eBag - A Ubiquitous Web Infrastructure for Nomadic Learning

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ABSTRACT

This paper describes the eBag infrastructure, which is a generic infrastructure inspired from work with school children who could benefit from a electronic schoolbag for collaborative handling of their digital material. The eBag infrastructure is utilizing the Context-aware HyCon framework and collaborative web services based on WebDAV. A ubiquitous login and logout mechanism has been built based on BlueTooth sensor networks. The eBag infrastructure has been tried out in field tests with school kids. In this paper we discuss experiences and design issues for ubiquitous Web integration in interactive school environments with multiple interactive whiteboards and workstations. This includes proposals for specialized and adaptive XLink structures for organizing school materials as well as issues in login/logout based on proximity of different display surfaces.

Categories and Subject Descriptors

H.5.4 [**Information Interfaces and Presentation**]: Hypermedia

General Terms

Hypermedia, Education

Keywords

eBag, WebDAV, HyCon, XLink, Context-aware, Adaptive

1. INTRODUCTION

Web technologies are currently in widespread use for distributed e-Learning [10, 20, 26] giving students and pupils collaborative access to shared learning resources while being physically remote from the school environment. However, so far there has been only little research in supporting children at school with Web technologies. In the Center for Interactive Spaces, we are developing Web technologies that become ubiquitous in the physical environment of the school.

With CoolTown [5], Hewlett-Packard presents their vision for pervasive computing where homes, schools, work-

places and life in general is digitally enhanced and connected through the World Wide Web. Small, mobile devices provide fast access to, e.g., presentation material (the CoolTown video shows a business woman "beaming" her presentation material up on a large, digital wall display) and makes studying fun (represented in the video by a little girl who is learning Spanish through a voice-activated program she has downloaded to her wrist watch). But, the CoolTown vision also assumes a lack of privacy that is quite disturbing, e.g., exemplified by the same little girl using a public display on the refrigerator to receive a message from her teacher and consequently getting her test scores broadcast on it, or Bob who is loudly and repeatedly congratulated by the technology he comes into contact with because he has received a reward. The vision also lacks a fundamental technical soundness that makes the underlying infrastructure for the "wired world" they describe believable. However, we agree with the basic idea of being able to move and access digital material through a number of heterogeneous technologies that allow users to choose the tool they find most useful in the given context; a vision quite similar to Mark Weiser's concept of ubiquitous computing [32].

From our studies [7, 22, 27] of school activities we see that learning becomes more project oriented and nomadic in the sense, that pupils spend their daily life as "nomads" in transit between many physical places ("oases") such as classrooms, labs, workshops, libraries, museums, the city, nature, clubs and at home. Carrying a heavy portable PC between all these places is often problematic: It is vulnerable, the PC may be lost or stolen. It is cumbersome, in that it needs to be turned on, reconnected and logged onto the network every time the pupils move between the oases. As an alternative to this we are developing a Web based portfolio system with seamless proximity based login from all interactive surfaces in the physical school environment. The system is called the eBag system - associating to an electronic schoolbag. The eBag system supports nomadic and project oriented learning characterized by ongoing production of material anywhere depending on the tools and materials at hand. The eBag system is integrated in the physical environment of the school supporting collaborative learning (CSCL) in both distributed and co-located groups. The eBag system takes advantage of our previous work on mobile and context-aware hypermedia, the HyCon (HyperContext) framework ([8, 18]). The HyCon architecture includes inter-

faces for a sensor layer encapsulating, e.g., GPS, Bluetooth, RFID and other sensor technologies. HyCon represents the hypermedia objects in structures based on the XLink and RDF standards. The HyConExplorer client supports classical hypermedia features such as browsing, searching, annotating, linking, and collaboration in context-aware hypermedia. HyConExplorer runs on both cell phones and ordinary PC platforms, it integrates GPS devices and takes advantage of GPRS and other IP based cellular networks. The integration of the eBag system with HyCon makes it easy to include resources being produced in outdoor contexts into the eBag system, moreover, it supports the sharing of common hypermedia data structures. The eBag system prototype has been developed in Java and it is running as a Web start application which can easily be distributed to many workstations and interactive whiteboards in a school setting. The system has been tried out by several school classes both in our lab and in a field test at a local school. Although the eBag system has been developed for the school domain, we see many prospects in supporting nomadic work and learning activities in other domains such as hospitals, engineering companies and a rich variety of other workplaces. The paper is organized as follows: Section 2 describes a scenario of eBag use in a school environmnet. Section 3 presents the eBag infrastructure, datamodel, and applications. Section 4 discusses related work. Section 5 makes status on current work and future work. Section 6 concludes the paper.

2. eBAG USE SETTING

The eBag can be seen as a digital counterpart to each pupil's physical school bag. It serves as a link between different types of displays, through which its contents can be seamlessly accessed, and allows the pupils to collect, carry, access, and share digital information very easily. In the following we outline a use scenario illustrating the eBag in an educational setting.

It is Monday morning and the pupils of 8th Grade are gathering in the classroom. Today they are doing a project entitled "Our Town" with the purpose of investigating how the city of Aarhus has changed during the last 100 years. The pupils are to collect material in the form of pictures, video, and interviews from locations around the city and present this to the rest of the class at the end of the day. As the pupils enter the classroom their individual eBags emerge on the interactive board.

Before starting the project work they discuss in plenum the day's work and the pupils choose different topics relating to the general theme. The teacher divides the pupils into groups by dragging together the eBags on the interactive board. When the eBags are grouped, a shared project folder is created where the group members may store the links, pictures, video, and documents gathered during the project.

In advance, the teacher has prepared some concrete assignments and inspirational material to get the groups started on the project. The teacher opens his eBag on the interactive display and finds the assignments. After discussing the links and assignments in plenum, the teacher puts the material in the pupils' eBags by dragging it onto the icons representing the groups. The material is automatically placed in the shared project folder of each of the eBags. The material is assigned to the specific project folder by evaluating a range of variable properties, e.g., time of day, teacher/pupil relationship, physical location, and class schedule.

Figure 1: Pupils working with the eBag on a large display in the school library.

Before setting out to collect material the individual groups gather around the interactive displays located around the school to discuss which locations to visit and who to interview. As the groups members approach the display their eBags emerge. They gather relevant background material from the Internet concerning their specific topic as seen in Figure 1. When the group is done preparing they collect all their material in the shared project folder of the eBag and set out to visit the different locations in the city. As they leave their eBags disappear from the display.

The pupils are equipped with mobile phones capable of taking pictures as well as making audio and video recordings. They visit different parts of the city, interviewing museum custodians and local business vendors and taking pictures of streets and building as they look today. As interviews and recordings are made these are saved directly from the phone into the eBag. Such an interview session could look like presented in Figure 2.
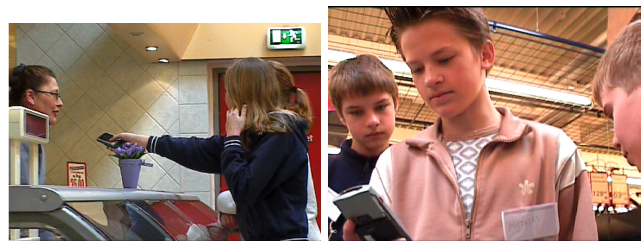
Figure 2: Project work in the field with interviews.

Having conducted their interviews and taken pictures of the different locations, the group returns to the school in order to finish their presentation. At the school they once again gather around an interactive display to view the pictures and listen to the interviews collected during the day from the shared project folder in their eBags. As they begin to prepare their presentation they search for additional material for some of the locations they have visited. One of the group members goes to the school library to find a book containing pictures of Aarhus 100 years ago. Having found the book he sits down at the computer and watches his eBag appear on the screen. He scans the pictures, puts
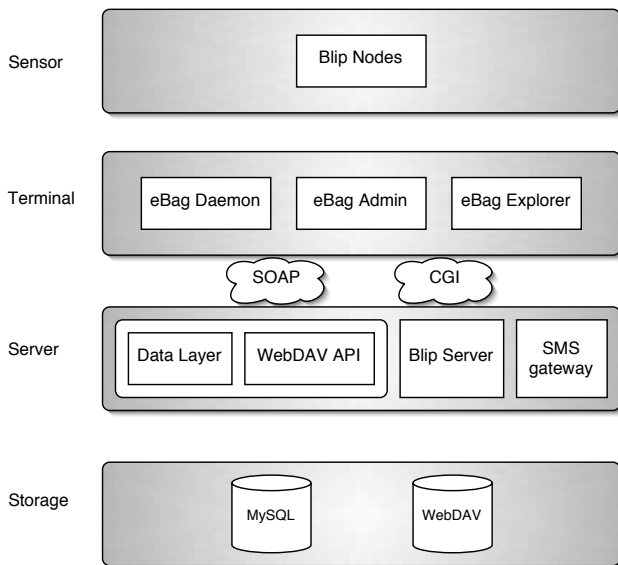
Figure 3: The eBag service presented in the logical layers of the HyCon architecture.

them in the eBag and returns to the rest of the group. When the group has finished their presentation they return to the classroom. As they present their project they share the pictures, videos and interviews collected during the day with the rest of the class.

The scenario illustrates the eBag in an educational setting using the seamless login as students move between locations inside and outside the school. In the next section we describe the eBag infrastructure and the XLink based datamodel.

3. eBAG INFRASTRUCTURE

The eBag infrastructure is build upon the HyCon framework and architecture [8]. The HyCon framework and architecture for context-aware mobile hypermedia was developed to provide a general platform suited for experiments with hypermedia mechanisms in a context-aware and mobile environment as described in detail in [8]. The HyCon architecture consists of four layers: Storage, Server, Terminal, and Sensor. The bottom layer, the Storage layer, handles persistent storage. The Server layer offers components handling data manipulaion in the storage layer and computations upon the storage layer data. The functionalities of these components are offered through services, which are realised as Web Services and Java servlets. Through these interfaces applications in the Terminal layer can communicate with the services in the Server layer. Applications in the Terminal layer are not limited to a specific platform, but may be running on a variety of hardware platforms and software environments (phones, tablets, laptops, Web browsers). The key property of the HyCon framework is the top layer, the Sensor layer. This layer is introduced to logically group all sensors deployed to obtain contextual information.

The eBag service is realised by components in all four layers of the HyCon framework and architecture as seen in Figure 3. Starting from the bottom, the storage layer consists

of a database in our case a MySQL[1] database for storage of eBag profile information. This profile information includes an ID of the eBag, name of the owner, a password, a URL to an icon for the eBag (typically a picture of the owner), a BlueTooth ID registered for the eBag, and more. Besides the profile information of an eBag the actual content of an eBag such as digital pictures, video, music, text documents also has to stored in a content repository. This is handled by a WebDAV server[2], providing storage capabilities and mechanisms for file locking and versioning. In the Server layer a Data layer component encapsulates functionality for creating new eBag profiles or modifying existing ones in the persistent storage. The Data layer component implements a WebService interface, thus communication to the component is through SOAP messages. A WebDAV access component is also present in this layer as it is implemented as a Java servlet. To collect sensed contextual information from the BlueTooth sensors (known as BlipNodes) we use a central server (known as BlipServer[3]) in the Server layer. An advantage of using a central server to collect the sensed information is that a uniform interface for accessing this information is provided independent of the sensor hardware used, and queries throughout the sensed information from all sensors can easily be supported. In the Terminal layer three applications forming the eBag suite are found. The eBag Daemon is the basic application that presents an eBag icon on a display when a BlueTooth device registered for this eBag is discovered nearby. When clicking on the eBag icon the content of the eBag is opened in a new window ready for retrieval or storing of digital material. Furthermore the eBagExplorer application provides an "offline" access to eBags by showing all eBags in the system by their icons in a list. When clicking on an eBag icon the eBag is only opened if the password given is valid according to the eBag profile information. The eBagAdmin application is very similar to the eBagExplorer. However the password protection is removed from each eBag to a single login when starting the application. This application is only intended to be used by an administrator or a supporter of the eBags. In the Sensor layer of the eBag infrastructure the BlipNode BlueTooth sensors are placed. As mentioned above the sensed information from these sensors is collected by the BlipServer in the Server layer from which the eBag applications can access the sensed information. The reason for using the BlipNode hardware is the facility it offers to regulate the signal power of the BlueTooth unit. Thus discovery of nearby BlueTooth units of a BlipNode can be configured to reach a certain distances from a few centimeters to approximately 20 meters. This allows a setup where a BlipNode, that is configured to discover BlueTooth units in a distance of, e.g., 2 meters, can be placed nearby a screen display of a computer running the eBag Daemon application, and in this way show eBag icons of nearby BlueTooth units.

3.1 The eBag Datamodel Based on XLink

The eBag can be described as a link composite locating the pupils' resources into a single structure. A proposal

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[1] http://www.mysql.com

[2] We use the Jakarta Slide WebDAV implementation. http://jakarta.apache.org/slide/

[3] The BlipNodes hardware and BlipServer software is developed by the company BlipSystems. http://www.blipsystems.com

```
<ebag xlink:type="extended"\
      xlink:role="http://fahbentor.daimi.au.dk/ebag"\
      id="ebag_ID">

  <!-- Basic profile information-->
  <profile>
    <btid>Bluetooth ID</btid>
    <name>eBag name</name>
    <icon href="..."/>
    <password>password</password>
    <message>eBag Message</message>
  </profile>

  <repositories>

    <!-- WebDav repository -->
    <repository name="webdav" xlink:title="WebDav"\
             xlink:type="locator" xlink:href="..."\
             username="..." password="..."\
             xlink:label="webdav"/>

    <!-- HyCon trails repository -->
    <repository name="hycon" xlink:title="HyCon"\
             xlink:type="locator" xlink:href="..."\
             username="..." password="..."\
             xlnk:label="hycon"/>
    ...

  </repositories>

  <!-- List of friends' eBags -->
  <friends>
    <friend xlink:title="Friend's name" xlink:type="locator"\
          xlink:href="..."/>
    ...
  </friends>

  <!-- Digital eBag contexts -->
  <ebagcontexts>

    <ebagcontext xlink:type="locator"\
                 xlink:href="#xptr(id("ebagcontext1"))"/>
    ...

  </ebagcontexts>

</ebag>
```

Figure 4: The eBag datamodel expressed as an XLink structure.

for a link format in XLink [11] is presented in Figure 4. The main `ebag` element has the XLink attribute `xlink:role` which identifies the structure as an eBag structure, and defines the semantics for the `repositories`, and `friends`. The `profile` element is an optional element which may contain as many properties of the eBag profile as wanted; however, eBag applications are not required to implement support for all of these properties. The `repository` element is the element to describe which resources or respositories to integrate in the eBag. If further configuration of how access to a certain repository is needed, this information can be supplied via additional attributes in the element. Finally, a list of friends and links to their eBags can be expressed by the `friend` elements. With the list of friends and links to their eBags, an eBag application could easily allow a pupil to follow the link to a friend's eBag or even integrate it, so, e.g., the friend's eBag status message was shown. With the `ebagcontext` elements, context views on the eBag resources can be included.

By describing the eBag as an XLink structure a light weight version af the eBag application can be supported by transforming the XLink structure with an XSL [2] stylesheet.

This could be used to produce a Web version (or other platform specific versions) of the eBag applications and thus support easy migration between platforms for the pupils. The idea of supporting a wide variety of platforms is ultimately to allow the pupils to access their resources from anywhere.

3.2 Adaptivity of the eBag Based on Context

A certain degree of adaptivity is an important aspect of use of the eBag. Taking advantage of the current context when placing and retrieving information provides the teachers and pupils with another sense of seamless interaction with the digital material. Thus when the physics teacher wants to distribute a new project folder about Ohm's law to the entire class an Ohm's Law sub-folder is created in the individual pupil's physics folder. The teacher can also add additional material for the weaker students and more challenging assignments for the stronger students and thus support a differentiated teaching strategy. Naturally, the teacher has no access rights to the eBag in general but it is vital that she can add material that is placed in the right context in order to avoid material getting lost in a general "inbox". The pupil can grant access to the teacher and other students for different folders in different contexts.

An eBag context element (`ebagcontext`) should define a set of resources from the eBag, and a set of conditions which have to be met for the eBag context view to be active. The conditions are then evaluated by a context interpreter which have access to context information such as schedules for pupils and teachers, locations of eBags and more low level information such as time of day, outside temperature, and more. This model is inspired by the Context Toolkit [12]. When an eBag context view becomes active, the pupil would be able to open the view of associated resources. This could be visualised in the eBag applications with an eBag context indicator icon, that would open the active view when clicked.

An example of an eBag context definition can be seen in Figure 5. Notice that it is an XLink structure with the `xlink:role` attribute set. This defines the semantics for the elements `default-store` and `resource`. The `conditions` element contains an address for the context interpreter to be used and the conditions that should be evaluated by it. When all the conditions are met (logical and between conditions), the context interpreter sends a notification back to the eBag application, notifiyng that the eBag context is active. A notification to inactivate the eBag context is also send from the context interpreter when one or more conditions evaluates to false. The `default-store` element points into a repository from the eBag, and is used when the eBag context view is not opened, but active, and a resource is dragged upon the indicator icon of the active eBag context. The `resource` elements locates the resources associated with the eBag context, and which are made accessible to the pupil when the eBag context is active. This approach is similar to the generic link structure and context-aware linking described in [13, 15]

3.3 eBag Applications

As described earlier, the Terminal layer of the eBag infrastructure contains the eBag applications. These applications are the tools which pupils interact with when equipped with an eBag and want to change profile information or content

```
<ebagcontext name="Physics project" xlink:type="extended"\
            id="ebagcontext1"\
            xlink:role="http://fahbentor.daimi.au.dk/ebagcontext"/>

  <conditions contextinterpreter="http://...">

    <condition name="Physics is on the schedule"\
            expression="schedule(pupil1,time) = physics"/>
    <condition name="Group gathered"\
            expression="group = {ebag_ID1,ebag_ID2}"/>
    ...

  </conditions>

  <default-store xlink:type="locator" xlink:href="#XPointeExpr1"\
            repository="webdav"/>

  <view>
    <resource xlink:type="locator" xlink:href="#XPointerExpr2"\
          repository="webdav"/>
    <resource xlink:type="locator" xlink:href="#XPointerExpr3"\
          repository="hycon"/>
    <resource xlink:type="locator"\
          xlink:href="http://www.physicsclassroom.com"/>
  </view>

</ebagcontext>
```

Figure 5: The eBag context datamodel expressed as an XLink structure.

of their eBags. The eBag Daemon application shows the eBag icons of registered BlueTooth devices nearby a preselected BlueTooth sensor. An example of how eBag icons are presented is depicted for the eBags of two pupils Trine and Monica in Figure 6. The eBag icon has the profile name at the top, the associated profile picture in the middle and can have a message if supplied at the bottom.
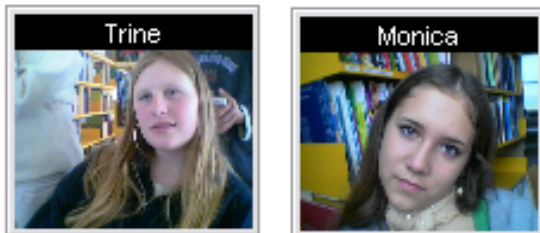

Figure 6: The eBag icons for Trine and Monica's eBag.

The eBagExplorer is an "offline" browser for eBags, in that all eBags are accessible even if they are not in proximity of a sensor. This allows a more traditional login mechanism where a pupil can find her own eBag icon from the list and open her eBag by password authenticating herself. A screenshot of an eBagExplorer is shown in Figure 7, where the eBag icons are listed together with the profile name and an optional awareness message.

As described earlier an eBag is opened when a pupil clicks either on the eBag icon shown by the eBag Daemon or in the eBagExplorer list. The eBag is visualised by creating a new window showing the contents of the eBag in a hierarchical structure, as can be seen in Figure 8.

These applications can be running on various platforms, affording different kinds of interaction. The platforms and display types that we have currently used range from tablet-
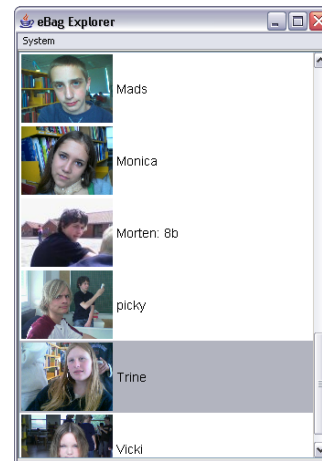

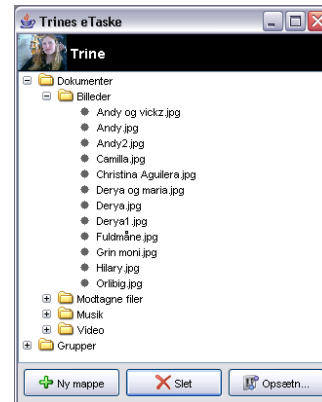**Figure 7: The eBagExplorer with a list of eBag icons.**

Figure 8: Trine's eBag opened.

PC, laptop, and desktop computers with screen display, SmartBoard display, and floor projection.

3.4 Seamless Login to eBag Resources

A key feature of the eBag infrastructure is the deployment of sensors to provide a proximity based login and logout mechanism to the eBag. As the BlueTooth sensor hardware allows the signal power to be adjusted, we can configure the signal power to reach only a certain distance. This is a valuable property because we are then able to fairly accurately ($\sim$1 meter) control the extend of the area where a BlueTooth unit is discovered (login) by a sensor and equally important when a BlueTooth unit is not discovered anymore (logout). The login procedure begins when a BlueTooth unit is discovered. The BlueTooth ID is used to lookup an eBag profile with this ID registered, and if found the pupil is logged in and the eBag icon is presented. Thus, a pupil can get instant access to her eBag resources, just by walking (with a BlueTooth unit in her pocket) up to a display (with a sensor) and click on her eBag icon. Issues dealing with proximity based login and instant access to resources have also been discussed in [3, 4, 30].

Figure 9: Trine and Monica have formed a group by dragging their eBag icons close together.

3.5 Collaboration Support

The eBag supports project work by allowing eBags to form groups in which the distribution and sharing of material becomes very easy. By dragging two or more eBag icons close together, a group is formed. When doing this, a group name is prompted for and a shared group folder is created, which all the members of the group have access to from their eBags. The eBag icons are now assembled into a group icon, where each eBag icon is included. An example of this where Trine and Monica have formed a group can be seen in Figure 9.

To put the result of an assignment in the form of, e.g., a text document to the eBag, the pupils can drag and drop files to an opened eBag into a specific folder in the eBag hierarchi. This can also be accomplished by dragging and dropping files directly to the eBag icons. This feature is also supported by the grouped eBag icons. Thus a teacher can easily delegate, e.g., new assignments or evaluations to a whole group at once without having to open each pupil's eBag.

3.6 Adaptability for Awareness

As briefly mentioned above an awareness message can be attached to an eBag, and will then be displayed together with the eBag icon. The message functionality is used by the pupils to communicate what they are doing or where they are, e.g., "Taking the bus back to the school at 11 o'clock" or "Visiting The Old Town - going to the town hall at 10". This is particularly useful on field trips as a means of asynchronous communication with other group members or teachers back at the school. The message can be set either from an opened eBag or by sending it as an SMS from a mobile phone to the SMS gateway. Thus by providing this simple message functionality an awareness between the pupils is accomplished.

Another mechanism to increase the awareness of the progress of each other's work in a project group, is a notification service. As our primary resource repository for the eBag is a WebDAV store, we are interested in support for notifications from the WebDAV server when actions are performed on resources in the store. Only recently support for this mechanism for WebDAV has been investigated and implemented by, e.g., the AwareDAV framework [23].

4. RELATED WORK

In the following, we will discuss how Web based learning systems and the introduction of mobile technology has and may support the teaching in elementary schools, with particular focus on collaborative project work where the children are actively engaged in knowledge production.

4.1 Web Based Learning Systems

Web support for learning has been on the agenda in the computer supported learning communities (CSCL, EdMedia) for many years. However, many Web based learning systems are focusing on supporting distributed learning (as opposed to supporting the concept of local mobility presented in [6]) and introducing a primarily administrative system for sharing documents and awareness about classes and group work ([10, 17, 20, 26]). With the eBag focus is on the ubiquitous aspects of web support in learning environments that let the digital information travel seamlessly across technological platforms. In the following we will discuss some of these solutions in relation to the eBag concept.

An example of a web based learning system that calls itself a digital school bag is the Norwegian system, Fronter which is used in several Danish high schools[4]. Fronter is a Web based conference system not unlike First-Class (which also forms the basis for Uni-C's school portal, SkoleKom). With Fronter, the teacher can create a virtual building which is separated into rooms in which pupils and teachers can collaborate with different tools on different subjects. Fronter is basically an administrative system that allows the teacher to, e.g., open and lock rooms or folders in which pupils hand in their assignments. If the paper has not been uploaded on time, the teacher will know. However, Fronter does not support differentiated teaching and it cannot support the social structures that are essential to the pupils in order to function well as a virtual community. It may use the metaphor of building a house, but it is a space rather than a place [19].

Some Web based learning environments, however, take a quite different approach to teaching and learning by introducing elements of gaming rather than focusing on providing the student/pupil with administrative tools. One such is Case/Melved by Learning Lab Denmark[5], an excellent and very compelling Web based role-playing game for the 7–10 grade [25]. As forensic detectives, the pupils are required to use many of the school's facilities, e.g., physics and chemistry, to analyse clues and ultimately solve the murder case. Naturally, Case/Melved has a much more limited scope with respect to how it may be used at what it can contain, compared to some of the previously mentioned systems, but it presents an interesting new focus for introducing Web based learning systems in education. However, the game design is not concerned with how the students can carry the digital information with them to the labs or how they can take advantage of the current context.

4.2 Use of Mobile Technology in Teaching

When we look at how mobile technology has been introduced in education, we discover that many systems focus on introducing mobile technology to support a traditional classroom type teaching in ([1, 28]) and outside ([9]) of the classroom. A possible explanation for this is that a considerable number of the projects are dealing with higher education [16, 29] and the predominant lecture format for teaching at universities. The Ambient Wood project [31] presents a

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[4]See http://fronter.dk
[5]http://www.lld.dk/

notable exception to that rule with their fine example of how we may move education out of the classroom. Their goal was to provide students with contextually-relevant digital information that would support them in discussing and reflecting on what they were doing and learning

We acknowledge the importance of supporting reflected learning but we also see a great need and great possibilities in supporting constructive contextual feedback from the students, allowing them to produce material that is tied to the current activity and location.

[14] presents some interesting pedagogically-founded perspectives on how mobile technology may support the natural science subjects in the field, e.g., data gathering and cooperative learning. However, as with Case/Melved they do not consider how context-specific information and services can support the work.

The *school*Bag is Uni-C's proposal for an electronic school bag. It is a Web based service that provides each pupil with space on a web server (webdisc) for the files he or she wishes to save along with notes, links and addresses. While the *school*Bag is distributed because it is Web based, it is not mobile unlike the eBag that allows the pupils to bring their digital context with them as they move around on the school or go on field trips. Uni-C's vision for an electronic school bag does include aspects of mobility [21]; however, it is largely based on providing every pupil with a notebook computer that they can carry everywhere and access the digital material. We support the idea of introducing more mobile technologies in the learning setting, but we find this vision questionable because it still is so PC-centric that it fails to even consider the range of mobile technologies that are available, e.g., mobile phones that become increasingly powerful and are already an integrated part of most pupils' social lives.

An electronic schoolbag is also an important component in building ad hoc classrooms in [9]. Their eSchoolbag consists of a number of components, e.g., the electronic book, parents' contact book, pencil case and can be accessed through a notebook computer or PDA. In their example, they present a vision for school work where everything is done through the PDA, from reading and doing exercise to communicating with the pupil's parents. While we support the idea of making digital information accessible outside of the classroom and on the move, we want to emphasise that supplying the pupils and teachers with a range technologies to support school work rather than replacing one technology for another is a crucial point if we are to succeed in supporting education and learning. Furthermore, we find the assumption that the eSchoolbag can and should be shared between the pupil and his or her parents (parent check the e-contact book on the PDA) to be a violation of the child's privacy.

5. STATUS AND FUTURE WORK

An early prototype of the eBag application has been tested at a local elementary school where two 7*th* grade classes each used the eBag for project work for one week. Each pupil was equipped with a mobile phone (Nokia 7650, 3650 or 6600) whose Bluetooth id worked as the unique identifier for their eBag. A SmartBoard and three PC's in the library were hooked up to BlipNode units, providing the pupils with seamless access to their eBags. The small-scale setup was chosen to provide proof of concept on both the eBag and the technology we employed before implement-

ing it in a larger scale for a longer period of time. During the test period, the pupils entered different types of digital material (but primarily photos of themselves and their family and friends) to their eBags. The average number of items entered increased in week two as we initially experienced some technical problems. Overall, the children found the eBags engaging to work with despite the fact they were hampered by a slow and at times non-existent internet connection which rendered the eBags unusable.

We are currently in the process of re-designing the eBag, particularly with respect to the user interface, information structure and navigation. From our preliminary tests with pupils from Vestergaardskolen, we see a need to provide the pupils with the possibility to personalise their eBag beyond changing name and picture, e.g., supporting the social structures by displaying their friend's pictures and eBags, and making it possible to showcase themselves to others through a gallery and a blog-type message board. We are also developing the context dependencies with respect to groups to include class/teacher- and class/school relations. Finally, we are supporting a user-controlled awareness service on the eBag that allows pupils to change their status from the mobile phone.

In its first implementation, the eBag is "tied" to a mobile phone whose Bluetooth unit serves as a unique identifier for each pupil's eBag. However, it can easily be associated with other types of Bluetooth carriers (e.g., BlueTags) and shaped like key-chains, buttons, toys, or whatever form is most appropriate for the children in question. There are, however, great advantages of using the mobile phone when working with older children. First, most children in the 7th to 10th grade already carry a mobile phone and are often very attached to it to support their social networks. Second, a variety of mobile phones offer cameras, audio recorder and video recorder functionality that provide valuable means of capturing data, e.g., during project work.

6. CONCLUSION

This paper has described the eBag infrastructure, which is a novel Web based infrastructure that supports collaborative handling of digital resources in a school environment. The goal of the eBag design is to support school kids in working in project oriented and nomadic learning, i.e., learning where the kids may work in many different places in and outside the school buildings.

The key contributions of our work with the eBag infrastructure are:

- A seamless login and logout mechanism based on BlueTooth proximity sensors for accessing Web resources. The login mechanism is based on the HyCon architecture supporting a sensor layer.

- An exchange format for the eBag datamodel with an XLink structure, integrating the eBag resources and profile information into a single composite, thus supporting easy migration between platforms. This is an example using XLink to implement classical hypermedia composite structures.

- Support for adaptive behaviour by context dependent views on the eBag structures, including an XLink based format for expressing views, content and conditions.

This includes a proposal for handling context-interpretation as an integral part of an XLink structure.

The paper describes a case for the use of eBag in public schools, and it discusses initial experiences from a field test with school kids. The eBag infrastructure and applications are under ongoing development and a new long term field test is planned for March 2005.

7. ACKNOWLEDGEMENTS

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