ELAN: An E-Learning Infrastructure for Ad-Hoc Networks

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1. OBJECTIVES

Mobile ad-hoc networks are characterized by spontaneously connecting systems using wireless technologies. Such networks have inherently high dynamics, because mobile terminals can randomly enter or leave the reachability scope at any time. Besides the dynamic changes in the infrastructure itself, there are also dynamic changes in provided services, content and reachable users within the ad-hoc network.

The objective of this project is to design and to implement an adaptive infrastructure for an efficient collaboration support in E-Learning scenarios which take place in mobile multi-hop ad-hoc networks (MANET). Therefore, it is necessary to develop special concepts in order to be able to cope with the high dynamics in such networks.

Rather than adopting traditional concepts and dealing with the effects of mobile ad-hoc networks, the characteristics of the inherent dynamics will instead be analyzed for possible benefits regarding collaborative E-Learning scenarios. Following the notion of spontaneously connecting computer terminals, an efficient infrastructure should suggest potentially useful collaboration partners and resources according to the educational profile of each student or service respectively. Hence, a spontaneous exchange of experience and knowledge should be supported.

Firstly, we have to specify what kind of collaboration should or can be supported. In general, collaborative work defines a group of people working together for a common goal. Our approach focuses on an E-Learning scenario. Hence, similar educational objectives – up to a certain level of abstraction – can be assumed. Those similarities could motivate the collaboration of different students in an ad-hoc network – if they would just be *aware* of each other.

In order to find groups of students with similar educational objectives which may enter or leave the sphere of activity of an ad-hoc network at any time, several requirements must be met: all students participate in the same educational system which mainly supports independent studies. The E-Learning system supports personalized learning environments and each student sets up his own schedule and objectives. The independent studies should be promoted by well-founded literature references in the chosen area of interest, and by discussions with students with similar interests and especially more experienced ones. It should be possible to exchange experiences as well in a synchronous as in an asynchronous manner. The participation in the E-Learning system should be supported by several kinds of mobile terminals to provide the opportunity to study any-where and any-time.

MOBICOM'02, September 23–28, 2002, Atlanta, Georgia, USA.

2. COMPONENTS OF THE ELAN INFRASTRUCTURE

One of the main objective of an infrastructure for E-Learning in ad-hoc networks is the development of efficient methods to find students with similar interests and to find services providing useful information. Therefore, special mechanisms for distributing awareness information must be provided on several layers – on the network layer and on the application layer – which take into account the high dynamics of mobile ad-hoc networks. Our concept of such an infrastructure is based on several components, the most important four of these will be outlined in the following.

Awareness: In order to continously update the knowledge of the current composition of the ad-hoc network with its systems, services, and users, efficient awareness mechanisms for serveral layers need to be developed and integrated. Infrastructural awareness mechanisms keep track of changes of the ad-hoc topology. Application based awareness mechanisms informs about currently reachable services, contents, and users. These mechanisms are covered by the so called *location awareness*.

To detect potential collaboration partners with similar interests or educational objects, special user awareness mechanisms are needed which in particular support contact facilitation. *Service awareness* mechanisms offer students helpful services within the current range of reachability.

Another kind of awareness is the so called *context awareness*. Hereby applications which are running on mobile stations are informed about the capabilities of the station. Applications then can adapt to the display and user interface constraints of the specific mobile station.

MANET-Routing for ELAN environments: The development of routing strategies usually focuses on calculating routing information within one protocol layer – the network layer. Our research is based on the idea of using additional information from other protocol layers, e.g. intercomponent communication messages on the application layer, to improve and optimize the routing strategies. We are also investigating how far precalculated routing information gathered by "sniffing" data packets from other ELAN stations can be used.

The ELAN routing layer will also provide means to support a maximal availability of services to applications. Applications can indicate their interest in specific services to the routing layer and the construction and the continuation of established routes to stati-

ons providing these services will be handled. In a further step, the routing layer will extract these prefered services directly from the awareness information block on the application layer. These mechanisms will lead to an awareness based routing strategie (Application triggered Routing, Clusters of Interest).

ELAN-Middleware: Given the available bandwidth, the strong dynamics and the limited hardware capabilities of stations in wireless ad-hoc networks, there has to be developed a special middleware layer, which takes these impacts of mobility into special account. Only such a mobile middleware can provide the maximal possible distribution transparency similar to middleware solutions known in stationary systems. We therefore will develop a mobile middleware incorporating *reflection* techniques.

Since the ELAN-Middleware is already awareness based, it will also be responsible for the distribution of this awareness information. The topology in ad-hoc networks is continually subject to change which prohibits using a fixed distribution scheme. Each station has to distribute the information in dependence of its current neighbours. Therefore we are working on a self organized distribution scheme that will adapt to these changes. It will also use the distributed awareness information to optimize routing (see MANET-Routing).

A connected aspect is the *persistence of service*. Depending on mobility schemes in ad-hoc networks the status of availability of services is also subject to change. This can either be caused by a movement of the service user, which moves out of the service availiability area, by the movement of the service provider or even by the movement of a station connecting two otherwise unconnected clusters. In order to provide a maximal persistence of service the mobile infrastructure has to adapt to these changes – either by service migration or -replication (at middleware level) or by reconfiguring the routing strategies (at routing level).

E-Learning Profiles: In our E-Learning scenario, potential collaboration partners are students with similar knowledge or learning interests or students who provide “interesting” services. In order to find collaboration partners in Ad-Hoc networks, which are not neccessarily aware of each other, their interests must be compared. Therefore every potential participant has to provide a list of interests which is realized in terms of *knowledge*, *learning* and *service profiles*.

To support the automatic finding of collaboration partners, the knowledge, learning, and service profiles need to have a certain structured description format which enables an automatic parametric correlation algorithm. We have evaluated several available formats and have settled on a customized XML-based representation which will be interoperable with most of the recent profile activities, e.g. such as WSDL (Web Service Description Language) or the SLP (Service Location Protocol).