Development of Mobile Applications based on the Tools & Materials Approach

Joachim Sauer

Software Engineering Group, Faculty of Computer Science, University of Hamburg & it Workplace Solutions, Ltd.

Vogt-Kölln-Straße 30, 22527 Hamburg, Germany

sauer@informatik.uni-hamburg.de

Abstract:

The Tools & Materials approach is a methodology for object-oriented, evolutionary system development. Its roots lie mainly in the design and development of workplace applications for experienced users. They are given software tools to work on software materials, e.g. an account tool to transfer money between accounts.

This paper describes how this approach can be used to develop mobile applications. These are in many respects different to stationary applications, so the approach is adapted to fit the new needs. New guiding metaphors are introduced and existing design metaphors are checked for compatibility with mobile applications. Two example projects are presented, where this approach was successfully used.

Keywords:

Mobile computing, Tools & Materials approach, mobile device, functional device, multi-channeling, domain service

1. Introduction

In this paper we describe a methodology for the development of mobile applications using the Tools & Materials approach (T&M approach).

The Tools & Materials approach is a methodology for object-oriented, evolutionary system development. Its roots lie mainly in the design and development of workplace applications for experienced users. In this paper we extend this approach for developing mobile applications that require a different proceeding than conventional workplace applications. We look especially at the integration of mobile devices into big application systems that run on servers and client computers.

The next section gives an overview over the basics of the Tools & Materials approach that are relevant in this setting. Then we examine its applicability in the mobile context and introduce and examine new metaphors.

2. The Tools & Materials Approach for Workplace Applications

2.1 Fundamentals

The Tools & Materials approach is a design- and construction technique for software (Züllighoven, 1998). It is based on the idea of customer oriented software with high suitability for usage. It incorporates different elements like guiding metaphors with design metaphors, requirements engineering with specific document types and an evolutionary, customer oriented proceeding.

Central idea of the T&M approach is the establishing of a structural similarity between things in real application areas and their implementation in software systems. This gives developers a decision basis for the design of the system and users a better orientation in the application.

The T&M approach encourages an evolutionary system development in which a product emerges in continual refinements (Floyd, 1993). In author-critic cycles the developers get feedback from the users of the system. Basis for this purpose are prototypes – executable programs that represent certain aspects of the system.

2.2 Guiding Metaphors and Design Metaphors

The T&M approach is centered around guiding metaphors and design metaphors.

2.2.1 Guiding Metaphors

According to (Züllighoven, 1998) "A guiding metaphor — or leading motif — is a theme, or other coherent idea, clearly defined and named whose purpose is to represent or symbolize a person, object, place, idea, or state of mind". In software development, it serves as a common orientation for designers, developers, users and other groups of the system.

One common guiding metaphor in T&M systems is the **expert workplace** for autonomous activities. Users who are experts in their profession are supported in their work. The software provides them a workplace where they find tools and materials (see below) that they can use to fulfill their tasks. Another one of the more common types is the **functional workplace** that does not have to be as flexible as the expert workplace but instead provides optimal support for repetitive tasks. Therefor few, but specialized tools and a well-built process control should be provided.

2.2.2 Design Metaphors

Design metaphors detail guiding metaphors. They aid in the design and usage of software systems by using metaphors – figurative expressions that are used in other contexts to replace the actual expression – for referring to parts of the system. It is for example quite common to speak about graphical operating systems in terms from office work: desktops, workplace, folders, documents, garbage cans and others. See (Madsen, 1994) for further information and guidelines on using metaphors in the design of applications.

The most important design metaphors of the T&M approach are tools and materials. During the design of software systems things of daily use are classified into these categories.

Tools are things that can be used to work on other things, the materials. For example a hammer is used to handle nails. The usage of a tool has to be learned by the user. Then he can use it to work on many materials of similar type. He can decide for himself at which time and how he uses the tool.

Materials are things that become the result of the work through processing. They must be able to be edited by tools, often by varying ones under different

aspects. Most often materials of the real world can be transferred quite easily into software materials.

The T&M approach also uses other metaphors like automaton, desktop, environment, container and others, but those two are the most important ones.

3. The Tools & Materials Approach in the Mobile Context

In this paper we will not argue about the value of the T&M approach for software development nor will we contrast it with other software design methodologies. Instead we concentrate on evaluating the T&M approach for designing and developing mobile applications.

Bringing the T&M approach to the mobile world has several advantages:

- It is a thoroughly described methodology which is successfully used in many projects, so you can build on solid ground.

- Developers who have designed and developed software systems based on the T&M approach can use their existing knowledge and do not have to learn a new methodology from scratch.

- There have been built quite a few frameworks, libraries and tools for the T&M approach that could also be used for mobile applications.

- Mobile applications can be easily integrated with stationary software systems when they rely on the same approach and technological foundation.

3.1 Metaphors for Mobile Applications

Mobile devices have other characteristics than stationary desktop computers. They are used for handling of different tasks. The input and output mechanisms and the usage model are quite different. Researchers are still looking for methods to assist users accordingly. For an overview see (Abowd & Mynatt, 2000).

One has to check whether the old metaphors still work or whether new ones are needed.

3.1.1 Guiding Metaphors

The usage model of mobile application is different from that of desktop applications on some points. The different usage context, different expectations of users, limitations of the devices, varying input- and output methods among other things require an adaption of handling and presentation of the applications. Some of these characteristics result from practical influences of mobility (see (Weilenmann, 2003) for a recent study on this subject), some from technical limitations of the devices used.

To cope with this, the applied guiding metaphors should also reflect the different, mobile usage context. They remind application developers explicitly of the specific requirements of mobile devices and enable a development with regard to these right from the start, which results in more functional applications.

The type of applications developed following the T&M approach does not change completely. Experts in their field can handle their tasks in their own responsibility. It does not matter whether they are in their office or offroad. But the use of computers changes. The computer doesn't only display a workplace but becomes part of a general workplace. The user doesn't see the computer as device on with software runs but as digital tool as a whole. This is caused by the handy form factor of the devices that often is adjusted to the tasks which the device can handle and by the usage outside of a fixed working environment. This development was already foreseen by Mark Weiser in 1991 (Weiser, 1991).

Based on the experience in our projects (see chapter 4), mobile devices are mainly used in two usage contexts: As mobile information devices that enable the fast lookup of important personal and job-related information everywhere and also serve to communicate with others. And as specialized functional devices that help handling tasks on site providing data input and output and simple computations. From this we derived two guiding metaphors: the mobile device for experts and the functional device.

The **mobile device for experts** makes an environment available to the expert user in which he can access his most important data outside of his office. This can be personal information that is important for his work like appointments, addresses and a task list. On the other hand he needs data for the execution of his business tasks. This information can not only be looked up but also entered into the device to be synchronized with stationary application systems. An important aspect is also the communication with colleagues and customers to access information that is not available by other means. This follows the philosophy of the mobile device as swiss army knife (Marcus & Chen, 2002).

The **functional device** is tailored to a specific task and should be used by an
expert user. Some tasks cannot be carried out on a fixed working place. Some
tasks can only be carried out with mobile devices, like work in the nature. Often
both cases apply, e.g. with work in varying, difficult accessible places. Here the
functional device can be used. It can be tailored to its jobs in software and
hardware, with special styling, specific input- and output mechanisms, inte-
grated peripherals and so on.

These new guiding metaphors are compared with the existing ones for work in
offices in figure 1.
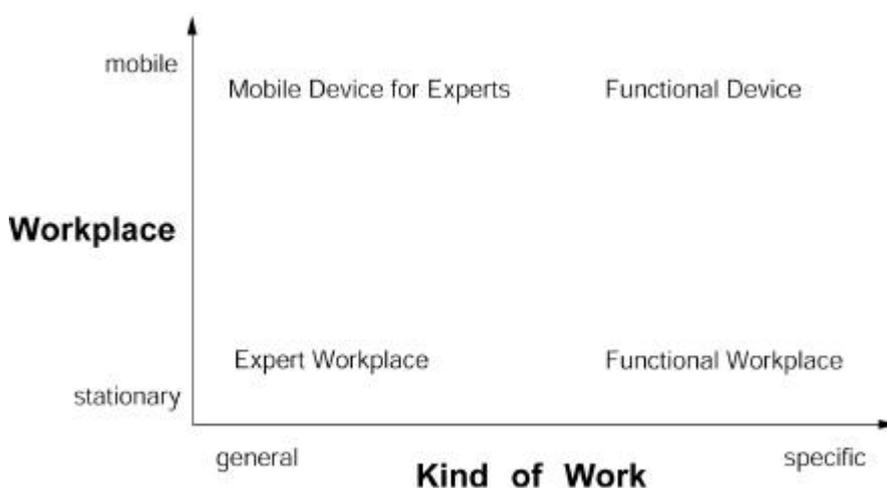
Figure 1: *Guiding metaphors for mobile applications*

3.1.2 Design Metaphors

You also have to check whether the design metaphors of the T&M approach can
be applied to the development of mobile applications. Because of the different
characteristics of mobile devices this is not assured.

With the experience from our projects we arrived at the conclusion that it is in-
deed possible to use existing design metaphors with consideration of some con-
straints:

Materials are as a rule quite easily convertible because they do only possess do-
main-specific operations. They do not have a visual component or predefined
handling. Instead they are manipulated by tools. Often necessary is their syn-
chronization with stationary systems to reconcile data modifications. Some-
times users will only work on duplicates of materials that are kept in stationary
systems and will have to integrate/merge changes they made during the mobile
use. We often applied an original/copy concept in these situations. There may

only exist one original of a material in the system but many copies. Changes on
the copies can be transferred to the original once this is accessible (e.g. during
synchronization of the mobile data).

The tool metaphor is also well portable. This is remarkable because it cannot be
applied to some common usages. An example are web applications. These rely
on a submit/response-pattern that prohibits the sense of directly manipulating
the tools. Web applications are also often stateless and can be used by many us-
ers, so they bear a closer resemblance to services than to tools. Mobile applica-
tions do not suffer from such grave limitations. As long as applications are not
too complex and difficult to handle, users can be given the feeling of using tools
with direct interaction. One should bear in mind that it is usually not possible to
work in parallel with different tools because of limitations in processor power
and screen space on mobile devices.

4. Experiences from our Projects

Here we present two projects in which we could practically test the value of the
new guiding metaphors and the applicability of the design metaphors.

4.1 Project A

In this project we developed a mobile application in the context of a quite big
application system for one of Europe's biggest water suppliers.

In the stationary system it is possible to plan tours for cleaning the sewers using
maps of the city from a geographical information system (GIS). The reports
from the cleaning crews can be fed back into the system for documentation and
evaluation. The system was developed using the T&M approach. It was based on
a corresponding framework.

In a subproject a mobile application was to be developed for the cleaning crews
to replace street and sewer maps on paper with digital images and to allow the
direct registering of the sewers' states. The mobile device was to be a functional
device, being specifically designed for this one task. It was carried out as a tablet
PC with specific gadgets, such as a kind of pistol to read status information from
water counters.

The application system was built using services that provided access to the ma-
terials and domain-specific handling of them. Several tools were using the ser-
vices. Nearly all of the services were using relational databases for persistence.

Most of the tools that were needed for the mobile application already existed in the application system. By developing other implementations for the services that were based on xml-files instead of direct access to relational databases and by providing user interfaces that were adapted to the limitations of the mobile device's input and output facilities, we could reuse most of the domain-specific functionality. Some tools had to be developed from scratch, such as the map viewer that uses jpeg-images instead of vector graphics that come directly from the GIS.

We communicated the new guiding metaphors in the development team and were able to develop a mobile application that was well usable in a very short time.

4.2 Project B

In this project we developed a mobile application for the documentation of diagnosis and treatments in hospital wards. This application makes these tasks much easier and enables the doctors to concentrate better on their patients. During the daily round in the hospital the doctors can lookup data on their patients, like treatment plans, given medications and noticed side effects. After the patients' discharge, a first draft of the doctor's letter (which is important for the billing with health insurance companies) can be generated automatically from the collected data. This speeds up this process a lot and makes sure that no relevant data is lost.

As hardware device a tablet PC was used. We designed it as a functional device. Tools, services and materials had to be implemented for the mobile application from scratch, using a procedure based on eXtreme programming. All members of the development team had well-founded knowledge of the T&M approach. Using the design metaphors tool, material and others helped a lot to gain a common understanding of the system. The mobile context was always present and care was taken to develop a system with good software ergonomic properties.

During the development it became apparent that some tools had also to be used on stationary computers. Because of the foundation in the T&M approach this was no problem. The same tools could be used for this task.

5. Conclusions and Outlook

In this paper we described the adaption of the Tools & Materials approach to the development of mobile applications. We introduced two new guiding metaphors for the mobile context: the mobile device for experts and the functional device. We also discussed the fitness of the established design metaphors tool and material and found them to be adequate.

We designed and developed two extensive commercial systems with the integration of mobile devices based on this approach and found it to be well suited. With the development of more mobile applications, we hope to be able to further refine the concepts.

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