# Advanced Networks in Dental Rich Online MEDiA (ANDROMEDA)

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**Abstract**: There is growing demand for dental education and training not only in terms of knowledge but also skills. This demand is driven by continuing professional development requirements in the more developed economies, personnel shortages and skills differences across the European Union (EU) accession states and more generally in the developing world. There is an excellent opportunity for the EU to meet this demand by developing an innovative online flexible learning platform (FLP). Current clinical online systems are restricted to the delivery of general, knowledge-based training with no easy method of personalization or delivery of skill-based training. The PHANTOM project, headed by Kings College London is developing haptic-based virtual reality training systems for clinical dental training. ANDROMEDA seeks to build on this and establish a Flexible Learning Platform that can integrate the haptic and sensor based training with rich media knowledge transfer, whilst using sophisticated technologies such as including service-orientated architecture (SOA), Semantic Web technologies, knowledge-based engineering, business intelligence (BI) and virtual worlds for personalization.

**Keywords: A**NDROMEDA, Service-Oriented Architecture (SOA), Knowledge-Based Engineering (KBE), Semantic Web

## 1. Introduction

Over the years, teaching and learning has changed from the traditional classroom model to an interactive online learning-platform utilizing the internet increasingly to communicate, collaborate and enhance the learning experience. The internet is no longer a novelty. It is recognized as a vital component for e-commerce, research, telephony and leisure. The health sector has been rather slow to fully adopt the possibilities this technology offers, however, this when global economies are heavily constrained, this technology offers the most efficient method of achieving healthcare solutions anytime, anywhere and for everyone.

The European Union is seeking to develop an integrated health strategy to tackle new challenges resulting from increasing social diversity, economic inequality, globalization, aging of the population and the impact of innovation and technological

development. Directive 2005/36 lays down minimum training requirements for dentistry, requiring at least five years of full-time theoretical and practical training. This may provide an insuperable financial burden for many new and existing accession states, which may not be sufficiently developed at the present time to provide all aspects of such a curriculum locally. The magnitude of this burden will be different for each institution.

ANDROMEDA aims to address this challenge and create a common online training environment between different universities, hospitals and private research establishments. Each institution has their own sets of requirements in terms of the level and the pace of the learning environment engagement; their separate technology infrastructure; different mobile connections and networks; hence a common learning platform has hitherto been unobtainable. Currently the PHANTOM project[49], is combining haptic-engagement with the virtual worlds to teach clinical dental students. ANDROMEDA can build on this knowledge to construct an open, scalable, mobile platform to achieve the aim of the European ICT FP7 initiative of education "Anytime", "Anywhere" and for "Everyone", harnessing new technologies such as service-orientated architecture (SOA), the Semantic Web, knowledge-based engineering, business intelligence (BI) and virtual worlds (see figure1).
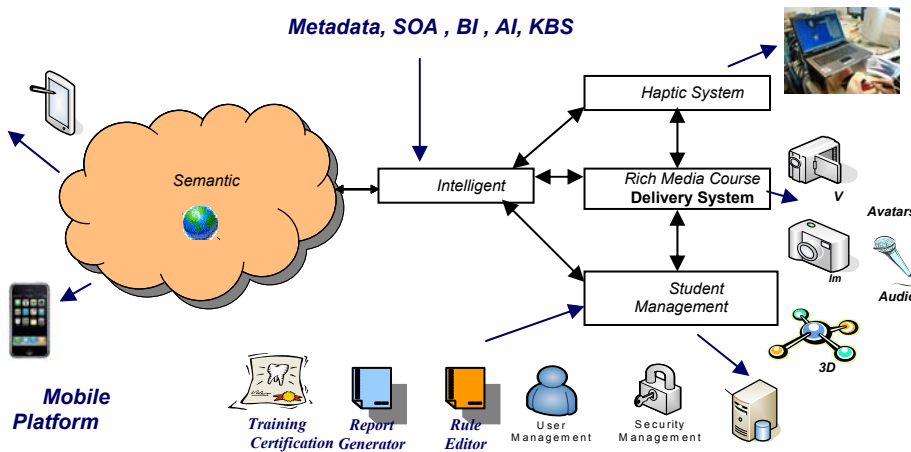


Figure 1: The ANDROMEDA infrastructure

## 2.   The Need for Change

Providing an innovative learning environment that is dynamic and addresses cultural and ethical challenges, as well as, incorporating the necessary means to engage the student with lecturers has always been the challenge for educational establishments and organizations is problematic. Differing hardware and software platforms limit the

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[49]   Bruce Elson (Birmingham City University), Patricia Reynolds (Kings College London –Lead)

development of a seamless collaborative environment that is transparent to the end-user yet capable of delivering rich media content.

Currently, a number of companies have developed partial solutions, (mainly for use in the business sector[50]), such as, collaboration and content management software, where users have some level of interaction using web-casts; document and presentations sharing; VoIP and chat. Virtual 3D environments such as Second Life, although popular, lack sufficient support for development and integration with other learning platforms.
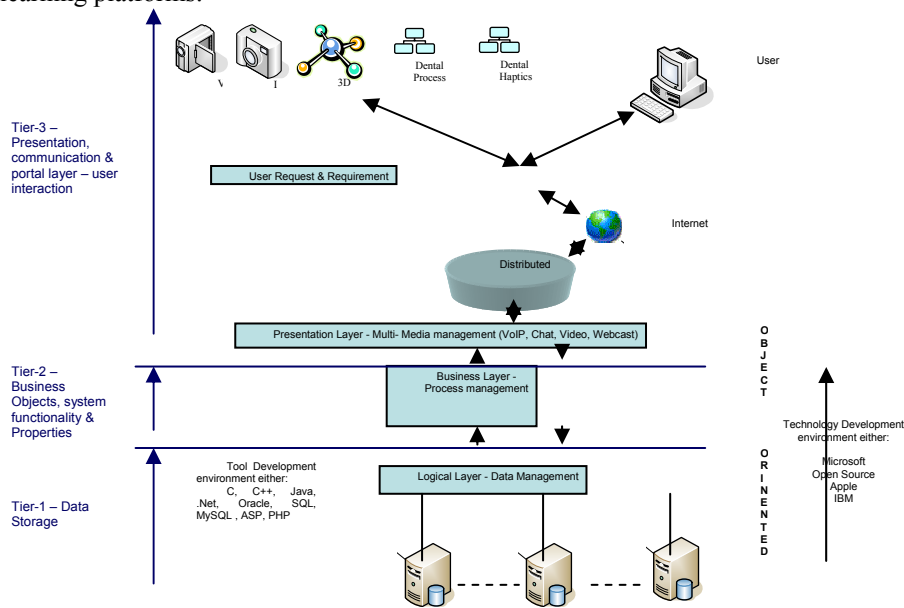


**Figure 2:** the current status of technological architecture for online learning environment

## 2.1 Methodology

Many organizations have adopted different types of methodologies, such as the Structured Systems Analysis and Design Methodology (SSADM), Rapid Application Development (RAD) and Spiral Model. Each has its own set of development tools and techniques for capturing data to establish a dynamic IT infrastructure, in order to address the organization social, cultural, political and economical demands, as well as rapid response to market changes. However, implementation of an IT infrastructure for flexible learning requires a hybrid approach.

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50  Cisco(Webex) http://try.webex.com/meet/sem/webmeeting/ and IBM(e-Learning) http://www304.ibm.com /jct03001c/services/learning/ites.wss/us/en?pageType=page&contentID=a0000050

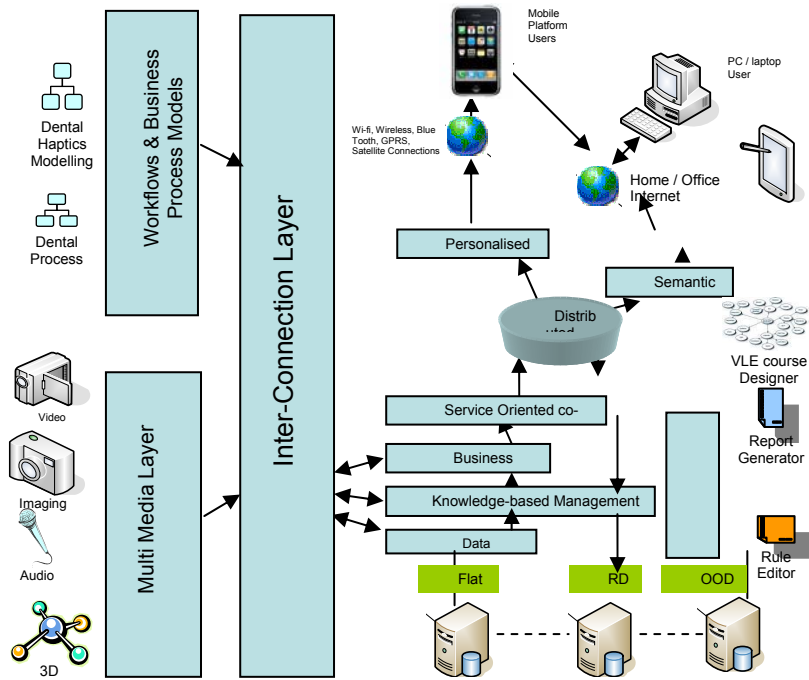# 3. The New Technology Environment Architecture (TEA)



**Figure 3:** the proposed technological environment architecture for online learning environment

## 3.1 The Object Oriented Model

The object-oriented model easily supports the distribution of one database across a number of servers; however, has difficulty in providing a means whereby different database infrastructures may be amalgamated together.

## 3.2 Knowledge-based Systems & Artificial Intelligence

Knowledge-based systems have been around in different shapes and forms since the 1980s, however, they have not been adopted by many organizations due to the lack of technology and the unwillingness of the people in organizations to participate, as the thought of passing their knowledge to a computerized system could be seen as taking their job away.

### 3.3 Service Oriented Architecture (SOA)

SOA, as Mark and Bell[51] explain, is a concept that enables business architecture and its functionality or application logic be made available to the end-users, as shared or reusable services on any IT infrastructure, where services are seen as a model within the architecture that could be used within different interface framework, and are invoked by messages. Service Oriented model would allow the current system to integrate without needing to change the existing systems by integration, loose coupling and abstraction.

SOA has been introduced as the evolution of the object-oriented model to overcome a fundamental limitation regarding integration. A true SOA model will enable various components of a system which are based on different platforms to interact with each other using a protocol accepted by all components.

### 3.4 Mobile Platform

The mobile technology has advanced in recent years with the introduction of the personal digital assistant in the late '90s followed today by the so-called 'smartphones' such as Apple's iPhone©, Research in Motion's Blackberry Storm© and those based on the Symbian© and Android© platforms of Nokia© and Google© respectively. These devices, with their internet connection and GPS accessibility, have enabled instantaneous messaging, social networking, and access to multi-media objects both locally and via the internet, in effect, giving PC functionality in the palm of the hand at anywhere and anytime.

The software development kits for these devices are being increasingly open-sourced, allowing easy development using common programming languages such as Java and C++.
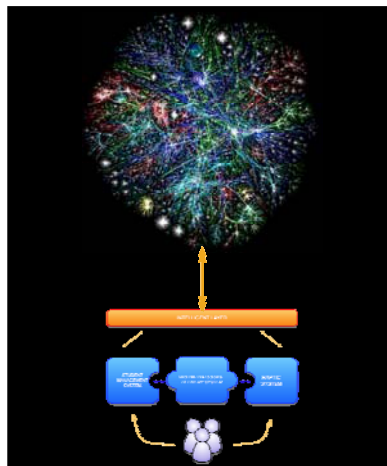


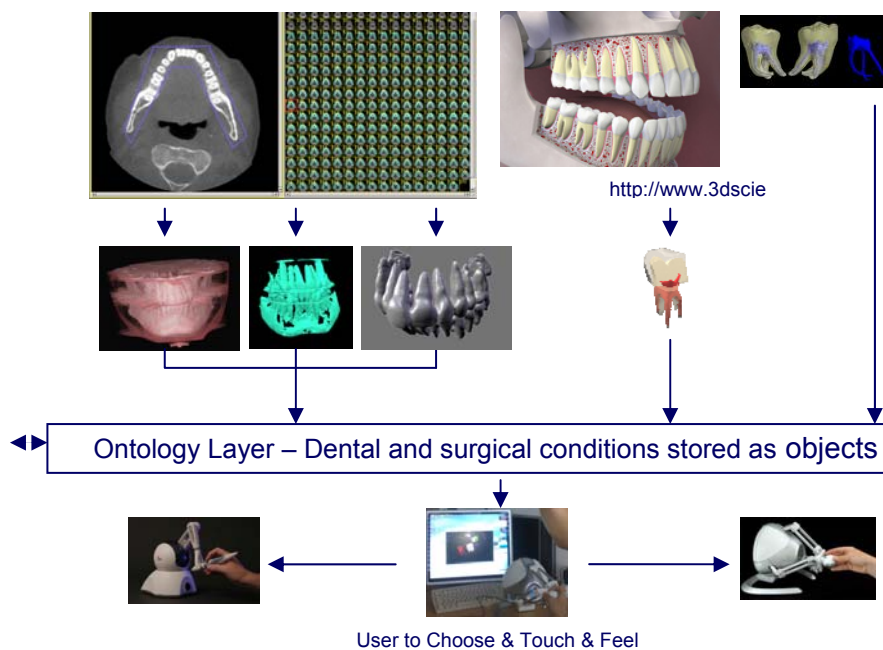Figure 4: the framework for linking semantic web and clouds to intelligent and contents layers

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[51] Eric A.Marks & Micheal Bell "Service Oriented Architecture"

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### 3.5 Semantic Web and Clouds

The Semantic Web was introduced by Berners-Lee in 1998 as a natural progression of the world-wide web. The aim is to enable people to co-operate and collaborate with computers more effectively. According to Geroimenko and Chen:

> "[the aim of the] Semantic Web is to delegate many current human specific web activities to computers. They can do them better and quicker than individuals. This can be achieved by adding more and more metadata to web data using XML, RDF technologies."

## 4. The Andromeda Ontologies



http://www.3dscie

Ontology Layer – Dental and surgical conditions stored as objects

User to Choose & Touch & Feel

Figure 5: the ontology layer of the system to capture data from different sources

The system will be based on the ontology's that are being developed for the digital description of dental conditions, and will allow any particular condition to be represented in an automated manner in a virtual, haptic-augmented, oral cavity. This approach greatly reduces the quantity of data that has to be handled by the system. Additionally it allows almost limitless flexibility for training purposes. For example, the system might store data for dental decay. Instead of the system requiring a computer model of each decayed tooth, this data can be combined with any tooth data to represent that particular decay-tooth model. In this way we aim to build taxonomy of dental and surgical conditions based on object-oriented principles. Conditions will be divided into classes and subclasses with multiple inheritances. This will represent the teaching the pre-clinical training aspect of the system. The second aspect of the system is live and involves real-time interaction with dental and surgical data.

The system will enable surgical planning and surgical rehearsal using patient-specific data. Standard imaging sources, such as computed tomography, magnetic resonance imaging, positron emission tomography and ultrasound scanning will be used to reconstruct a virtual patient that will be navigable and eventually haptic-augmented. The system will use an automated image acquisition and reconstruction process that will be transparent to the end user. Haptic-augmentation will vary according to the particular clinical situation, however, it is envisaged that a number of commercially available haptic devices will be useable. An additional feature of the system will be clinical review, where it will be possible to review surgical rehearsal.

## 5. ANDROMEDA Proposed Framework and Timescale

Requirements, testing and assessment will include dental schools from University of Timisoara, Romania, Brescia University and Barcelona University. Specifically the project will be tackled via several work packages
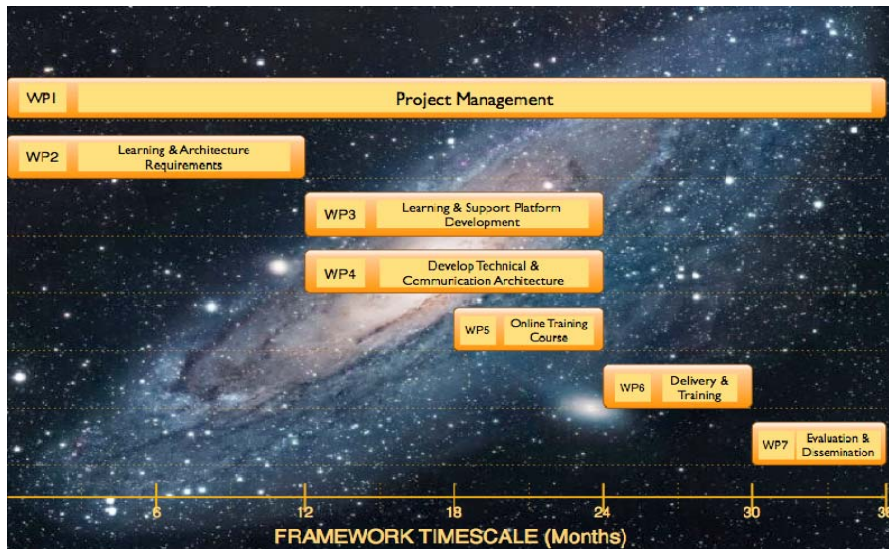


**Figure 6**: the Framework Timescale

### 5.1 Project Management - WP 1: Months 0-36

Manage, Collaborate, Risk Analysis, Quality Assessment

### 5.2 Learning and Architecture Requirements - WP 2: Months 0-12

Undertake requirement analysis to understand the user requirements and define the support and learning platform environment. Investigate the current state of semantic

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web and SOA technologies in the field of dental bioinformatics to define the system architecture.

### 5.3 Learning and Support Platform Development – WP3: Months 12- 24

Incorporate results from previous WP to construct required Learning Platform. Release results to other members of consortium for future WP's.

### 5.4 Develop Technical & Communication Architecture - WP4: Months 12 – 24

Incorporate results from WP2 to incorporate Semantic Web technologies with Intelligence Layer to manage data and communications. Report on results.

### 5.5 Develop Online Training Course – WP5: Months 16 - 24

Transition to a live environment, initial user acceptance testing. Dental School validation is needed at this point.

### 5.6 Delivery & Training – WP6: Months 24-30

A 'live' online version to be broadcast with user training and haptics according to trial design. This is to be validated by the consortium.

### 5.7 Evaluation & Dissemination – WP7: Months 30 – 36

Using the results from the Validation, evaluate the impact of the system on the learner, the systems delivery and its effectiveness. From the validation, report on the success of the system, and what advances need to be made. Develop guidelines and suggest advancements

## 6. Conclusion

We anticipate that our research will benefit a broad cross-section of society through potential improvements in dental and oral surgical training, leading to more effective and safer patient treatment. Our research addresses the need for a risk-free simulation environment either for basic training or for rehearsing difficult procedures. This method of training has been hitherto available only using cadaveric specimens -a method no longer available in many European States. The ability to import "patient specific" data allows takes the pre-operative rehearsal a stage further than cadaveric training allowing training on an unique surgical condition.

A working demonstration platform will be produced with the aim of producing a commercial tool that can be sold to academic institutions across the European Union. Project partners, will be fully able to give demonstrations and specific training on all

aspects of the training platform. It is planned that the software will be made available to non-commercial partners via a Gnu public licence or similar to facilitate a co-operative approach to the system's future enhancement while safeguarding the IP necessary for its exploitation.

## References

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