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Title

Approaching the mobile complex - In search of new ways of doing things

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Abstract

The *mobile complex* consists of carried devices like smart phones and pads, the networks such devices use, the (mobile) Internet and all its services, and the increasingly digital and technology competent users. This complex is, in the non-military world, showing us new ways of doing things. We are currently conducting experiments searching for insight into how the military may relate to the mobile complex. That is, how to exploit the possibilities and reducing the risks. Our hypothesis is that the mobile complex will be an integral part of future C2 arrangements.

We deploy a *seeding - evolutionary growth - reseeding* approach in our experiments and use *meta-design* actively to encourage *evolutionary growth*. This approach aims to empower the users and expose local innovation.

On the local level we gain insight into what the opportunities are and how the technology may be used. At the same time, the experiments expose some of the actual risks. From several experiments in different local domains, we hope to aggregate our findings into something usable for concepts on how to, from a military stand, relate to the mobile complex.

Introduction

The mobile internet with smart phones and pads is giving us social platforms with increasingly ease of access to each other, information, and services. These social platforms are made available to us in new places and in new situations. Also, we observe a trend of convergence: these devices are turning into universal tools which complement and replace existing technology, and they enable new ways of accessing information and services - This technology yield new models of doing things together.

This *mobile complex* has, in the non-military world, shown us new ways of doing things, for example communicate, coordinate, share and manage information; aspects often associated with Command and Control (C2). There are numerous mobile apps available from repositories like Google Play or Apple App Store which address military use-cases. Mobile devices and the mobile internet seem to spur much enthusiasm also in the military world. The *apps4army* competition(s)[1] of the US Army is a good example of this enthusiasm and innovativeness. There are high expectations bound to this technology as people imagine ways to exploit this technology, the processing power, the networks, and the sensors of the devices for harvesting information, communicate and share information. Finding good ways to channel such enthusiasm into constructive arrangements and practices is a challenge.

The *mobile complex* consists of devices like smart phones and pads, the networks such devices use, the mobile Internet and all its services, and the increasingly computer and technology literate users. In order to understand this mobile complex we are conducting a series of experiments. We are searching for insight into how the military may relate to the mobile complex. That is, how to exploit the possibilities,

reducing the risks, and doing the right trade-offs. One of our hypotheses is that the mobile complex will be an integral part of future C2 arrangements, but then one first need to get the trade-offs right.

This mobile complex is evolutionary in nature, therefore, it is a challenge to find ways and methods to experiment that will yield useful results. We have chosen to deploy a *seeding - evolutionary growth - reseeding* approach [2] in our experiments and use *meta-design* actively to encourage *evolutionary growth*.

In this paper we first introduce the mobile complex and then a short discussion of the possibilities of the mobile complex. Then some consequences of working with a complex are discussed. The approach of our experiments and our portfolio of services/meta-designs is discussed then. Finally, results and experiences from the experiment series this far and further work is presented.

Introducing the mobile complex

The phenomena of the mobile internet, smart phones and pads and the social platforms, we think of it as *the mobile complex*. We approach the mobile complex with a four part model (see Figure 1): The *carried devices* like smart phones and pads, the *networks* that mainly give access to the Internet, the *services* available, and the *people* as users.

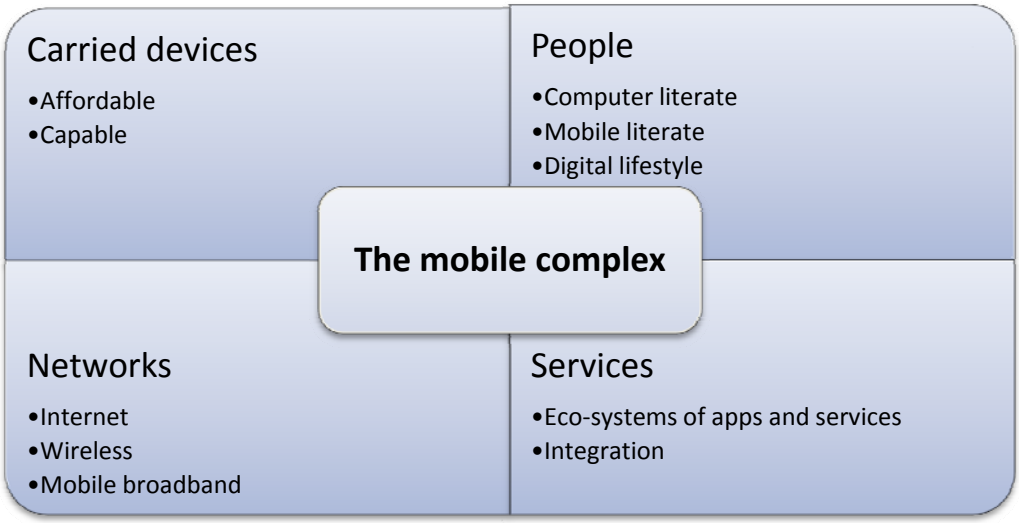

Figure 1: The four parts of the Mobile Complex

The four parts of the mobile complex

With *Carried Devices* we think of the handsets, the terminals, smart phones, pads, and tabs. The devices, not only mobile, but those we find the effort to carry along and bring with us. These devices get increasingly capable; the trend is more performance per cost. We get better user interfaces that let us interact with the devices with less effort. We get improved and new kinds of sensors. Batteries, screens, network integration; all is improved.

With *Networks* we think of the networks that make it possible for the carried devices to stay connected to other devices and the services. These are the networks that give access to, and constitute, the

Internet. The trend is that they reach further with better capacity and they do it more efficiently. The devices can stay connected to the services, and the devices can stay connected to each other with better coverage and better capacity using less energy.

With *Services* we think of the vast services of the Internet or other in-house services. Everything from e-mail, chat, file sharing, the services of facebook, google, twitter, yahoo and alike, forums, and blogs, the list is almost endless. In this setting we also think of open-source projects that allow for the running of more locally targeted services. The trend, in general, is more services, more functionality, and tighter integration of services.

With *People* we think of the users, the ones carrying the devices and using the services through the networks. A distinct trend is that users get more digitally literate and competent. It is not necessarily that we get more "MS Office super users", as the skills of the Internet and the mobile complex is something different: One is gradually adapting to a digital lifestyle with new practices and principles of doing things.

Disruptive technology

In the non military world, most of us treat this mobile complex in an opportunistic way: We buy the phones and pads we like, we use the networks available to us that is able to connect us to the services we are interested in, we use the services available if we find the service meaningful and its terms not too intrusive, and we do all this with confidence, in ways more and more familiar to us.

As professionals we are likely to be less opportunistic and more cautious. In many military settings, we could even regard this technology, such arrangements and our digital skills for irrelevant. We find it risky, and the services, the technology, the ways of doing things will not fit the currently given policies. Nevertheless, in most military settings, in an operation or in more of an administrative context, it is not hard to imagine this technology, these services, and these ways of communicating and coordinating decisions, being applied. That is, to imagine military use-cases involving the mobile complex should not be hard. The technology and arrangements the technology enables are relevant in many crisis settings, not necessarily planned for, but in many cases it is obviously supporting C2 in these situations. The applicability of this technology when the military is one of several actors that need to coordinate is obvious. A little harder to imagine is this technology in scenarios of excessive military character, but the mobile complex as an enabler of agile C2 arrangements is one of our hypothesis.

The conservative attitude toward this technology for military uses are mainly concerned with security issues like availability of the networks and services, disclosure of information, authenticity issues or undermining of reliable established ways of doing things. Most often are these valid arguments, but then the result is a growing gap between this, mainly Internet based, mobile complex, and the military networks and dedicated technology and practices. Accordingly, our experience is that there is a growing tension between the existing policies and practices and what one imagines could have been done with this technology in military settings.

We would like to explore this gap:

> *Is it necessary, could policies have been different and could we relate differently to this technology? Is it possible to imagine the military world in symbiosis with the mobile complex, and so, what would it look like?*

When recognizing this tension, we make associations to "disruptive technologies". Bower and Christensen [3] say:

> *"disruptive technologies introduce a very different package of attributes from the one mainstream customers historically value, and they often perform far worse along one or two dimensions that are particularly important to those customers."*

One could think of an attribute like security, especially non-disclosure, as something highly valued in military contexts. As more and more people see the value of advantageous attributes of the mobile complex, like the availability of services or communication channels to reach other people, more and more may be willing to trade, for example, some of the security aspects to get more of other attributes they have come to value. However, attributes that are challenged, may, after a while be taken care of or solved differently. Identifying such "alternative solutions", if they exist, is also in scope of our experiments.

Military organizations may be facing an "Innovator's Dilemma", similar to the ones described by Christensen [4], originated from the technologies and the ways of the mobile complex. That is, the innovations and new ways of doing things that will satisfy future requirements will at the same time require us to make decisions that today, force upon us what we will think of as unacceptable risk. For the military, in policymaking and resource allocation, one should closely monitor this technology, and if its disruptive character is for real, one should take actions to navigate this "innovators dilemma". How to allocate resources, if and when to let go of the old "business", these are questions our experiments may help us understand.

The opportunities

The opportunities of the mobile complex are rooted in technology that is more connected, that is more available, can be accessed more often, is useful in new situations, and may be used with less effort. When all this evolves together it should enable many practical new uses.

In the well known paper *The Computer for the 21st Century[5]* Mark Weiser described a vision of ubiquitous computing. Ubiquitous computing means pushing computers into the background. The technologies disappear into the background and then "pose no barrier to personal interactions". The paper describes scenarios of technology use. It describes not only hardware (boards, pads and tabs), but also how it would be used; networked (available, seamless), some services (location, documents in a cloud), and how the people are relating to the technology in their environment, in a very relaxed way. Our four part model of the mobile complex (Figure 1) is inspired by these thoughts.

The latest developments with smart phones, pads and the mobile Internet has made Weiser's paper relevant again. With the ongoing developments in mobile technology, the internet and the mobile internet, we seem to be sprinting towards this vision. The opportunities described by Weiser, as a consequence of ubiquitous computers, are that of technology residing in the human world to be used on the human's premises. As a vision, this may also describe the opportunities of the mobile complex: technology in the human world on the human's premises.

The work of SAS-065 *NATO NEC C2 Maturity Model* [6] suggested three dimensions to describe C2 Approaches: *distribution of information among entities*, *patterns of interaction among entities*, and *allocation of decision rights*. If one could improve on the environment for distributing information, for pattern of interaction and for allocating decisions rights, one should imagine that certain barriers for reaching higher C2 maturity would be removed. Our experiments aim to improve on such environments. Higher levels of C2 maturity are associated with higher/better C2 agility. Our hypothesis is that the mobile complex could contribute to higher C2 agility and enable higher C2 maturity.

Regarding the complex - a "wicked problem"

We have chosen to use the terms "mobile complex" on this phenomena of carried computers, networks, services and people. The mobile complex is also made up of a high number of individuals and organizations with their individual needs, ideas and decision making. The mobile complex also contains a high number of technologies and practices.

The mobile complex inhibits uncertainties. Together with a high number of heterogeneous elements it yields a phenomenon that is complex in the sense that it exhibits behavior that is not obvious just by analyzing its individual parts. Analyzing its individual parts, unless on a high level of abstraction, is practically an impossible task.

Complex systems evolve over time, and so will the mobile complex. They are what they are as a consequence of the co-evolution, or combinatorial evolution, of its parts. It has evolved to where it is today, and it will continue to evolve. Brian Arthur [7] points to combinatorial evolution as a key function in development of technologies and practices. Combinatorial evolution, for example between the four parts of the mobile complex, is a model to better understand the developments of the mobile complex.

In many ways, in our experiments, we are facing what is often called a "wicked problem": the military vs. the mobile complex is not fully understood, there is no right or wrong solution, it is a 'one-shot-operation', it is a unique problem. To approach this problem we have picked the following pragmatic reminders to help navigate our experiments:

1. It is hard to model and analyze at a detailed level. The approach using reductionistic tools on a complex may be particularly resource intensive, and is still not likely to yield good result.
2. Removing parts, or introducing parts, may yield unforeseen consequences. It may be obvious, but reducing the complex to a controllable problem, by removing elements of the complex, like not using the Internet, using only such and such hardware or limit the number of services available is different from approaching the complex as-is.

3. The complex will evolve. Few properties of the complex will stay static. How the complex may evolve and how it is possible to influence this evolution is part of what we are looking for.

Approach - *seeding, evolutionary growth, reseeding*

The main idea behind every of our experiments is to bring as much of the opportunities of the mobile complex into that local domain where the experiment is conducted (see Figure 2). Besides that, we do our best to leave the local domain untouched. That is, our experiments include a group of people doing tasks that originally are independent of our experiments. Our experiments should only affect how they solve their tasks.

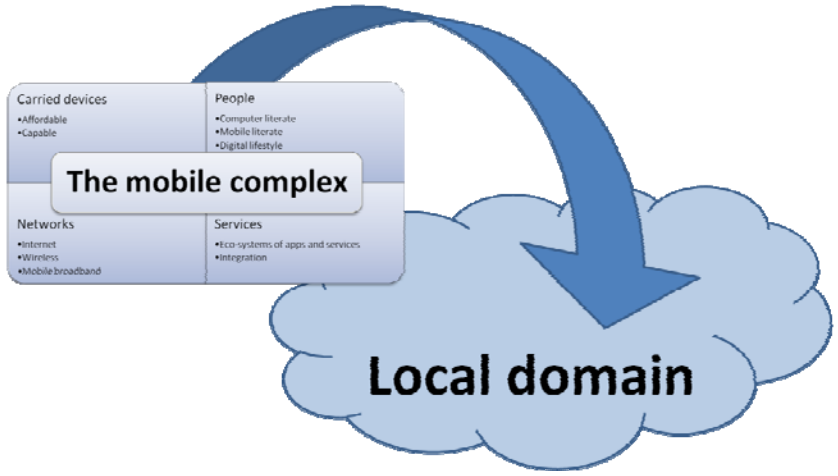

Figure 2: Bringing the Mobile Complex into a Local Domain

We have conducted multiple experiments with this high-level approach. The group of people, and their tasks, may vary: it may be military lecturers giving a practical course together, a group of military students within the same class, a group of people in an exercise setting or a wargaming setting. Of practical reasons, mostly due to the risks of using unclassified services and networks, we have found settings of military learning and exercises to be more accessible to our experiments. The experiments are conducted in different time spans: from short experiments of a single day to experiments of several months.

Introducing the mobile complex to a local domain is done by providing smart phones or pads, let them be connected to the Internet, let the people use their digital skills gained from using such technology and being on the Internet in their non-professional life, and finally encouraging them to use Internet services commonly available like search engines, content sharing services, app marketplaces, in addition to services made available to them for the purpose of the experiment. This initial phase may be considered *seeding*.

Fisher [8] makes an argument that for software systems, requirements cannot be completely specified before system development, and therefore vast resources are spent redesigning systems. He also states that the needs for enhancements are experienced by the skilled domain workers rather than by the

system designer. From there one could argue that skilled domain workers should be empowered to create the required enhancements. In such an environment the paper suggests using the *seeding, evolutionary growth, and reseeding model* [2]. The paper also states "that systems that evolve over a sustained time span must continually alternate between activities of unplanned evolution and periods of deliberate (re)structuring and enhancement".

For the seeding, evolutionary growth and reseeding model, Fisher presents these guidelines:

- Software systems must evolve; they cannot be completely designed prior to use.
- Software systems must evolve at the hands of the user
- Software systems must be designed for evolution

The mobile complex is more than a software system, but the similarities are many. The complexity may be more obvious and the evolutionary aspects more prominent. Hence we find the basic ideas of the *seeding, evolutionary growth, and reseeding model* of Fisher to be appropriate for explorative experiments with the mobile complex in local military domains.

Seeding: A seed is not a complete implementation of a system, but something that will evolve as it is introduced to that domain. In domains with no elements of the mobile complex - due to security issues, most military local domain are - the initial seeding may be as simple as providing smart phones or tablets, and encourage the participants to look for apps and services on the Internet they may find useful in their local domain. However, more often substantial effort is put into identifying use-cases and domain specific aspects to be able to do more intelligent seeding.

Evolutionary growth: Evolutionary growth should happen as participants do real work. New ideas on how the technology may be used may be discovered, and with flexible systems and arrangements, users will be able to develop in their own environment. In our experiments, we should enable evolutionary growth by designing for evolution; intelligent seeding or reseeding is our opportunities to influence the evolution. It is necessary with a design that is as emergent as the learning and experience gained. Fisher argues for the method of meta-design to design for evolutionary growth.

Reseeding is a deliberate effort of revision and coordination. The reseeding phase is an opportunity to do corrections as to influence the evolution. In our experiments, reseeding may be changes to the services we provide, access to new services, sessions and discussions with the participants, to make smart phones or pads with different specifications available or simply a different network plan.

To illustrate how experiments are conducted we may use the Observe-Orient-Decide-Act (OODA) loop model to understand the *seeding, evolutionary growth and reseeding* model. The iterative, or loop, characteristics are similar. The *act* will be the *seeding* or *reseeding*. After a seeding, one will try to monitor and try to understand the evolutionary growth (Observe and Orient). For example looking for how systems are used, what is the communication like, and is there any creative or unintended use. Thereafter, one need to decide if, and how to reseed. This is illustrated in Figure 3.

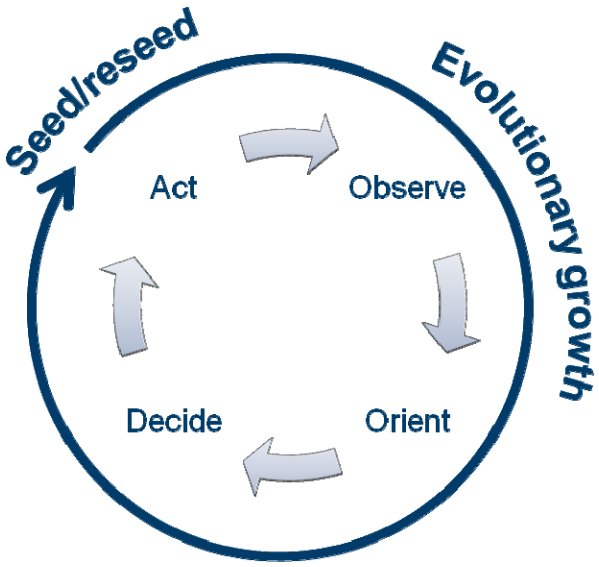

Figure 3: The OODA loop of the seeding - evolutionary growth- reseeding model

Meta-design

Fisher argues for the method of *meta-design* and brings meta-design forward as a way to design for evolution. With meta-design one should not focus on the final solution, but on creating spaces or environments in which users, as developers and designers, can create their own solutions to fit their needs. Meta-design should create environments that allow "owners of problems" to act as designers. On a high-level, the goal of meta-design, to empower the users, is similar to the behavior that is encouraged and communicated in newer C2 ideas like the ideas in *Power to the Edge* [9], and which should promote agile C2.

Finding and designing these environments is central. These are the open systems or arrangements that may allow for new ways of doing things, like new approaches to C2, to evolve. Meta-design should not only aim at creating technical infrastructures, but also social infrastructures. Using our four part model of the mobile complex should be an aid in getting the focus right.

Wiki, like the technology and collaboration model behind Wikipedia, is unique in the sense that a wiki lets the users edit both the content and the structure [10] in a collaborative way. We think of the wiki-model, both the technology and the collaboration model, as parts of a meta-design. It is flexible and well suited to support different ways of doing things. In theory, a wiki is a perfect facilitator for evolutionary growth.

The *apps4army* contest may be an example of a meta-design, so are repositories for mobile applications. These are arrangements that enable use and allow for users to help design and contribute to the complex.

We also follow a meta-design and a similar open experiment approach in a parallel experiment series. For these experiments we arrange for wargaming, not necessarily including mobile devices, but computer aided wargaming supported by Web 2.0 related open systems like wiki, chat, blogs and e-mail

to facilitate the collaboration environment. These experiments also show indications of participants quickly taking ownership of the technology, innovative use and a quick forming of processes and ways of doing things, including, from our point of view, unforeseen use of the technology [11]. To us, the results from these experiments are valuable in doing intelligent seeding when entering a new local domain with a mobile complex experiment.

Designing for evolution in the mobile complex

It is not obvious which meta-designs will provide the spaces that facilitate evolution within a domain. These should be spaces to promote collaboration and contribution, and to empower the users also as designers. Luckily, some such designs are already available to us as commonly available services on the Internet or the skeletons of such designs are available as open-source projects. However, many of these projects target the Internet and the desktop user and may not be used directly in a mobile setting. In the mobile complex, the mobility of the users, the wide availability of services, the ease of use of smart phones and pads make us think that open systems designed for evolution targeting the mobile complex is somewhat different than those thought of as open systems designed for evolution mainly targeting desktop users.

In addition to the services available on the Internet, we also keep and continuously develop a portfolio of core services available to the participants in our experiments. These are services that we provide, promote them, and strive to adjust or develop such that the services will handle use-cases suggested by the users. Obviously we do some domain specific adjustments. Most of the services we provide comply with the ideas of meta-design. The services mainly approach problems at a meta-level: The services are flexible in the way that they allow for the users to work in many different ways, as well as being open for the users to contribute to the experience of the service. As we conduct more experiments, this portfolio is constantly under development. We believe in a Web Oriented Architecture (WOA) for most of our services [12] as that has proven flexible and well suited for an evolutionary approach. Currently our portfolio of services/meta-designs consists of:

Wikis

As mentioned earlier, wiki is a technology and collaboration model and unique in the sense that a wiki lets the users edit both the content and the structure [10] in a collaborative way (see Figure 4). In a wiki users may edit both the pages and links, and it excels in uncovering structure of information and practice. We use semantic wikis [13] in our experiments to also allow for more formal structure and dealing with semi-structured information. We have also developed a mobile application to provide less troublesome access, and ease the contribution of content to the wiki for the mobile users. After all, most wiki-implementations are made for desktop users. Two screenshot are shown in Figure 5.

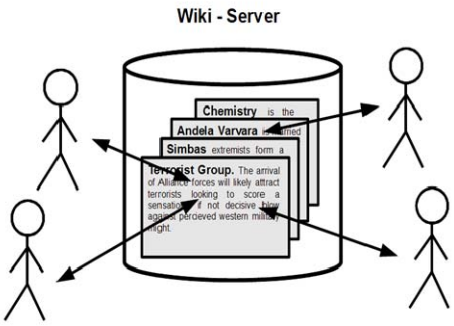

Figure 4: Wiki a technology and collaboration model

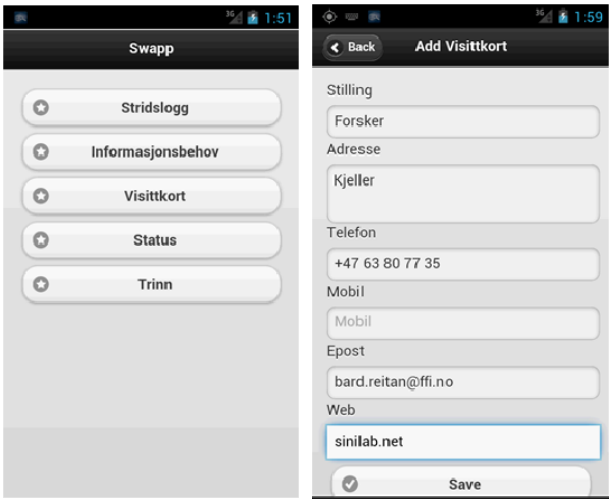

Figure 5: Our Android app for reading and editing a semantic wiki

Location and mapping

We keep a location and a social tactical reporting service (CEI - Collective Environment Interpretation). The CEI is a system to work with location based information, and to help understand the current environment. The initial motivation behind the services were similar to that of the US Tactical Ground Reporting System (TIGR) [14]. The CEI has evolved into a flexible social mapping service. Screenshots from the Android app of the CEI service is shown in Figure 6.

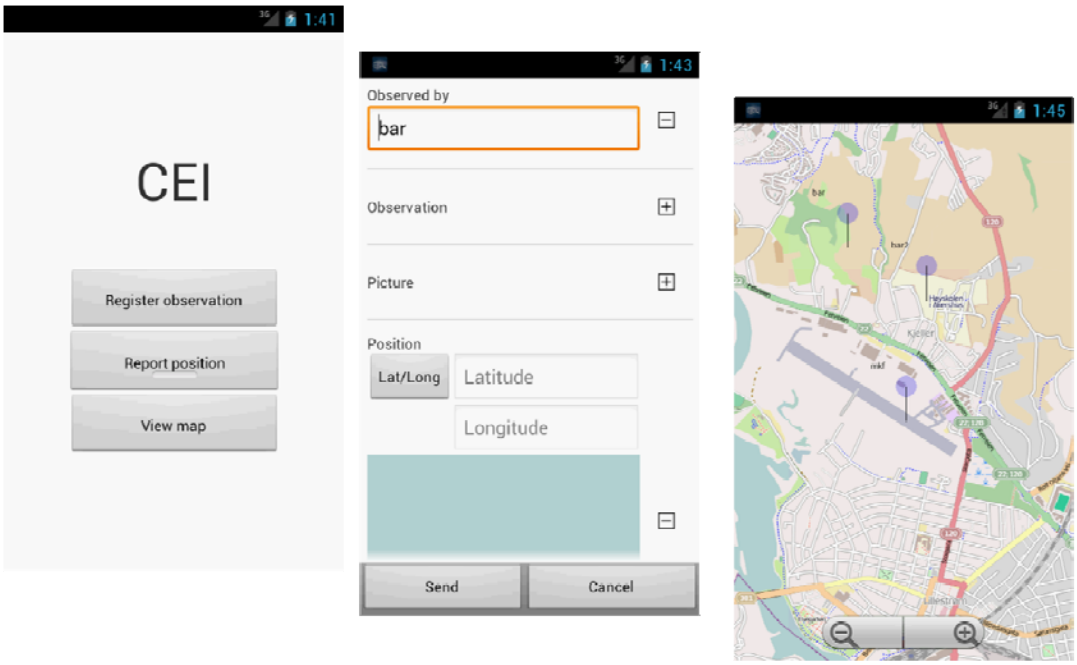

Figure 6: The Android app of the CEI service

Application repository

We keep an internal repository for mobile applications, similar to, but simpler than, Android Market/Google Play. Screenshots are shown in Figure 7.

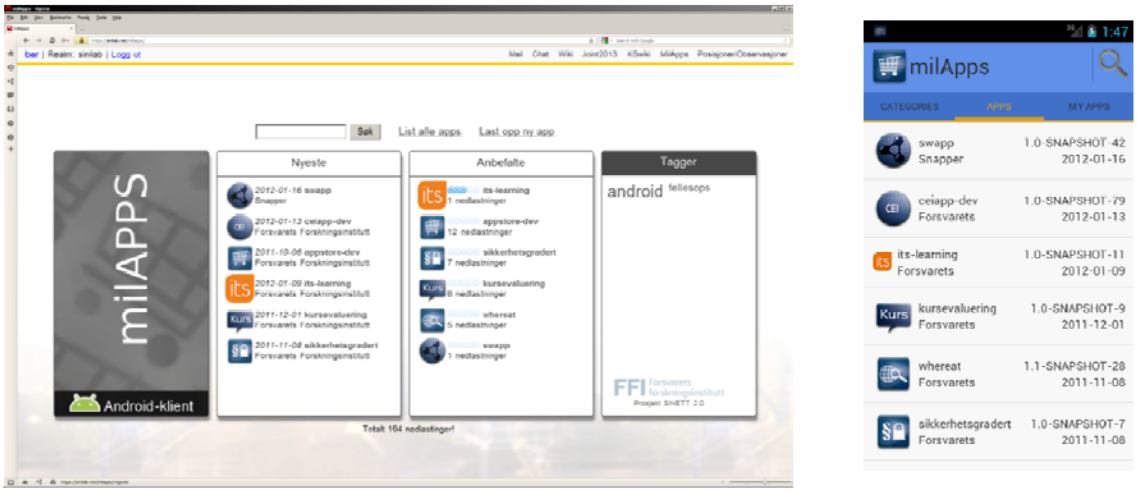

Figure 7: Our repository for Android apps

Chat server, *e-mail* server, cloud *file sharing* service.

These are open technologies able to facilitate many different ways of doing things. Although excellent Internet based file sharing services, chat services and e-mail services are commonly available, having in-house servers providing these services were commonly asked for in early experiments. Information shared is not classified in any way, but users did flag a concern for the terms one would agree on when using these commonly available services in a professional setting.

This portfolio, as it stands, may also be regarded as a result of our experiments so far. Through our experiments the portfolio and the different services/meta-designs have evolved into what it is today.

Experiences and results

Our experiments are open and explorative and as such the findings are on many different levels. The experiments are also local domain experiments and hence yield local results. We have made many findings within these local domains. These are insights into what works and what does not, and new ways of doing things, including all four parts of the mobile complex (services, devices, networks, and people). The participants are bringing forward ideas and elements we never thought of designing up-front. Some findings are taken care of in our portfolio of services/meta-designs, but there are many more than we are able to relay forward. Hopefully the users will also be able to put forward requirements for future systems and arrangements targeting improvements in their own domain.

We will be able to aggregate the findings from the local experiments. In that manner we may find popular, and frequently asked for and used services. Also, we should be able to identify promising meta-designs. At a higher level we should be able to say something about what works and what does not. Common risks introduced by the technologies should also be identified.

From the first experiments, "in-house" cloud file sharing, e-mail and chat services targeting mobile devices is a high priority. Good location based meta-designs are lacking, so are the services. In general, the aggregation of our experiences is included in our portfolio of services and also how we now do seeding and reseeding.

As indicated early in this article, there may be a tension between the existing and the new possibilities of the mobile complex. Thereof, a returning issue is the trade-off between *availability* and *security*. Our experiments are unclassified, but security, especially non-disclosure, is still a major issue. For the first experiments, few self hosted services were included in the initial seeding. For example, the participants were pointed to public cloud file sharing services. Some participants started using these services, but others were reluctant, saying they did not trust these services and would not use them with their information. In general, these public services should provide better availability than a self hosted service, but in this case, lack of trust seemed to be the decisive issue. For reseeding, these groups were provided with file-sharing, chat and other services hosted by us and the groups have expressed much more confidence in these self hosted solutions.

Trade-offs, like this one of security/trust vs. availability is the sort of gaps and trade-offs we seek to address. In this case, this particular trade-off where addressed with an in-house cloud. This raised the trust to an acceptable level and only with a minor reduction in availability. This should be an overall better solution.

We regard the experiment series as a proof of concept. Meta-design is not a main stream approach, but the element of development through evolution has been obvious and constructive in our experiments. Empowered end-users do show local innovation, and the motivated and inspired users have brought forward new uses of the mobile complex in their local domain.

Conclusion and further work

In the spirit of the methods we use for our experiments, this is still a work in progress as it is evolutionary in nature. Also, we are in the early stages with these experiments. We have ongoing experiments in the "evolutionary growth" phase, and as such we are considering constructive and feasible ways to reseed these experiments. At the same time, in our activity, we will continue with experiments that introduce the mobile complex to new military local domains.

Our portfolio of services and meta-designs, which aim to support evolutionary growth, is constantly being developed as we gain insight from our experiments. We consider each of these services, or meta-designs, to be results from our work and experiments. We will work towards more intelligent seeding/reseeding and search for better designs that support evolution in the mobile complex.

The method of *meta-design* and *seeding - evolutionary growth -reseeding* model is valuable in giving insight into the mobile complex in relation to the military opportunities. The experiments are conducted in a non-intrusive way and they are low on resource requirements. The experiment approach, in our case, seems to yield good results relative to its cost.

Through the remaining period of our experiments we hope to gain substantial insights of the possibilities the mobile complex may represent in new ways of doing thing for the military. Central is identifying the gaps and the related trade-offs one is facing, like the trade-off of trust and availability. Finally, we will be searching for ways to address these trade-offs.

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