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ANYTIME-ANYWHERE: PERSONALISED TIME MANAGEMENT IN NETWORKING FOR E-LEARNING

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Anytime-Anywhere: Personalised Time Management in Networking for e-Learning

ABSTRACT

Personalisation in the provision of higher education (HE) has gained traction driven by socio-economic, demographic, and employment changes in the student population. Concomitant with these changes is the evolving capability and ubiquity of mobile technologies. These developments have resulted in interest in e-learning to accommodate the diverse student population and leverage the power of mobile technologies. To address the changing educational demands 'anytime-anywhere' personalised e-learning utilising mobile technologies is becoming ubiquitous in the domain of HE, and increasingly e-learning is embracing Web 2.0 technologies to provide networking functionality at both a pedagogic and personal level. Personalisation requires the creation of an individual's profile (termed a context), a context defining and describing a user's current state. This article considers personalised e-learning in a university domain with consideration of networking (in a collaborative and social networking sense). Following consideration of the factors driving the interest in and take-up of e-Learning (in a mobile context) Web 2.0 technologies will be considered. The nature of context and related research is considered followed by a brief overview of the proposed approach which is designed to enable effective personalisation with constraint satisfaction and predictable decision support. The article closes with final observations and conclusions.

KEYWORDS

Personalisation, e-learning, Web 2.0, Networking, Computer supported collaborative learning, Intelligent context.

1. BACKGROUND

The *'anytime-anywhere'* concept as it applies to higher education (HE) has grown out of the changing socio-economic, demographic, and employment conditions as experienced by students and universities nationally and internationally. Concomitant with these change are: (1) the developing capability and ubiquity of mobile technologies and the related wireless infrastructures, and (2) the improving availability and speed (globally) of broadband communications (Kismihoc *et al*, 2010). These developments have resulted in growing interest in the delivery of HE education using personalised e-learning anytime and anywhere.

The developing Web 2.0 technologies have arguably reached a critical mass – *facebook* have reported in excess of 750 million active users (facebook, 2011) with corporate, academic, and personal 'facebook' pages becoming increasingly popular as a means of personal, institutional, and corporate *networking*. As such Web 2.0 applications are being increasingly used by both universities and students and have reinforced the demand for, and the availability of, anytime-anywhere access to pedagogic resources and computer supported collaborative learning (CSCL) (Lin Hsiao, 2005) leading to personal and institutional networking.

The evolving socio-economic, demographic, and employment conditions, when taken with the technological developments and the popularity of Web 2.0 applications, has resulted in an increasingly diverse and distributed student population who are computer literate and accustomed to using social networking applications. This arguably represents a new HE paradigm; in this paradigm networking forms an important component and the design of the next generation of pedagogic systems should reflect these realities. To effectively provide HE in this evolving educational landscape the targeting of resources and collaborative activities – termed *personalised service provision* (PSP) – is an important requirement. Effective PSP demands that resources are matched to potential recipients (Moore *et al*, 2010a, 2010c). A resource can be either a physical resource (such as documents, multimedia files, links etc) or an interactive online collaboration (*networking*) (Moore *et al*, 2010b, 2010c). The matching of resources to individuals is termed *context-matching* (Moore *et al*, 2010b, 2010c). Context-matching requires the creation of a profile for the resource and potential recipients – termed a *context* (Moore *et al*, 2010b) (an *input* and *output* context respectively). A context is highly dynamic and must reflect, in the case of a resource (the *input*) the features that identify it (Moore, 2009); while for a user (the *output*) a context must reflect the user's current *state* (Moore *et al*, 2010b, 2010c). A state includes parameters that identify the users location at a given time (spatio-temporal data) along with h/her current study aims and objectives, needs, desires, beliefs, and interests (*contextual information*) (Moore *et al*, 2010b, 2010c).

Historically within university domain(s) e-learning has been achieved (generally) using *virtual learning environments* (VLE) such as Moodle (Moodle, 2009) implemented using both Internet and internet solutions (Moore *et al*, 2010b). The online presence has demonstrated positive (albeit often limited) benefits for students by providing learning *'on demand... anytime and anywhere'* as discussed in (Goh & Kinshuk, 2004; Rushby, 1998; MacKnight, 1998). HE delivered using computerised pedagogic systems have traditionally used internet and Internet based approaches to implement a VLE (termed *'e-learning'*). Over time developments in mobile technologies have resulted in a blurring of the distinction between the 'e-learning' and mobile learning ('m-learning') concepts, the terms frequently being used interchangeably (Coppola & Della, 2004; Kossen, 2005). In this article the term *e-learning* will be used to refer

to both e-learning and m-learning. Research undertaken from an e-learning perspective has demonstrated the potential efficacy of the anytime-anywhere approach to empower learning; it has however failed to effectively address the demand for personalised educational provision. The concept of anytime-anywhere personalised e-learning utilising mobile technologies with intelligent context processing (Moore *et al*, 2010c) is proposed as an effective approach to enable personalised HE.

The hardware in the form of sensor and mobile technologies with the related wireless infrastructures and GPS etc are well developed; the issues lie in the development of intelligent context-aware systems capable of processing the available contextual information to enable PSP. The aim of the research is to provide a basis upon which effective usage of the available contextual information can be realised to suit the diverse student population in a range of pedagogic systems designed to address the changing HE landscape. In essence, the aim of personalisation using the proposed approach is to provide a basis upon which resources can be distribute and CSCL with personalised networking can be achieved based on a user's context.

2. THE HIGHER EDUCATIONAL LANDSCAPE

HE is characterised by dynamic change driven by: (1) socio-economic factors, (2) demographic factors, and (3) employment and employability demands. These changes are reflected in the changing student population along with their diverse aims and objectives of study. To illustrate this consider the following typical illustrative examples.

The traditional *'talk-and-chalk'* approach is characterised by a stable student cohort where personal student/student and student/tutor communication was generally face to face (generally) in a single location during (again generally) timetabled study periods. The socio-economic, demographic, and employment changes have resulted in a very different and diverse student population far removed from the original concept of a student cohort. This new student paradigm is characterised by a broad range of study patterns which typically fall into a number of types including: (1) the traditional degree, (2) distance learning, (3) lifelong learning (these studies are generally optional), and (4) where professional qualifications must be maintained there is a need for *'Continuing Professional Development* (CPD) (which is not generally optional as it is frequently a condition for retention of a professional qualification).

Consider a specific example: the UK based Open University (OU) (The Open University, 2011) which delivers distance learning nationally and globally. The OU approach uses both on-line delivery of HE with (albeit reducing) traditional paper course materials (access to computing facilities is however a requirement) to deliver a range of courses, modules, and degrees which include foundation courses, bachelor degrees, masters degrees, doctorates, and special interest modules. The OU employs an e-learning strategy with an (albeit limited) collaboration/networking facility using an online forum. This approach enables student/student and student/tutor contact and interactions and provides an effective basis for flexible study anytime-anywhere with learning opportunities available at a time and place to suit the student's time availability irrespective of location and time-zone where international students are concerned. Student/tutor contact is generally achieved using networked online contacts with *tutor marked assignments* (TMA) being submitted online and results delivered online and in hard copy format. This is an example of e-learning with a networking capability.

Time management is an important factor for many students where study times and locations are restricted to, in many cases, unsocial hours that do not comply with the traditional timetabled approach to HE provision. Consider a student in full time employment with family responsibilities taking a course designed to provide CPD; in such a case time management is an important constraint for pedagogic systems design. Similar constraints may apply in cases where students are studying on a part time of block release basis.

The scenarios and examples cited above identify the need to personalise educational provision and provide anytime-anywhere e-learning. Networking forms an important component within an e-learning environment to provide a basis for collaboration on educational matters and provide for social networking at times to suit the selected study times. Networked e-learning incorporating PSP can benefit the teaching and learning process, mitigate an often felt sense of isolation, and help to build a community of students.

In considering e-Learning and the related study materials there are three approaches identified in Stead & Colley (2008):

1. **Shallow or supplementary learning:** Typically, these may be SMS prompts, school generated podcasts, and mobile games. They are good as a supplement to other activities.
2. **Focused learning:** Typically, these resemble a mobile friendly version of classic 'e-Learning', with targeted nuggets of learning that can be engaged with while on-the-move possibly context-aware.
3. **Deep learning:** Deep learners are immersed in a mix of mobile technologies, as creators or originators as well as the more common consumers of mobile media, following a *constructivist* model.

While the categories defined by Stead & Colley (2008) are relevant in terms of approaches to learning in practice all three approaches currently utilise a broad range of content including tutor prepared content, a mix of Web 2.0 technologies – also referred to as *'disruptive technologies'* in Cochrane, (2010), and interactive online networked collaboration (in the form of queries relating to studies) using Internet and internet technologies. In practice, HE provision uses elements drawn from all three approaches (Stead & Colley, 2008). Accommodating these diverse content types calls for high levels of PSP to achieve the anytime-anywhere goal whilst enabling compliance with constraints, preferences, and academic/system policies. Realising this level of personalisation demands the profiling of each individual (students and tutors) – termed a *context*, the matching of an individual's context (an *output* context) with an *input* context (a resource), and reaching a Boolean decision as to the suitability of a student to receive the resource. The following sections address the approach proposed to enable effective personalisation.

To advance the aims for *networked* pedagogies the advent of cloud computing may offer significant benefits. Initially the outsourcing of email provision to, for example, *hotmail*, *gmail*, and *yahoo mail* are examples of embryonic cloud-based systems. An example of such an approach is the outsourcing of the student email system at Birmingham City University using the Microsoft Outlook Web App (MS Exchange, 2011). An added benefit of this new system (for all students) is the provision for life of a *@mail.bcu.ac.uk* email address which will aid the *networking* potential for present and post graduate students. The system provides the usual calendar functions which can be useful for time management. The 'moodle' VLE has been retained and provides limited e-learning capability with limited networking and mobile functionality.

The cloud computing paradigm offers significant additional *networking* potential where the availability of course materials is concerned; the ability to share files in, for example, *Google docs* and Microsoft *SkyDrive* systems reduces the computational overhead required to distribute physical files (useful in a mobile context where data download limits and related costs may be an issue). Consider the potential saving that can be made by using shared files to distribute resources with only notifications of new resources (file updates) being sent to students who are part of a *network* attached to a specific course.

The potential for *networking* is possibly at its maximum where research is concerned. There are many research projects which are conducted between research groups both nationally and internationally. The Web 2.0 – along with the extension termed Web 3.0 and mashups (Anjomshoaa *et al*, 2009) – provides immense scope for interactive *networking* with the ability to exchange a wide range of resources. This can only improve the collaboration between research groups.

3. WEB 2.0 TECHNOLOGIES

A growing trend in HE is the inclusion of the Web 2.0 technologies; this is exemplified by the number of universities which have corporate *facebook* page and the number of individuals (both students and tutors) who are subscribed social networking sites such as *linkedin* and have a personal facebook page linked to their academia.edu personal web page. Within e-learning systems the availability of Web 2.0 applications presents opportunities for *networking on demand* and *anytime-anywhere* as discussed earlier in this article. The limitations of course lie in the need for access to a computer, mobile communications, and good broadband infrastructure. The growing ubiquity of mobile communications and broadband (mobile and fixed) means that for e-learning the limitations are not (generally) an issue however for HE provision using personalised networked e-learning consideration of these limitations must form part of pedagogic design to avoid disenfranchising students who do not have the full range of mobile services or adequate broadband often not by choice but caused by limitations in the service infrastructures.

The Web 2.0 applications, along with email, enable *networking* which when effectively implemented has the ability to: (1) provide a basis for and communication between students and between student and tutors, (2) improve the teaching/learning experience, (3) provide a platform upon which a sense of community can be created, (3) mitigate the isolation often experience by students studying on a distance learning basis (such as when taking an OU course of study with often at most one weeks residential study) , (4) accommodate the three learning styles identified in Stead & Colley (2008) enabling students to learn at their own pace, and (5) provide for improved time management to enable learning and networking at a time and place to suit the students availability to study.

The limitations for networked e-learning lie in the process facebook (facebook, 2011) use to 'recommend' friends. In the absence of genuine personal contact of friendship the recommendation process is by association with little correlation between shared beliefs, desires, and interests. For personalised networked e-learning recommendation requires identification of potential 'friends' based on context implemented using the context-matching process (Moore *et al*, 2010b, 2010c).

The *networking* potential to be derived from the use of Web 2.0 applications does however have possible negative aspects which have a correlation with a VLE. As discussed in Weller (2002) teaching staff need to feel comfortable

with the increased demands of a VLE [which are manifested in the need to monitor modules delivered in the context of a VLE and provide increased levels if interaction and feedback] for its use to be successful; this is not always the case which can be detrimental to overall process (Moore *et al*, 2010b). Clearly, given that collaboration and networking are arguably central to the use of Web 2.0 applications similar issues to those identified in respect a VLE may be experienced with negative connotations.

4. PERSONALISED E-LEARNING

Concomitant with the interest in PSP is the evolving capabilities of mobile devices (Moore *et al*, 2010b). Mobile devices fall into two broad classifications: (1) laptop and mobile computers (which whilst mobile are not generally useable 'on-the-move'), and (2) *wearable* computing devices (which typically include mobile phones, smart phones, and tablets (such as an iPad) with their burgeoning range and capability which can be used in a wider range of environments – albeit characterised by a diverse range of constraints – whilst 'on-the-move') (Moore *et al*, 2010b). There has been significant convergence in mobile devices and their capabilities resulting in a blurring of the distinction between the two classifications (Moore *et al*, 2010b) introducing increased complexity in the demands of mobile systems and applications.

There has been significant research targeting mobile learning; for example, Goh & Kinshuk (2004) observe that: *"from e-learning to m-learning, mobile learning is going to be the next wave in the evolution of learning environments"* and conclude that while 'm-learning' can compliment e-learning by creating an additional channel of access for mobile users to engage in learning *"anytime and anywhere"* many issues regarding mobile learning have not been exhaustively researched. The developments in mobile computing will "free users from the desktop" (Abowd *et al*, 1997); for example, Goh & Kinshuk (2004) have considered issues in the implementation of e-learning and observe: *"from e-learning to m-learning, mobile learning is going to be the next wave in the evolution of learning environments"* providing access for mobile users to engage in learning *"anytime and anywhere"*. To effectively implement personalised e-learning and leverage the power of mobile technologies context performs a pivotal role (Moore *et al*, 2010b), there being a natural alliance between learning as a contextual activity and personal mobile technologies: mobile learning being strongly mediated by its context. Personalised e-learning involves the targeting of resources and the matching of users in CSCL (Moore *et al*, 2010b, 2010c), this has a corollary in the provision of personalised services in related research which addresses issues related to the identification of entities based on their needs and preferences (Moore, 2009).

While the evolving capability and scope of Web 2.0 applications has provided an effective basis for networking between students and tutorial staff, to effectively implement social networking functions into HE education *personalisation* is an important component. The use of social networking within HE requires that the traditional *person-to-computer interaction* (PCI) is extended to involve *person-to-person interaction* (PPI). As discussed in Gentile *et al* (2011) PPI is achieved using a *human-to-input technology-to-virtual representation-to-output technology-to-human* path. In the approach proposed in this article this process involves initially selecting suitable individuals (suitably qualified individuals for collaboration) with contacting identified individuals being the second stage in the *networking* process; the overall process being: (1) identifying individuals, and (2) contacting

them to collaborate in a *networking* capacity. To visualise this process consider a scenario where a student requires help with a query related to a topic being studied. Initially, suitably qualified individuals (advisors) are identified; this requires the matching of the parameters that describe the students query (the *input*) with the related parameters that relate to the potential advisor (the *output*). This requires that a profile is created for the *output* and for each individual in the context-matching process. Such profiles are termed a *context* (Moore *et al*, 2005, 2010a, 2010b, 2010c). The following section considers the nature of context and consider the types of data that can be considered as *contextual information* (Moore, 2009) useful in the matching of *inputs* to *outputs* in resource distribution and networked interactive on-line collaborations.

5. CONTEXT-AWARE SYSTEMS

The first use of context in computer systems runs concurrently with the development of pervasive computing as envisioned by Mark Weiser in his seminal papers (Weiser, 1991, 1993) and the emergence of mobile computing components in the early 1990's. These developments have led to the desire to support computer usage in a diverse range of environments and domains. Context forms an important element in pervasive computing; for example, in location-based services (such as context-aware tour guides) context is a pivotal function (Moore *et al*, 2010b). This analogy clearly extends to personalised education in e-learning systems.

The goal for pervasive computing is on simplifying through digital environments that are sensitive, adaptive, and responsive to human needs; such a goal clearly has a correlation with personalised e-learning as discussed in this article . While research challenges remain in all areas of pervasive computing; all the basic component technologies exist today. In hardware, we have mobile devices, sensors, and even smart appliances. Supporting software technologies include digital signal processing and object-oriented programming. Advances in networking provide support for mobility management, and ad hoc routing with global reach (Saha & Mukherjee (2003). It is clear that effective implementation of personalized e-learning realized using context to achieve PSP lies not in the hardware (computing devices and mobile phones etc) but in software application(s) designed to realize intelligent context processing as discussed in Moore *et al* (2010c).

Central to pervasive systems is context-awareness. Context-awareness describes a concept in which the profile of an entity is defined by its 'context', an entity being defined in Dey & Abowd (1999) as: *"Any information that can be used to characterise an entity"* and *"a person, place or a physical or computational object"*. Context-awareness employs context to identify individuals to enable targeted service provision based on location, time, preferences and current needs with minimal user effort (Moore, 2009). Context is also pivotal in the matching of users in CSCL in interactive systems (Moore *et al*, 2010b).

Context is domain and application specific requiring the identification of domain specific function(s) and properties (Moore *et al*, 2010a). This is exemplified in 'e-learning' where the starting point in the definition of a context is *the "identification of the function and purpose in which we are interested"* (Lonsdale *et al*, 2003). A definition of the term *context* for a personalised e-learning system designed to enable resource distribution and CSCL is: *"Information consisting of properties that combine to describe and characterise an entity and its situated role in computer readable form"* (Moore *et al*, 2010b). A context is however highly dynamic and must reflect a user's current

state (Moore, 2009). Location is central to context in mobile systems, context however includes more than just location (Moore *et al*, 2010b). As identified in Schilit *et al* (1994) a broad and diverse range of context factors combine to form a context definition, in fact, almost any information available at the time of an interaction can be viewed as contextual information including:

- The variable tasks demanded by users
- The diverse range of mobile devices and the associated service infrastructure
- Resource availability (connectivity, battery condition, display, network, and bandwidth etc)
- Nearby resources (accessible devices and hosts including I/O devices
- The physical situation (temperature, air quality, light, and noise level etc)
- The social situation (who you are with, people nearby etc – proximate information)
- Spatial information (location, orientation, speed and acceleration etc)
- Temporal information (time of the day, date, and season of the year)
- Physiological measurements (blood pressure, heart rate, respiration and muscle activity etc)

In summary, if data relating to a users state can be measured, codified, and digitized it can be considered to be contextual information. The range of contextual information identified demonstrates the inherent complexity of context, its domain specific nature, and the difficulty in defining and measuring it. This difficulty is exemplified in the need to accommodate two general types of context: ***static*** context and ***dynamic*** context (Moore *et al*, 2007, 2010a):

- ***Static*** context (termed *customisation*) relates to a use-case in which a users profile (context) is created manually, the user being actively involved in the process and having an element of control.
- ***Dynamic*** context (termed *personalisation*) relates to a condition in which the user is seen as being passive, or at least somewhat less in control. In such a use-case the system monitors, analyses, and reacts dynamically to a user's behaviour and *'state'* or *'situated-role'*.

The two types of context are reflected in the two principal ways context is used, these are: (1) as a retrieval indicator (a *static* context) and (2) to tailor system behaviour to match users system usage patterns (a *dynamic* context).

6. CONTEXT RELATED RESEARCH

Context-aware solutions have been applied in many diverse domains where the provision of personalised services mapped to an entities context is a system requirement. A detailed discussion on the related research is beyond the scope of this article however a detailed review of the related research with conclusions and observations can be found in (Moore *et al*, 2010b). The review of related research considers a number of areas including research from the early 1990's to the present day. Topic areas addressed include: context, context-aware systems, motion sensing systems, health monitoring systems (ECG and EEG), tourist guides, office applications, pedagogic systems, 'the application of context-awareness', 'personalization and adaptation in mobile systems', and' ad-hoc networks'.

The research reviewed addressing *personalisation and adaptation in mobile systems* (Moore *et al*, 2010b) identifies the need to adapt the mode of delivery to suit the diverse range of mobile devices and their graphical interfaces. This is clearly a context related issue given the broad and diverse range of potential contextual information. An area not (generally) considered

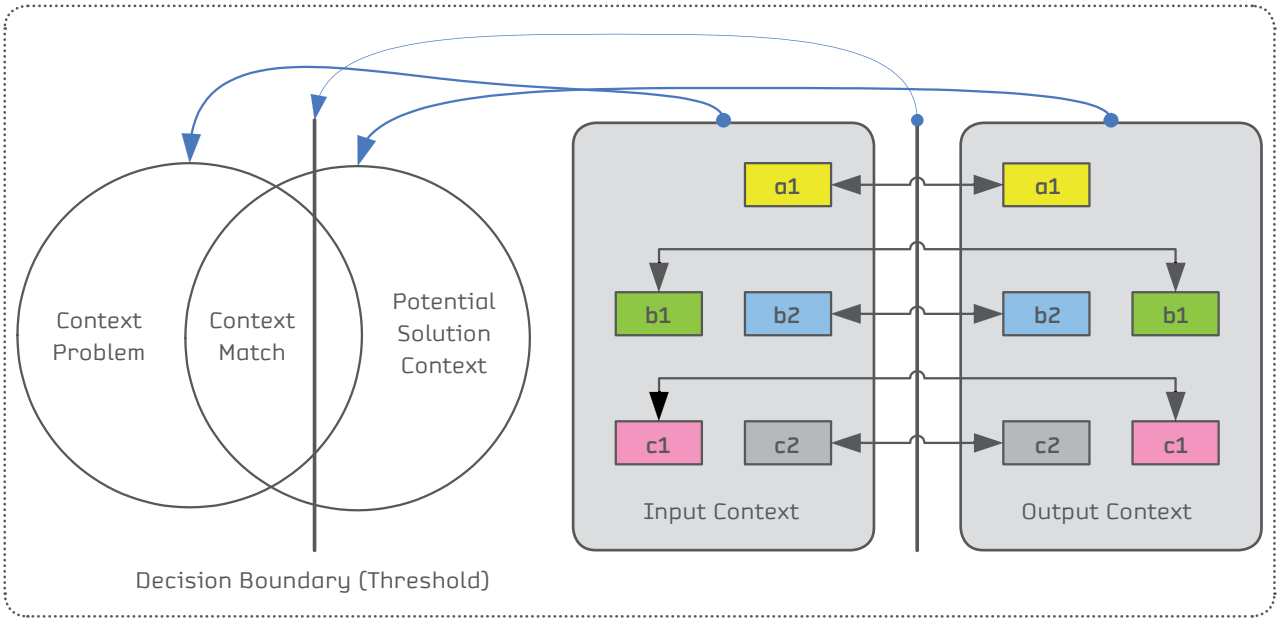
where context-awareness is discussed is *ad-hoc networks* (wireless networks where nodes – e.g., mobile phones – join and leave a network or change their state dynamically). Such networks are however context-aware having location, identity, and often proximate data to identify and locate the device, the user, and in a social context other individuals in close proximity. Proximate contextual information is potentially useful where networked collaboration can provide a basis for improved interaction between users of a context-aware pedagogic system. In considering personalised e-learning and the related networking capability accommodating and managing the demands of adaptation and the increasing use of wireless ad-hoc networks is becoming increasingly important where *anytime-anywhere* personalised networked e-learning is implemented in HE provision (Moore *et al*, 2010b).

An important conclusion drawn from the review of the related research addressing context-aware systems (Moore *et al*, 2010b) is the predominance of spatio-temporal and identity contextual information in mobile systems, this is (arguably) the result of the inherent complexity of context (as demonstrated in the broad range of potential context properties identified) and the difficulty in defining dynamically a users context (or state). Addressing these limitations demands the use PSP; the approach introduced in this article [as discussed in (Moore *et al*, 2010c)] in applying intelligent context processing has been shown to provide an effective basis upon which computational intelligence can be implemented and the inherent complexity of context leveraged.

7. INTELLIGENT CONTEXT PROCESSING

As identified in the preceding section context historically has (generally) focused on location and identity contextual information; while the available range of contextual information is being increasingly investigated (generally in

Figure 1. Personalization and the context-matching problem; shown is the partial matching problem with a decision boundary (threshold) used in the CPR and FECA rules algorithm [2][5]. Note: the proposed approach enables multiple thresholds in, for example, context-aware health monitoring systems [6] where multiple decisions (progneses) must be accommodated.



research projects as opposed to commercial applications) the generality of usage remains location and identity based. The *context-matching* approach attempts to provide a basis upon which the available range of contextual information can be accessed and processed in an intelligent context-aware decision support system that enables constraint satisfaction and preference compliance with decision support.

The proposed approach is predicated on the processing of contextual information using the *context-matching* (CM) process (Moore *et al*, 2007, 2010a, 2010b, 2010c); the *Context Matching* function is designed to create the *input* context and access the *output* context(s) definitions and using the context-matching algorithm to determine if the *output* context (properties) are an acceptable match with the *input* context (properties). Figure 1 graphically models the *context matching* problem, the partial matching issue, and the relationship between the *input* and *output* context properties the FECA rules algorithm is designed to address. Essentially, the context-matching process is one of reaching a Boolean decision as to the suitability of a specific individual based on his or her state (Moore *et al*, 2010b, 2010c IGI, CITEL). Given that a perfect match is highly unlikely the context-matching algorithm must accommodate the partial matching issue along with a number of related issues as discussed in (Moore *et al*, 2010c).

8. CONCLUSION

This article has considered personalised e-learning in a university domain with consideration of networking (in a computer supported collaborative learning and social networking sense). The factors driving the interest in and take-up of e-Learning in a mobile context have been considered along with the developing Web 2.0 technologies and their impact on the design of pedagogic systems for HE. Personalised e-learning has been considered. Context and related research has been introduced and a brief overview and introduction to the FECA rules approach has been provided.

The higher educational landscape is characterised by ongoing change which reflects the changing socio-economic, demographic, and employment conditions that impact individuals and the wider society. These changes reflect the new student paradigm where computer literacy and awareness of Web 2.0 services form a central role. Web 2.0 technologies have extended the networking capabilities of VLE's and pedagogic systems must reflect these realities and harness them along with the power of mobile technologies to provide fully networked personalised e-learning delivered *anytime-anywhere*. While the evolving capability and scope of Web 2.0 applications has provided an effective basis for networking between students and tutorial staff; to effectively implement social networking into HE pedagogic systems *personalisation* is important. The use of social networking within pedagogic systems requires that the traditional *person-to-computer interaction* (PCI) is extended to involve *person-to-person interaction* (PPI). This process involves initially selecting suitable individuals (suitably qualified individuals for CSCL) with contact being the second stage in the networking process; the overall process being: (1) identifying individuals, and (2) contacting them to collaborate in a networking capacity.

The implementation of personalised e-learning relate less to the hardware and mobile technologies with their related infrastructures than the operational software; the approach proposed in this article is designed to address the software issues and provide an effective basis upon which the intelligent processing of contextual information and enable personalised networked e-learning to the mutual benefit of students and universities.

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