New directions for lifelong learning using network technologies[1]

Rob Koper, Colin Tattersall

Rob Koper is Professor in Educational Technology at the Educational Technology Expertise Centre of the Open University of the Netherlands (OUNL), where he is head of Learning Technologies R&D.
Colin Tattersall studied Computational Science before working on his PhD at the Computer Based Learning Unit. In mid 2002 he joined the Open University of the Netherlands as an educational technologist.

Abstract
The requirements placed on learning technologies to support lifelong learning differ considerably from those placed on technologies to support particular fragments of a learning lifetime. The time scales involved in lifelong learning, together with its multi-institutional and episodic nature are not reflected in today's mainstream learning technologies and their associated architectures. The article presents an integrated model and architecture to serve as the basis for the realization of networked learning technologies serving the specific needs and characteristics of lifelong learners. The integrative model is called a "Learning Network" (LN) and its requirements and architecture are explored, together with the ways in which its application can help in reducing barriers to lifelong learning.

New directions for lifelong learning using network technologies

The concept of lifelong learning refers to the activities people perform throughout their life to improve their knowledge, skills and competence in a particular field, given some personal, societal or employment related motives (Aspin and Chapman, 2000; Field, 2001; Griffin, 1999). The need for better provision for lifelong learning in society is broadly recognised and is expressed in national and international policy documents. For example, the Commission of the European Communities (2000) states in its memorandum on Lifelong Learning: "Lifelong Learning is no longer just one aspect of education and training; it must become the guiding principle for provision and participation across the full continuum of learning contexts". The target formulated by the Commission of the European Communities (2002) is to increase the average level of participation in lifelong learning in 2010 to at least 15% of the adult working age population (24-64 age group). The average EU participation in 2001 was 8.4%, measured by asking people to indicate whether they performed any education or training activity in the last four weeks. In order to stimulate lifelong learning, one has to analyse barriers to it and to develop measures to overcome these barriers where possible. Longworth (2003) summarizes the barriers to lifelong learning as follows:

1. Poor family culture of learning, low aspiration, low self-esteem, bad childhood experience of learning (*mental barriers*).
2. Lack of finance to participate, and lack of study facilities at home (*financial barriers*).
3. Distance to educational provision for a large number of students (*access barriers*).
4. Learning provision which not geared to the needs and characteristics of lifelong learners and does not sufficiently take into account the individual differences and circumstances of learners during life (*learning design barriers*).
5. Learning providers who supply information which is inadequate in attracting people to learning and fail to ensure that people have access to good-quality advice about learning opportunities throughout their lives (*information barriers*).

The first set of barriers reflects issues that are in the minds of people, and the second barriers are economical and political issues, but the last three barriers can be surmounted by appropriate use of new networked learning technologies. The third barrier can be overcome by providing more and better *access* to distance education exploiting new information and communication technologies (ICT). These technologies, especially those with mobile access, offer the potential of reaching everyone, everywhere, and have many characteristics that can be used to create flexible, rich and interactive learning environments. However, making ICT facilities available is not enough to ensure that these facilities are applied effectively to overcome the two remaining barriers to lifelong learning. The facilities have to be arranged, ie, *designed,* in an appropriate way to meet the specific requirements for lifelong learning, including individual differences in needs, learning preferences, prior-knowledge and situational circumstances. However, well-designed learning events and courses do not guarantee the successful attraction of target learner groups. Measures have to be taken to attract the appropriate people to the appropriate learning facilities by providing

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information about the complete offering available in order to give sound and suitable advice for learners. Each institute typically sets up its own information and advice service. However, lifelong learners need an overview of the offerings of all institutes that are accessible.

In order to develop ICT networks for lifelong learners, a model is required which integrates the different issues mentioned above, serving the specific needs and characteristics of lifelong learners. This article presents an outline of such an integrated model and architecture. The integrative model is called a “Learning Network” (LN) and its requirements, architecture and use will be explored.

Learning Networks for Lifelong Learning

Requirements

There are several specific characteristics of lifelong learning that have to be taken into account when developing ICT networks for lifelong learners. The major characteristics of lifelong learning are already contained in the phrase itself: it is “lifelong” (from cradle to grave) and puts “learning” (and not instruction) centre-stage. Knowledge and competences grow during life in different fields, and learning facilities should provide the possibility to support the lifelong building of knowledge and competencies at different levels of proficiency in a given field. This has several implications, which we now explore.

First of all, putting the learner centre-stage means that the learner is responsible for his/her own learning processes and not a teacher or an institute (see also Shuell, 1992; Longworth 2003). Lifelong learners are *self-directed* (Brockett and Hiemstra, 1991; Candy, 1991), and can perform different learning activities in different contexts at the same time. For instance, on the same day a person can have a job-related training course at work, learn a new language in the evening from a teacher in the neighbourhood, read texts and search the Internet for information. For learners to be self-directed, they must be in a position to oversee what is available and determine how this matches their needs, preferences, prior-knowledge and current situation. One of the basic requirements is to be able to search for adequate learning facilities and to plan adequate learning paths to these and other facilities.

Second, learners are typically engaged in a variety of formal and informal learning activities during their lifetime. This implies that the provision of lifelong learning facilities cannot be a task for a single institute, but has to be seen as the collection of learning facilities that are provided worldwide by different providers in a specific field and over time. Lifelong learners need a single point of *mobile access* to the distributed information about the offerings, and—to avoid overload—learners should be *supported* in selecting the most suitable solution given their needs, prior-knowledge and current situation. Ideally, information about learning facilities should be amenable to automatic processing, thereby facilitating Learning Brokerages (Hämäläinen *et al,* 1996; Whelan, 1998) able to intermediate between learners and learning providers to identify the most appropriate steps to be taken at any point in a learning lifetime.

Third, the participants in an LN in any given field have different levels of competence, varying from novices to top-experts, from practitioners to researchers and developers. Traditionally the *heterogeneity* of students has been reduced as far as possible by providing clear entry requirements and using cohorts of groups that are considered homogeneous. In lifelong learning, the door is opened to exploiting the heterogeneity of learners by setting up learning communities in which novices collaborate with more experienced people. Such an approach is described by Lave and Wenger (1991), where novices are positioned in a more peripheral role and experts in a more central role when solving a problem jointly.

Fourth, it is necessary to *maintain a record* of an individual’s growth in competency in a persistent and standard way to ensure that learners can search for new learning facilities that fit and extends their current knowledge. One approach currently receiving much interest is the definition and use of portable ePortfolios. These portfolios are owned by the learners themselves and are used and updated over a lifetime, across informal and formal education and training (Mason, 2004; Treuer and Jenson, 2003).

To meet these requirements, educational institutions and other learning providers must offer flexible lifelong learning facilities that meet the needs of learners at various levels of competence throughout their lives. People must be able to use lifelong learning facilities to upgrade their knowledge, skills and competence in a discipline as required. They can also contribute to the facilities by sharing knowledge and supporting other learners. We call these network facilities for lifelong learners “Learning Networks” or LNs (see Koper *et al*, 2004b; Koper and Sloep, 2003). These networks support seamless, ubiquitous access to learning facilities at work, at home and in schools and universities. Learning resources from providers such as schools, companies, libraries and the learners themselves can be made available from a single point of access and learners can be helped in performing tasks more efficiently through support from software agents (Jennings and Wooldridge, 1996). The use of ICT networks implies the development of new ways of organizing learning facilities that go beyond course and programme-centric models and envision a learner-centred, learner-controlled model of distributed lifelong learning.

A Learning Network Model

In order to create an integrated model of LNs in which we can position the different issues, we formalize its structure. This is achieved by representing an LN as a graph of nodes in a disciplinary domain *D* (Figure 1). The nodes of the graph represent the available learning events, called Activity Nodes (ANs). An AN can be anything that is available to support learning, such as a course, a workshop, a conference, a lesson, an internet learning resource, etc. Providers and learners can create new ANs, can adapt existing ANs or can delete ANs. In a Learning Network, ANs are described with their metadata (title, objective, etc.) together with a link or reference to the actual AN.

An LN typically represents a large and ever-changing set of ANs that provide learning opportunities for lifelong learners ("actors") from different providers, at different levels of expertise within the specific disciplinary domain.

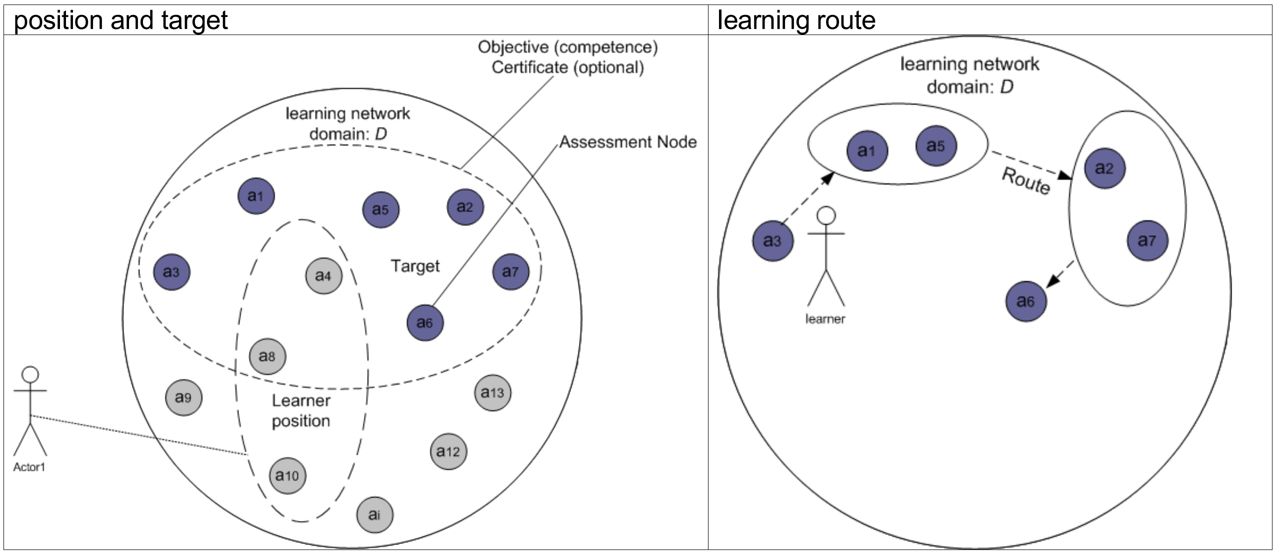

Figure 1: Learning network in domain D with activity nodes {a1,…,a13}

When using the LN, actors travel from AN to AN. The path of ANs completed sequentially over time by an individual actor is called a *learning track*. A track represents the actual behaviour of actors. Paths through a Learning Network that are planned beforehand are called *routes* (see Figure 1). In traditional education, teachers or instructional designers are responsible for this route planning (eg, curriculum planning). In lifelong learning, a different approach may be followed. Learning tracks can be shared between the participants in an LN. This can be a single track or an analysis of the aggregated, collective tracks from a set of participants to determine the most successful routes. This data is expected to help actors "navigate" in the LN.

Another concept in an LN is the learner's *position* in the LN (in Figure 1, the set {a4, a8, a10}). This is defined as the set of ANs marked as completed in the LN, based on the actors portfolio. This does not necessarily mean that the actor completed the concrete ANs, but covers situations in which the objectives associated with the ANs are already met by the actor (eg, as a result of exemptions arising from previous study or work experience).

A *target* is any set of ANs that is sufficient to reach a particular level of competence or expertise in the domain (in Figure 1 the set {a1, …, a8}). These targets and connected competency levels may be self-defined (eg, step-by-step) or are predefined in the network. When creating an LN conforming to a predefined competency framework (eg, European Language Levels/CEFRL, 2001), it is a requirement that every AN indicates its prerequisites and learning objectives in terms of the framework.

A target can be associated with one or more formal assessments to certify knowledge or a competency. This can either involve an additional, specific kind of AN, or can be integrated into one or more ANs. The difference between the set of target nodes and the set of position nodes defines the set of ANs that a learner has to perform to reach the target. Figure 1 shows this *to-do list* as the set {a1, a2, a3, a5, a6, a7}. Given this list, a sequence of learning steps can be established, by deciding on the order in which the ANs are taken (eg, first a3, then a1 *and* a5 simultaneously, then a2 *and* a7 simultaneously, and finally a6; see Figure 1). This decision can be based on the tracks of other successful and comparable learners in the LN. A learner can also follow a more exploratory route or can change routes on demand. Ultimately this will also create a track that can be shared.

The Architecture of a Learning Network

Using the above model and the pilot we described in Koper *et al* (2004b) we designed an architectural model for an LN (see Figure 2). This model is specified as a UML class model (Booch *et al,* 1999; Object Management Group, 2003). It identifies the entities (the named boxes in Figure 2) that are of importance in a learning network and it specifies the relationships between the entities (the lines in Figure 2). The main aspects of this architecture are the following. The available *LN*s are listed in a web *portal* where *persons* can come-in freely for information on the LNs. People can take on different roles in the LN according to certain policies in the community. Members can be learners, tutors, assessors, providers of learning content, etc (see Koper *et al*, 2004a).

The LNs themselves are not a part of the portal: the portal only describes the LNs and provides links to them. This allows also for the establishment of different portals, with different views on the available learning networks, running at different locations in the world.

Software agents (Jennings, 1998) can be integrated in the architecture to support users, eg, provide recommendations on next ANs to study, to search and filter information and knowledge sources in the network and to help users in performing certain tasks, such as filling in forms or using the system. Jennings and Wooldridge (1996) identified the following four characteristics of software agents:

- they are autonomous, work on their own and have some kind of control over their actions and internal state;
- have a kind of social ability, can interact with other agents (and humans beings) via some kind of agent-communication language;
- are reactive, perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the Internet, or all of these combined), and respond in a timely fashion to changes that occur in it;
- and are pro-active, do not simply act in response to their environment, but are able to exhibit goal-directed behaviour by taking the initiative.

The ANs in an LN are listed according to the learning goals they can be used to attain. The behaviour of learners is logged and feedback and advice can be provided based on analysis of the behaviour of learners. ANs can be rated by learners or other reviewers to indicate their quality. For every person enrolled in an LN, a dossier, including a portable ePortfolio is kept (together with some local data). The social interaction between the different participants is governed by policies, including terms of use, quality, membership policies, etc (Preece, 2000). We distinguish two aspects in every AN: its design as available in the so-called *unit of learning package,* and its *runtime resources*. Every AN is designed to a certain extent. This design plans the activities of the learners (and other *roles*) and the use of resources (distributed *objects* and *services*). The design can be described using the IMS Learning Design specification (IMSLD, 2003; Koper and Olivier, 2004) that represents the complete elaboration of the unit of learning package, including learning design, and resources.

When a unit of learning package actually runs as an AN, additional runtime resources become available. Examples are mail and conference contributions, and also the traces and resources produced during additional and non-described activities.

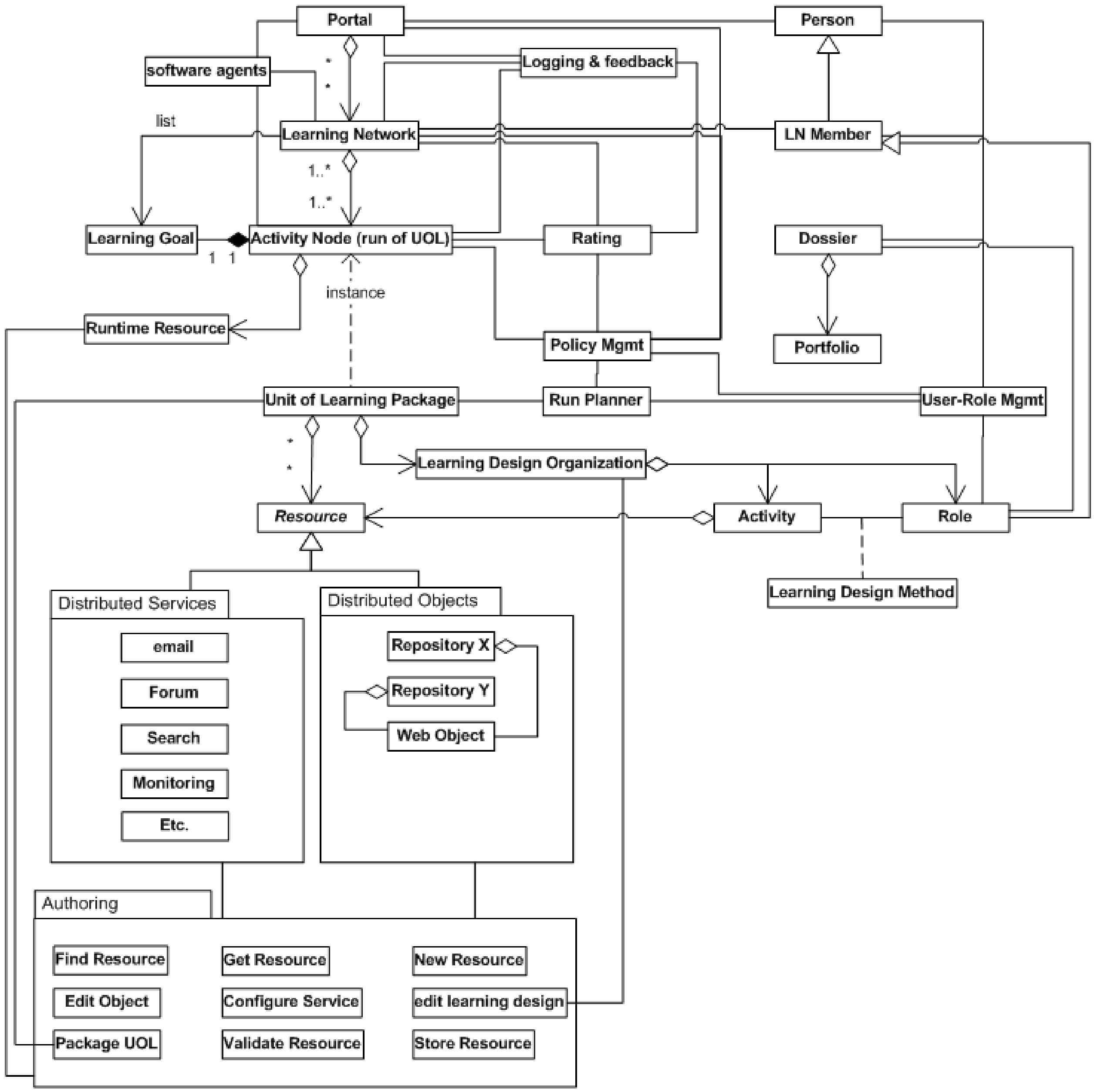

Figure 2. Conceptual model of a learning networks architecture

Removing Barriers to Lifelong Learning with Learning Networks

Offering learning facilities within the above architecture helps lower access barriers to lifelong learning. However, as noted earlier, learning design barriers and information barriers must also be overcome to ensure appropriate support for lifelong learners.

Learning Designs for Lifelong Learning Networks

How should effective and efficient ANs for lifelong learning be designed? The core aspects of any learning design are learning objectives, activities and assessments. These aspects are closely related to each other - the learning objectives define the intended outcomes of the activities, and assessments measure the attainment of the learning objectives. We follow Gonczi (1999) and others (Schlusmans *et al,* 1999) when stating that learning design should be based on an integrated competency-based approach. Such an approach can be distinguished from the approach where learning objectives and competencies are based on a decomposition of tasks to be performed in a job or discipline. These behaviouristic approaches to competency lead to endless lists of very small, prescribed learning objectives. In contrast, the integrated approach takes a more holistic and less detailed view. It is based on constructivist ideas, and, as Gonczi (p.

182) states, that “the competency of individuals derives from their possessing a set of attributes (such as knowledge, values, skills, and attitudes) which they use in various combinations to undertake occupational tasks. Thus, the definition of a competent person is one who possesses the attributes necessary for job performance to the appropriate standard”. Furthermore, based on cognitive learning principles, there is the agreement that learning designs should be based on real-world problems and not on a decomposition of knowledge domains and topics or exercises that are outside of any context of use (see Merrill, 2003). Another requirement for effective designs of ANs is that they should be built to allow collaborative activities of people with different levels of competencies. This introduces principles of cognitive apprenticeship, scaffolding, collaborative learning, and peripheral versus more central participation in problem solving and learning (eg, Lave and Wenger, 1991). ANs should also integrate assessments into learning activities that are related to the competencies (eg, Jessup, 1991, p. 46). Assessment is not considered to be a separate “post learning” activity. According to Gonczi these tests should be standards or criterion referenced, direct or authentic, based on expert judgments and use multiple sources of evidence. In addition to these functional requirements, we can state other requirements that affect, among other things, the efficiency of the design process. For instance, learning designs must be specified in such a way that they can be processed automatically and can be disaggregated into underlying patterns and components that can be exchanged with others. These non-functional requirements are met when design specifications like IMS Learning Design (IMSLD, 2003; Koper and Olivier, 2004) are used.

Advising Learners on Learning Opportunities in Learning Networks

At the heart of Learning Networks are self-directed learners interacting with learning resources. How can learners be supported in taking advantage of the available learning opportunities to attain their educational objectives given the dynamic, multi-provider environment which characterises a learning network? In this section we describe an approach to information provision for lifelong learners, focusing on the recommending of paths through a Learning Network towards learning objectives.

Learning Networks are designed to support Lifelong Learners over long periods of time. The interaction between the two is likely to be characterised by flurries of activity interspersed with long spells of inactivity, mirroring the coming and going of learning needs across the various phases of an individual’s life. This type of interaction can make the setting of learning objectives and monitoring of progress towards them a complex process for learners. Our work addresses the provision of navigational advice concerning the path through a learning network to reach a given target, drawing on Darken and Sibert’s (1993) definition of navigation as “the process of determining a path to be traveled by any object through any environment”.

Navigation involves movement between places—in Learning Network terms, between activity nodes—and tools have been developed over the years to ease the process of deciding how to move between places, such as maps and guides. Although the Learning Networks Model includes the notion of pre-defined *learning routes,* they may not represent “good” paths in terms of efficiency. Moreover, the dynamic nature of a Learning Network requires ongoing review and re-planning of routes. This raises a question—if we cannot rely on the pre-planning of navigational guides such as routes, how can learners be helped in reaching their destination?

Our approach is to create an additional source of navigational information for learners—insight into the progress of those who have preceded them along paths towards the same destination. The position being that an individual’s chances of reaching his or her destination are improved through the use of information on how others have reached this destination. The learner’s subsequent decision is, in turn, fed back to those following. The approach centres on a feedback loop, and is based on self-organisation theory, particularly the notion of *stigmergy*. Introduced by the French entomologist Grassé, stigmergy describes the indirect communications taking place among individuals in a social insect colony (Bonabeau, 1999). As Theraulaz and Bonabeau (1999) state, “The basic principle of stigmergy is extremely simple. Traces left and modifications made by individuals in their environment may feed back on them”. In Learning Networks, visits made to activity nodes by learners in a particular order are recorded and revealed to other learners as an aid to navigation—“others who went before you proceeded that way to reach the destination”.

Our work involves introducing new stigmergy-based learning technologies into Learning Networks, aiming to help learners by providing answers to questions such as “how did other learners progress in this learning network from where I am now?”, “which path through the learning network offer the most chance of success?”, “what has been the most efficient (ie, fastest) path taken by others through this Learning Network?” and “how does my learning track so far compare to any learning routes pre-defined by the provider?”

Learning network providers are able to benefit from the same feedback mechanisms, using the insights gained to better regulate their actions towards the accomplishment of desired organizational goals. Providers are able to use the technology to answer questions such as: “what percentage of learners followed the learning route(s) prescribed in the curriculum through the learning network?”, “is the learning route the most efficient way to progress through the learning network or are learners identifying better paths?”, “where are learners slowing down or dropping out?” and “are there any activity nodes which show a higher rate of non-completion than others and is this linked to a particular ordering of activity nodes?”

A first implementation of the architecture
A pilot infrastructure based on the ideas expressed in this article has been created with two central aims. First, to ensure that the architecture is implementable and second, to examine whether the resulting LN meets its functional requirements. The first question can be answered positively - we were able to set up an infrastructure based on Open Source components. A package to represent the LN and the portal was selected and configured (PHP-Nuke, 2004). PHP-Nuke represents the LN: it provides several views on the information about the different ANs available in the LN. The information *about* an AN is implemented as a PHP-Nuke item linking to the actual AN. The actual ANs can be any of a number of learning events - a face-to-face meeting or a course in a learning management system. We selected Moodle (Dougiamas, 2004), and an IMS Learning Design runtime system called CopperCore (Vogten and Martens, 2004) to represent the unit of learning packages. The idea is, however, that anyone can use his/her own systems that are integrated through the architecture. In future publications we will report on the experiments that we have with this architecture in real practice to examine whether the second aim has been fulfilled.

Conclusions and outlook
Networked learning technologies hold tremendous promise for supporting the lifelong learner, making e-learning available “anytime, anyplace, anywhere”. Through their application, access barriers to lifelong learning can be lowered, opening marketplaces for e-learning using rich, interactive environments. However, this promise cannot be met by today’s learning technologies. True support for lifelong learners revolves around distributed, evolving networks of learners and learning events. The support must embrace effective learning design and offer advice and guidance to lifelong learners over long periods of time, and across different phases in individuals’ lives.

Our position is that new models and architectures are needed to promote effective, efficient, attractive, flexible and accessible lifelong learning in distributed networks. This article introduces the notion of a Learning Network, designed to respond to the specific requirements of lifelong learning, and move away from course and programme-centric models toward learner-centred e-learning.

With the model and architecture in place, our work is now examining both the creation of Learning Networks in practice, and the provision of additional support facilities designed to help learners without unduly burdening staff. Questions we are investigating include: can software agents be used to perform learner assessment tasks? how can learners be encouraged to participate actively in learning networks? which information should be fed back to learners to promote speedy progression towards learning objectives? which policies should govern participation in learning networks? how can learners be positioned in learning networks un-intrusively? which tools do actors in a learning network need in order to participate effectively? how can rating information be used to evolve learning networks using survival-of-the-fittest techniques? how should subscription charges be handled? This article points in the direction we believe learning technologies for lifelong learning should progress and our on-going research will help to evaluate this course.

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