Abstract
Globalisation of the higher education industry has increased the mobility of students and workforce. For example students able to move across educational institutions, across learning modes and across borders, however, higher education offered in different countries is not identical, making it difficult to recognise learning credentials gained in another country. The lack of portability in learning credentials poses problems to the stakeholders of the higher education industry (students, universities, professional associations, employers, etc.) in terms of collecting sufficient evidences of previous learning and facilitating mobility for individuals.

The process of evidencing the origin and validity of an item over time, to keep track and uphold authentication, is called ‘provenance’. The concept and technologies of provenance have been used in various areas such as: antiquities; online learning; email properties; and e-science research. We explore this concept within the higher education industry.

It is hard to maintain logical records in multiple institutions, in various countries, and in multiple languages and formats. At the moment evidencing the learning credentials offered by issuing universities is truly ad-hoc, and validity of learning credentials is at best circumstantial and hardly efficient.

Provenancing learning credentials means attesting them at the point of creation/origin. Properly provenanced learning credentials are able to be carried across institutions, systems and borders. A provenance-based protocol is proposed to evidence learning credentials, promote the portability of learning credentials, and then the mobility of students and workforce.

Key Words: Portability; Individual Mobility; Provenance Artefact; Provenance process

Introduction
Individuals are increasingly mobile than they use to be. The growth of globalisation of education industry has enabled more individuals to move across educational institutes, across learning modes and across borders. The portability of learning credentials is recognised as a key facilitator of individual mobility. This paper proposes the concepts and technology of provenance as a solution to enhancing the portability of learning credentials, then to facilitating individual mobility.

Problem Domain
Individual mobility
The staff and student mobility is increasing globally and it is becoming common for individuals to study or work overseas. Many countries also see the mobility as a good opportunity to attract international students and export their education services. However the incompatibility of higher education systems in different countries hinders the mobility and breaks some countries’ hope of recruiting students worldwide.
Mobility of students is a well recognised issue in today’s higher education as a result of globalisation of the industry. Students are willing to take the advantage to broaden their horizon and develop an international outlook; meantime institutions, even countries are also competing for the best brain worldwide. It is also recognised that a single staged education is no longer the mainstream of education. Instead a life long learning pattern is gaining popularity. People are more “mobile” than ever before. (Ternouth, 2007) Students can move from one educational institution to another; for example, German universities allow students to transfer at any stage of their course. Individuals can move from country to country, for purpose of further study or employment, or seeking further study in a foreign country first then employment. Individuals can also move from one study mode to another, such as from full-time on-campus study mode to part-time distance learning (Teichler, 2003).

Two types of mobility are identified in (Teichler, 2003): vertical and horizontal. Moving vertically means pursuing education in another place that offers a higher level of education; and it is normally long term, for the whole duration of a degree. Moving horizontally means studying in a region that is similar in terms of educational service levels and it is normally short term.

Learning credential portability
According to Oxford English Dictionary, portability is defined as
1. The quality or state of being portable; suitability for being carried or moved from place to place, esp. with ease. Also fig. and in extended use.
2. In Computing terms, the property of software of being usable on different types of computer or operating system with little or no modification.

Although movements of students and professionals are gaining popularity, it is not barrier-free. Despite the barriers of language, culture and religion, the portability of learning credentials is one of the main barriers to mobility. Though there is an increasing focus on competences gained through learning, it is undeniable that competency based on certain educational paths or stated by learning credentials is better accepted (Teichler, 2003).

The portability barriers have been recognised in a number of countries and regions, and many efforts have been put to address this issue and promote individual mobility.

A Higher Education Scenario
An Australian university -- S University and its partner university C in China agree to employ Collaborative Articulation Programs (CAPs) as the form of cooperation (Li et al., 2008). CAPs allow bilateral accreditation and credentialing between S University and its partner university in China, which means students who successfully complete specific studies stipulated in CAPs in collaborating partner universities can articulate to S University and will be granted exemptions for the specific subjects. Students who undertake subjects at S University will be granted credits to the partner universities’ degree. Partner universities agree to teach equivalent content or programs and accredit students for the subjects undertaken in partner universities.

Accreditation and exemptions should be automatically granted to students enrolled in the CAPs by either University S or University C, given an agreement has been formulated. However, program content and learning credentials tend to change and are no longer equivalent over time, making accrediting students difficult.
Figure 1 and Table 1 depicts the credentials to be assessed in the collaborative education program offered by S University and one of its partner universities in China, C University.

Figure 1: Rich Picture showing the workflows involved in a CAPs case – the collaborative education program between S University and C University.

<table>
<thead>
<tr>
<th>Flows</th>
<th>Credentials</th>
<th>Activities involved in workflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow 1</td>
<td>The C University academic transcripts that assessed students take to S University</td>
<td>Students enrol in the collaborative education program and study two years at C University in China. Students who pass all the assessments of the program can go to S University, Australia a two-year further study. S University academic transcripts are sent back to C University for credentialing.</td>
</tr>
<tr>
<td>Flow 2</td>
<td>The S University academic transcripts that are sent to C University</td>
<td>Students who complete the two-year study at S University are given two degrees, one from C University and one from S University, after their units of study undertaken at S University are back-credited at C University</td>
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</table>
Efforts on Promoting Individual Mobility

Bologna Process
A number of countries initiated the Bologna Process to strive for consistency and portability of their higher education systems. Areas such as degree structure, credit transfer and quality assurance systems are being renovated and reconstructed. The Bologna Process was initiated in Europe but countries outside Europe also join in and try to make their tertiary education more compatible (Department of Education, 2006b).

Europe has proposed the Bologna Process to facilitate the mobility of students and workforce by issuing students qualifications that are “portable internationally and aligned to the evolving needs of the global workforce” (Department of Education, 2006a). According to the Bologna Process agenda, by 2010, the scheduled completion time, “Europe should be the world leader in terms of the quality of its education and training systems” (Ternouth, 2007).

By going through the Bologna Process, ‘qualifications offered by institutions are easily recognised and assessed by institutions and employers for purposes of further study or employment’. The parties involved in the implementations include governments, academic institutions, student organisations and professional bodies. In particular, employers, who might have trouble recognise the restructured degree structures, play a vital role in the implementation (Department of Education, 2006b).

To make degrees more recognisable, it is important to ‘clarify recognitions requirements’ in field of ‘recognition of periods of study aboard, cross institutional delivery, trans-national education, and education delivered through industry placement’ (Department of Education, 2006b).

The Bologna Process proposes the use instruments such as Diploma Supplement and European Credit Transfer System (ECTS) to achieve the compatibility of higher education systems across the signatories and quality assurance systems (Department of Education, 2006a). Among all the schemes proposed in Bologna Process, Diploma Supplement is recognised as an important element to facilitate smoother recognition of qualifications. Basically the Diploma Supplement is a document that provides supplementary information to a higher education qualification. Details include ‘a description of the nature, level, context, content and status of the studies’. The Diploma Supplements are supposed to be judgement free and mere factual (Department of Education, 2006b).

Bologna process has a number of implications, with both positive and negative aspects. Bologna process implies that more universities will be teaching in English; a rigid degree structure will be followed by all signatories therefore learning credentials will be transparent and portable cross-border(Ternouth, 2007).

European Higher Education Area has used Bologna Process to harmonise the degree structures in signatories, furthermore, to solve the problems encountered in qualification recognition and quality assurance. However, it does not mean an automatic recognition for the re-structured degrees because a wide diversity still exist in admission requirements, subject content, learning objectives and function, and in the rights they confer (Rauhvargers, 2004). Portability issues of learning credentials will remain in place unless all the education systems in the globe become identical.
Only a small number of countries sign up to the Bologna Process compared to the all the countries in the world; even if more countries agree to align their education systems to one another, the changes to education systems over time will eventually cause incompatibility. To facilitate individuals’ mobility and solve the portability issues of learning credentials, we propose the adoption of a provenance-based protocol, which can be used universally across higher education systems worldwide, has as few elements as possible, and holds true over time.

**Qualification recognition**

Three strategies of transferring qualifications from one country to another are examined in terms of facilitating the mobility of workforce (Deane, 2005). The three strategies are recognition, comparability and transparency of qualifications. Recognition of qualifications is mainly for professional jobs, such as medical practitioner. Various professional associations in Australia also take on the role of recognising qualifications and working experience gained overseas. Comparability of qualifications was too complex and is no longer in use since 1993. Since the 1990s transparency of qualifications became the aim of European education system. It was quoted:

> In the area of higher education, transparency of qualifications has been one of the agreed action lines within the Bologna process since it was initiated in 1999. …..the recognition of qualifications is a matter for the market, either the labour market or the ‘market ‘ of learning institutions.

The transparency will be achieved using the actions proposed by the Bologna Process, such as establishing common credit transfer and quality assurance systems across the signatories and issuing Diploma Supplement with qualifications (Deane, 2005).

Recognition is defined by (Rauhvargers, 2004) as the assessment of a foreign qualification with a view of finding ways for its application for further studies and/or employment in the host country. Qualification recognition is done for two major purposes – academic recognition for further studies and professional recognition for employment purpose. Two sub-types exist in the latter – professional recognition for regulated professions (i.e. Medicine, Accounting, and Engineering) and for non-regulated professions (Rauhvargers, 2004).

The recognition of foreign qualifications in Australia is performed at three major levels (Rauhvargers, 2004):

- Institutional
- National
- Regional (i.e. Europe, Asia-Pacific)

Recognition of qualifications is done mainly by:

- Higher education institutions, for academic purpose (further study);
- Employers, for employment purpose in the non-regulated sector of the labour market; and
- Professional bodies or other nationally appointed competent authorities, for employment purpose in regulated professions.

Some countries try to establish equivalence between the foreign qualifications to be recognised and local qualifications; while some countries focus on the assessment of learning outcomes. Although it is argued that employers are more concerned about “what the holder of the qualification can do”, which takes a focus on learning outcomes and
competencies, employers also wish to know “to which qualification of their country the foreign one corresponds” (Rauhvargers, 2004).

Credential evaluators are expected to do more than simply deciding the domestic equivalence for a foreign qualification; they should aim at promoting cross-border mobility for both study and employment purpose, with a view to finding the right path for further studies or employment in the host country (Rauhvargers, 2004).

Qualification Recognition in Australia

By 2009 there are 46 signatories of the Bologna Process, including some non-European countries. Australia is not among them. In 2006, the then Minister of Education issued a discussion paper called the Bologna Process and Australia: Next Step, urging Australia to align with the process and seeking responses from stakeholders of Australian Higher Education. However, respondents, including universities, industry bodies, unions, university peak bodies and other interested parties, are not as keen as the then Minister of Education. Main reasons of the lack of enthusiasm are aligning with Europe will not give Australia extra competitive advantages as Australian universities do not lag behind European counterparts; and some stakeholders are concerned of the lost of key advantages if Australia follows Europe inflexibly (Donaghue, 2008).

Australian higher education qualifications are administrated and issued according to Australian Qualification Framework (AQF). In terms of recognising learning credentials issued in Australia, AQF provides facilitation to accrediting bodies with qualification approval. AQF acts as guidelines. AQF provides online links to database and a public access point to accrediting bodies, which acquire information via the access point and verify qualifications. Approved qualifications are updated in the database which is run by AQF (Australian Qualifications Framework, 2008).

In terms of the verification of overseas qualification, a governmental agency called National Office for Overseas Skills Recognition compares the overseas qualification to Australian qualification and decides on the equivalent Australian qualification. Bodies such as Overseas Qualification Unit at each state also recognise qualifications gained overseas for migrants for general purpose. However their qualification recognition cannot be used for migration purpose (Australian Qualifications Framework, 2008).

Professional associations assess qualifications and work experience gained overseas for regulated sector of the job market. For example, Australian Computer Society uses “Body of Knowledge” as the basis of performing skill assessments and qualification recognition (Underwood, 1997).

Qualification recognition in China

China has shown interest in the better compatibility of education systems proposed by the Bologna Process and attended the 2007 ministerial meeting as an observer (Shah et al., 2007).

Chinese higher education qualifications are administrated and issued by Ministry of Education. The affiliates of the Ministry of Education are in charge of qualification recognition. Qualifications gained in China are accredited by the Accreditation department, and authenticated and verified by China Higher Education Student Information and Career Center, both entrusted by the Ministry of Education. Chinese Service Centre for Schol
Exchange, an affiliate of Ministry of Education, verifies the validity of foreign qualifications and authenticates them.

Australia and China currently have an arrangement on Higher Education Qualifications Recognition. It aims to facilitate the recognition of higher education degrees and graduate awards to students in Australia and China as well as their academic credentials, so as to make it easier for students to pursue further academic studies in the two countries (Shah et al., 2007).

Technology in Qualification Recognition
Deane (2005) holds the view that there is plenty of information already that can be used for achieving transparency; however the information is not coordinated well to be exchanged. A framework called Europass is put in place to “link separate documents for transparency of qualifications and competences into an ICT-based portfolio. The Europass portal is used as the access point for both citizens and organisations that wish to use Europass”. The “separate documents” are personal competences, language learning, mobility experiences and qualifications in vocational education and training or in higher education. A National Europass Centre is required to be set up in each nation that agrees to implement Europass to “set up and manage information systems to support the Europass Framework”.

Some of the existing learning outcome-based documents are suggested to be used for better transparency of qualifications in Europe. The documents are personal competences (CV), language learning (European Language Portfolio), mobility experience (MobiliPass), qualifications (Diploma Supplement), the Computer Driving Licence, and so on (Deane, 2005, Council of Europe, 2002). These documents can also be the basis for developing the provenance protocol. If these documents are all individuals needed to move freely cross borders of Bologna Process participating countries, the information contained in these documents is the information to be captured and provenanced.

In China, a nation-wide database called the National Higher Education Qualification Certificates Information Database has been built, which records all the higher education qualification certificates issued after 2001. The database supports certificate-related inquiries and verifies qualifications (China Higher Education Student Information and Career Center, 2009).

Provenance
Definition of Provenance
Provenance is defined as the origin or source from which something comes, and the history of subsequent owners or proof of authenticity, according to Oxford English Dictionary. Provenance for artwork has taken the form of Certificates of Authenticity since late 19th century. The ‘authorities’ and ‘experts’ of artwork signed the Certificates of Authenticity which provide information about the artwork and the artist, certifying the authenticity of the artwork. However, Certificates of Authenticity are regarded as a weak provenance because they can be forged easily and the so-called experts sometimes created fake Certificates of Authenticity for various reasons. This leads to a debate as to the availability of current technology and documentation manipulation, which have implications in the provenancing of learning credentials. Examples are fake degree certificates and fake academic transcripts created.
The definition of provenance can vary depending on the domain of application. For example, Knowledge Provenance is defined as the approach to determining the origin and Validity of web information by means of modelling and maintaining information sources and dependencies, as well as trust structure (Fox and Huang, 2003). The provenance of a piece of data is the process that led to that piece of data (Groth et al., 2006). Provenancing learning credentials means attesting the learning credentials at the point of creation/origin.

Provenance information can be used for a range of reasons, depending on the context of application (Goble, 2002). The provenance of learning credentials is used mainly for ensuring the authenticity and validity of learning credential assessments, reusability of assessments, and tracking the change and evolution of assessments.

The subjects of provenance used by the current systems are either data or process (Simmhan et al., 2005). Data products generated by various systems are provenanced with lineage metadata. The process that leads to a piece of data is defined as the provenance of that piece of data (Groth et al., 2006); therefore, processes are also used as the subject of provenance by some provenance systems. The two major methods of representations of provenance are annotation and inversion. Annotation is a collection of metadata comprising of the derivation history of a data product, and descriptions about source data and processes. Inversion method inverts derivation data to its source data using pre-defined properties.

The 7Ws Model of Provenance

A 7Ws Model is used to define major questions provenance needs to address, the data provenance needs to capture; and how the provenance information be used. The 7Ws (who, what, where, why, when, which, how) model can be applied to define the semantics of all types of provenance (Ram and Liu, 2006):

- Who -- “Who” refers to agents involved in actions leading up to an event;
- What – “what” defines the actions that lead to an event in broad terms;
- Where -- “where” represents space and captures the location of an event;
- Why -- “why” is defined as the decision rationale of an action;
- When – “when” records the temporal dimension of an event;
- Which – “Which” refers to the method that is selected from a set of possible approaches; and
- How -- “how” documents actions that leads to the occurrence of an event with particular instance.

Table 2 presents the semantics of three forms of provenance (i.e. knowledge provenance; data provenance; learning asset provenance) using the 7Ws Model. These three forms seem most viable for our project.
<table>
<thead>
<tr>
<th>7 Ws</th>
<th>Knowledge provenance (Fox and Huang, 2003)</th>
<th>Data provenance (Chen et al., 2005)</th>
<th>Learning asset provenance (Beetham, 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who</td>
<td>Creator of the web information</td>
<td>The set of all agents involved in the events (individuals, organizations, artificial agents)</td>
<td>Managed and owned by the learner; accessed by the learner, teachers, peers, assessors, awarding bodies, prospective employers</td>
</tr>
<tr>
<td>What</td>
<td>The actions that create the web information</td>
<td>The sequence of events that affect the data objects during its life time</td>
<td>A collection of digital resources that evidence individual’s progress and achievements</td>
</tr>
<tr>
<td>Where</td>
<td>The locations where web information is stored and used</td>
<td>The set of all locations where events happen</td>
<td>In education institutions, workplace and any other places where learning occurs</td>
</tr>
<tr>
<td>Why</td>
<td>Web is full of uncertain and incomplete information. Validating web information is expected to be optimized but not fully assured</td>
<td>The set of all decision rationale associated with various provenance events</td>
<td>Individuals are able to review, reflect and plan for personal development; can be accessed by other parties, i.e. Teachers, accrediting bodies, prospective employers for official accreditation and unofficial skill assessment</td>
</tr>
<tr>
<td>When</td>
<td>The time of creation and modification of the web information</td>
<td>The set of all timestamps; the time of various events that affect data during its lifetime</td>
<td>Throughout all the sectors over a lifetime</td>
</tr>
<tr>
<td>Which</td>
<td>A methodology called ontology is used for knowledge provenance.</td>
<td>The set of all devices used in data creation, analysis and transformations</td>
<td>Electronic form of evidence</td>
</tr>
<tr>
<td>How</td>
<td>Classify web information into four levels according to their certainty. Apply different evidencing framework to decide their origin and validity</td>
<td>The set of all actions leading up to the events</td>
<td>Draw evidences from both formal and informal learning activities and professional development programs. An official record of assessed achievement called a Transcript and a set of unofficially assessed achievement and other informal evidences of the learning and development process called a Personal Development Record comprise the e-portfolio</td>
</tr>
</tbody>
</table>

Table 2: Data Knowledge Provenance, Data Provenance and Learning Asset Provenance need to define using the 7Ws Model. Adapted from (Beetham, 2006, Chen et al., 2005, Fox and Huang, 2003)
Existing literature focuses on provenance in a specific context. For example, Knowledge Provenance (Fox and Huang, 2003) is only used for provenance of knowledge/information on the web; data provenance is best used in computerised systems (Chen et al., 2005); whether antiquity provenance applies to all kinds of antiques in every country remains uncertain. A lack of pervasion exists in the current provenance systems. With the mobility and globalisation of education, it is inefficient and insufficient to have a process that evidences learning and credentialing in a specific education system, e.g. in Australia or Europe only. The Learning and Credentialing Provenance should be applicable across education systems and boarders.

**Conclusion and Next Steps**

In this paper, the problems in enhancing portability of learning credentials so as to facilitate individual mobility are addressed. Various efforts on promoting individual mobility have been recognised and the portability of learning credentials is one of the key facilitators in terms of influencing the way individuals get accredited overseas.

The next step of the research will involve applying the existing provenance recording protocol to the higher education scenario and test its fitness for purpose.

**Reference:**


CHINA HIGHER EDUCATION STUDENT INFORMATION AND CAREER CENTER (2009) Verifications of Certificates or Diplomas


