweden, this is typically 30-40 Euro flat rate per month for 10 mbit/s bi-directional.

Radio base stations, (IEEE 802.11b), popularly called RadioLAN's at 11 mbit/s, are sold for 300 Euro, with announced dramatic price decreases over the next year, (yes, there is IEEE802.11a and c, HiperLAN, which may further strengthen my arguments). They have a coverage radius of 50-200 meters. Bluetooth chips, for shorter ranges and lower speeds, are expected to be sold for below 10 Euro, possible to build into most kinds of equipment. Philips recently announced the release of IEEE802.11b chips at the level of 7.5 dollars. In any case, RadioLAN basestations are now at a price-level where it is considered consumer electronics. I have it at home, and soon it will be available in every gas-station, at every hotel, at every supermarket, at every airport, in every living-room. It will be built in as standard equipment in stationary computers just like DVD-players are today.

By assuming a RadioLAN station connected to most wired Internet sockets we get, in principle, high speed mobile Internet access for a very low fixed cost that is orders of magnitude below what is planned for the much discussed UMTS.

What we need is a way of automatically manage this system and make it attractive to share bandwidth. We need society-wide, neutral and hustle-free ways of authenticating people. We need easy to manage ways of handling access-rights to basestations. We might need ways to automatically, by distributed negotiation, adjust the emitted power of stations. For many applications we need to deploy a mobile IP allowing us to address a terminal under a static ID while its actual IP-address changes. If really going for the full hit and completely replace both UMTS and GSM, we need to deploy IP-telephony with the special problems it means to ensure QoS in a mobile and radio access situation. We need to exploit the client-to-client and efficient multicasting potential of the RadioLAN technology.

Then, we can expect every gas station to have a RadioLAN, and all those who bothered to get a bonus card get free access to the network. Shopping centers will offer free parking and free mobile Internet. Airlines offer the gold-card owners free access. Well, you will probably have it as soon as you get the paper-slip for having applied for the bonus programme.

At CDT we run the so called Arena project, (http://www.cdt.luth.se/projects/summary/arena.html), where we extend the ice-hockey match experience, (I like it, since I still play hockey myself), by putting a camera in the referees helmet, pulse-sensors on hockey players, info from other matches, and much more, all distributed using RadioLAN to PDA-owning people in the audience. Audience get many replays and flashy pictures to choose among.

The technology has been operated by a traditional telecom operator, but Luleå Hockey already has a 100 mbit/s connection to the Delfinen Arena, (local hockey arena), from the city network. In a next step they buy a number of basestations and introduce a system so that you get access as you buy the ticket. Automatic expiry at midnight the same day. Obviously, you can buy an electronic-only ticket as well, sitting in a restaurant downtown.

And so we take the final step and establish the People's Movement for Free Mobile Internet and let each other in to our basestations. I have a base station at home already, of course. As you come to my home, I let you in. Probably.

Installation and operation of basestations is then distributed, and stops being a bottleneck. No more need for serious men in white coats nursing equipment, since any computer interested teenager will install the basestation just as if it was a new graphics card or a joy-stick. In general, growth and operation of this Mobile Internet can grow in the same efficient and robust way as the young wired Internet. The principle is the same. It will work again.

The far reaching consequences of this should thrill any anarchistic soul and sense of drama: Inexpensive operator free mobile Internet as a side-effect of the flat rate wired internet to homes and gas-stations. UMTS becomes an economic disaster and operators have to drastically decrease their size or refocus. It is good, however, very good, for the general public. Talk about changing society!

As an extra bonus we note that DVB access equipment allows very high quality audio-visual contents for applications that need this. It can also be used as a unidirectional carrier of arbitrary digital data. Terrestrial DVB has the nice property of both small coverage area, (compared to satellite), allowing for efficient reuse of radio spectrum just like for cellular telephony. An effect of this is also very modest antenna requirements, which means mobility. The Terrestrial DVB receiver cards can be inserted into mobile computers and integrate with Internet-provided contents into a single homogeneous end-user experience. This is, in fact, also the future of Interactive Television. Now made real. As part of Mobile Internet. What a killer device!

PDA's are already powerful enough to support this. Examples of such "killer-applications", like the Marratech Pro multicast audio/video/data meeting application, (http://www.marratech.com), have in fact already been ported to for example the Compaq Ipaq PDA's with IEEE802.11b card.

The RadioSphere project will explore all this by building a working prototype for the scenario at several campuses throughout Europe, among them the Luleå University of Technology, (http://www.luth.se), which has campuses in Luleå, Piteå, Skellefteå, Boden and Kiruna and connect those to a single virtual campus. Wherever you are, you will have wireless access to Internet and all the information, people and equipment that lives there, including homes and village surrounding the campus.

If shown to work, the implications are dramatic, since it means that the much talked about large investment in UMTS are made obsolete. Mobile Internet access can be provided to a broad public for a fraction of previously perceived costs.

While the basic principles hold, there are several problems to solve and many research issues to address. There needs to be a reliable yet flexible and easy-to-manage system for authentication and encryption of traffic. While we usually want to ensure that only known people get access to our network, we also want to let newcomers or guests in without any hustle, when so desired. Among several measures that need to be taken is the introduction of a "public key infrastructure" which binds identities to public keys when using asymmetric encryption.

This is also a prerequisite for addressing other problems like packet forwarding and route optimization in a mobile network. The incoming IP-telephony call to your home IP-address should be rerouted to your current mobile connection point, and be so along the nearest path between the caller and your current location. To allow this, we must be sure that it is actually *You* who asks for all your traffic to be rerouted to this new place.

The application of flowing media like IP-telephony and (interactive) television makes the issue of quality of service in IP networks urgent. The RadioSphere must also extend this technology to a radio-access environment that is inherently not connection and reservation oriented. While Mobile IP, (Perkins 1998, Solomon 1998), shows some possible solutions on how to handle hand-over of IP streams, there are many reasons to expect problems. Especially so in combination with QoS ambitions and the very frequent handovers that can occur as a result of very small cells and moving terminals. Another question is, however, how much complexity this should be allowed to generate, or if a majority of Mobile Internet usage patterns are not involving physical movement during use. I suspect the latter. Mobility is in my experience mostly a question of immediate access, using my private device, at any time and place, rather than actually running around.

We must also address issues of "ad-hoc networking", that is communication directly between clients without using any fixed infrastructure like base stations. If the receiver of your data is within direct radio-coverage, it should be received without unnecessary detour into fixed network. This is especially important in multicasting applications like network distributed lectures and group cooperation.

Positioning of mobile units becomes natural, either by integrating inexpensive GPS receiver or utilizing the known positions of radio base stations or terrestrial DVB/DAB emitters. Software to guide or localize people and equipment will emerge as the infrastructure is in place.

Finally, we need to address the rather difficult problem of user interfaces in a mobile context. The problem is that of providing the large screen area and convenient keyboard input while keeping to the physical constraints of what can still be regarded "mobile". Glasses in one approach, while redoing user interfaces to accept small screens is another. This is however still largely unsolved. Maybe we adapt as humans.

Final cleaning up

Having shown how the major obstacle to Mobile Internet, the pricing and capacity issue, can be solved, we turn to a couple of the other objections.

First the problem of requiring huge storage and lots of programs in your phone or PDA. There are possible solutions to this. One is currently living under one of those buzzwords that come and go: "ASP", (Application Service Provision/Provider). The basic idea in most interpretations of this concept is to run the application, and keep the files, at the hopefully powerful, well updated and well backup'ed server of the Provider, while User Interface shows up at the (remote) customers screen. Users now don't need to maintain their own computers and software installations.

This is no revolutionary idea from a technical point of view. It is the Mainframe with Terminals. We who were brought up with Unix and X-windows also think about the "Set Display" command. For some time X-terminals were quite popular. At the old ISDN times I often started programs at the server at work, while directing display i/o to my home computer screen. It worked well, actually.

This is a good solution when...

1. Local computing resources are sparse, CPU as well as storage.
2. Bandwidth is limited, making moving of large files unattractive.
3. Necessary programs are not available locally.

The intelligent reader has since long seen the similarity with the Mobile Internet situation. Restricted terminals and restricted bandwidth can to some extent be compensated for by what is nowadays called an "ASP architecture". So, maybe one way forward is to accept the mobile device as a rather limited device and take the architectural consequences.

Concerning new applications it is obvious that positioning services are inherently of interest when being mobile, your actual position is inherently of interest since it is changing.

Positioning is forever coupled to maps, (just knowing geo-coordinates is rather uninteresting), where certain coordinates may have "attributes", representing grounds at sea, roads in the city, pizzerias, restrooms or (electronic) grafitti, (notes left from other people bound to some position).

A few minutes analysis makes clear that PDA's will never be able to store maps with associated attributes for any but the most immobile of users. It would require too large storage and impractical update procedures. Rather, maps with requested attributes, representing a given radius around the PDA'a current position, must be downloaded to the PDA on demand. The *network*, represented by cooperative websites and servers, has the large volume information. The PDA knows its geo-position, understands an application level protocol, and provides a nice user interface.

So, the PDA essentially needs two calls:

```
Class TheWeb {...

    Map get_Map(Position, Radius, AttributeList)  {...
       /* Returns a Map covering Radius meters around */
       /* Position, with attributes inserted according to   */
       /* what is specified in AttributeList */

    setAttribute(Position, AttributeList) { ...
      /* Associates AttributeList with Position for    */
      /* later retrieval by anyone or restricted users */
```

Let us assume The Web has evolved to a stage where the tag <POSITION> is always present if a web-page represents anything that has geographical coordinates. If Alta-Vista can efficiently search the whole web for an arbitrary keyword, we must be able to search for this attribute and narrow search based on Position.

For all matching web-sites, we now see if there are further attributes that match, such as "restroom", "bus-stop", "pizzeria" or any other characteristic that the user asked for. A map with a suitable resolution, (implicitly given by Radius), is then returned to the PDA together with the found attributes positions.

The PDA can now quickly present the result to the user, having used little CPU power and little bandwidth.

The GeoNotes application is a simple special case of this. Given that you have a server allowing it, You can "write" your grafitti to any Position for later amusement by your friends.

So, by building this straightforward (?) platform we cover essentially all applications of positioning. They all become minor variations on a general framework.

Related Work

While the general mobility debate today is dominated by 3:rd generation UMTS efforts, there are still many projects developing, or exploiting aspects of, Radio LAN technology. The currently most popular standard, IEEE 802.11b, was standardized in 1999, (http://grouper.ieee.org/groups/802/11/index.html). Se also (O'Hara & Petrick 2000).

Work within Mobile IP, (Perkins 1998, Solomon 1998), is active and important, and is often assuming Radio LAN as the context. It does not rely on it in any way, however. Related to this, much authentication and security is done, for example IETF Diameter, http://search.ietf.org/internet-drafts/draft-calhoun-diameter-18.txt. There are many drafts available in this area and can they be found starting at http://www.ietf.org/ID.html.

UMTS is the much talked about 3:rd generation mobile telephony, or really Mobile Internet, (http://www.umts-forum.org/). In many countries, licences for UMTS have

been sold for surprisingly high fees. Many now start to doubt the value of those licenses.

The much cited "i-mode", (http://www.nttdocomo.com/i/index.html), in Japan, is a kind of mobile Internet, but not at all the full uncompromised case we are looking for. It has been much more successful than the European WAP initiative, (http://www.wapforum.com/), because of much better "telephones", (Java, larger colour screens, etc), and an ability to stimulate i-mode contents production. The business model of letting contents provider keep most of the revenue may have something to do with this.

Many companies offer RadioLAN access at hot spots like airports, (for hot prices), like Telia HomeRun in Sweden, (http://www.homerun.telia.com/eng/start.asp). The US coffee shop chain Starbucks offer RadioLAN access at their 3000 shops, and many airlines offer it in cabin during flights, (such as SAS, http://www.sas.se). Many smaller companies start to offer limited coverage Mobile Internet using this technology, or provide support for its installation. A couple of Swedish examples are PowerNet AB, (http://www.powernet.se/), and Åkerströms Björbo AB, (http://www.akerstroms.se/). The Swedish companies Columbitech, (http://www.columbitech.com/), and "A Brand New World", (http://www.abnw.com), are further examples of new brave startups taking this direction.

There is however still far too little work on the path shown in this paper, maybe because of its "too" far-reaching effects. Work here seems this far largely to be guerrilla-like loosely connected communities like Elektrosmog, (www.elektrosmog.nu), and Rooftops, (ref). Many more exist, and the "links" page of Elektrosmog, (http://www.elektrosmog.nu/links), contains some of those.

With the RadioSphere project at CDT we do however make a serious and larger scale attack on the issue.

Conclusion

I have pointed out a number of very serious problems inherent in the idea of Mobile Internet, but also shown how the most serious of those can be solved.

What we want is Internet, but without a wire. We do not want any "special services" or other things. We want *Internet*, and we want it wireless. How can we get that?

The core idea is a somewhat ruthless exploitation of two facts: 1) that wired broadband Internet is becoming ubiquitous, inexpensive and flat rate, and b) the availability of inexpensive radio basestations of high capacity.

Combining those gives us a Mobile Internet while essentially keeping the price/performance characteristics of the wired Internet. This may make 3:rd generation mobile systems, UMTS, obsolete before being deployed. It may make the role of mobile operations redundant. It is stunning.

If this scenario is right, which I believe, the following conclusions should be drawn for telecom equipment suppliers, (like Ericsson, Nokia, Motorola, Siemens, etc):

- ?? The terminal issue must be approached from the pocket computer side rather than from the mobile phone side.
- ?? Radio basestations become consumer electronics, just as already is the case for computers and phones.
- ?? Equipment for building the open network of “broadband to homes and gas-stations” become much more important than the closed transport network behind traditional cellular mobile systems.

This all harmonizes wired and non-wired systems, with great efficiency gains for society at large. It is certainly an improvement for all of us.

Somewhat worrying is however the fact that while Private Ryan was saved, Tom Hanks died.

References

Network references have been included directly in the text and are not repeated here.

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