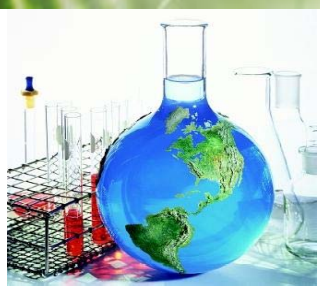
IEEE Science and Engineering Graduate Research Expo

September 25, 2009, Melbourne, Australia





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IEEE Science and Engineering Graduate Research Expo 2009

25 September 2009
The University of Melbourne, Australia

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Foreword from the IEEE Victorian Section

Paul Kubik
Vice-Chair
Secretary, IEEE Victorian Section
Melbourne, Australia

The IEEE Victorian Section is proud to support the inaugural Science and Engineering Graduate Research Expo, hosted by University of Melbourne.

The IEEE would like to continue the encouragement of research and innovative thinking in Australia. Australia has a national resource of highly qualified engineers and our Universities have a reputation on an international level. By fostering on the enthusiasm of the younger generation we intend to keep the momentum required for investment in the R&D industry.

We would also like to bring together our IEEE Graduate Members and the industry, to showcase the skills and talents of our younger members. The focus of the expo is to highlight the achievements of these members. We wish to retain our most talented graduates in the Australian industry, through local opportunities and actively competing with the international market.

The quality of research projects and our Engineering Graduates in Australia is alive and well. I would like to encourage everyone to see the quality of these projects for themselves.

Foreword from the National ICT Australia (NICTA)

Professor Rob Evans
Director, Victoria Research Laboratory
National ICT Australia Ltd (NICTA)

NICTA is proud to be a sponsor of the 2009 Science & Engineering Graduate Research Expo. This event is a wonderful opportunity for students to showcase their talent, share their research interests and demonstrate the contributions they are making at this early stage in their careers.

Research is about collaboration and sharing. The Expo is bringing together graduate students from all over the State, working across a range of disciplines, forging connections that they will take with them into the future. As the problems we face become more complex, these collaborative links are becoming increasingly important in determining our ability to come up with solutions.

Graduate students are an essential part of the NICTA research community bringing skills, ideas and energy that are vital in achieving research outcomes that impact on society. Being able to discuss their activities with their peers, academic leaders and industry professionals as part of the Expo is a rewarding experience for the research leaders of the future and we encourage everyone to make the most of the opportunity.

Congratulations to the Expo organizers on an event that promises to be a rewarding experience for all who attend and to those whose research has been selected for presentation. And to everyone we wish you an enjoyable day.

Foreword from the Computer Science and Software Engineering Department

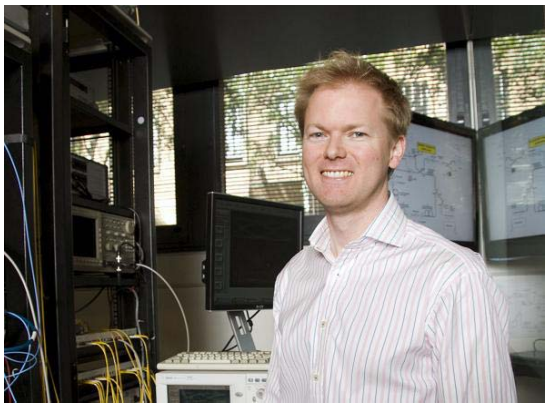
Professor Alistair Moffat
Head, Department of Computer Science
and Software Engineering
The University of Melbourne

The "Science & Engineering Graduate Research Expo 2009", organized by the graduate students of University of Melbourne, is an initiative in which students, researchers, academics and professionals from industry come together to exchange information and communicate their knowledge and experience. In 2009 the Expo is drawing in expertise from all over Victoria, and has the full encouragement and support of Department of Computer Science and Software Engineering, and also the Melbourne School of Engineering.

The projects presented in the Expo demonstrate the strength of research in engineering in Victoria, and the depth of knowledge and commitment shared by the young researchers who are contributing to it. The University is fully supportive of this type of Knowledge Transfer activity, and anticipates that all Expo attendees will benefit, even if in different ways.

The Department and School congratulate the organizers of the Expo on their initiative, and thank all of the contributors for their participation. And to all of the attendees -- have fun!

Foreword from the Electrical and Electronic Engineering Department



Associate Professor Jamie Evans
Head, Department of Electrical and Electronic Engineering
The University of Melbourne

It's a pleasure to be part of the IEEE Science and Engineering Graduate Research Expo 2009, which brings together a wide range of Masters and PhD students across Victoria. The event will be highly valuable to participants both in terms of technical aspects and networking opportunities. Activities include project demonstrations, poster presentations, panel discussions and career advice seminars. Attendees from both industry and academia further strengthen the multi-disciplinary and knowledge transfer focus of this event.

The Department of Electrical and Electronic Engineering always encourages and supports pure and applied research that is beneficial for technology enhancement and end-user satisfaction. The IEEE Science and Engineering Graduate Research Expo 2009 will be a unique platform to exchange ideas and to demonstrate the applicability of projects undertaken by graduate research students from all over Victoria. On behalf of the Department of EEE, I am very happy to be a part of this knowledge transfer process and glad to contribute to the successful organization and completion of the expo.

Finally, I congratulate all the award winners, participants and most importantly the organizers for the successful planning and staging of the event. I wish you all good luck and big impact in your future careers.

Foreword from the Organizers

IEEE Science and Engineering Graduate Research Expo 2009, hosted by University of Melbourne is dedicated to capturing the imaginations of graduate students of universities and broader communities; from the industry and academia throughout Victoria, Australia. The main objective of this Expo is to provide a platform for graduate students to demonstrate their research capabilities as well as enable them to receive valuable feedback and informed ideas from experts in the relevant fields.

The event features an interactive knowledge transfer process among various graduate student communities through keynote speeches, research demonstrations, poster presentations, panel discussions, and job opportunity seminars covering different research areas of science and engineering. Moreover, it will provide them the opportunity to establish professional networks for further research collaborations and career opportunities.

We sincerely hope that the multi-disciplinary focus of this Expo will attract diverse graduate communities of different universities throughout Victoria and facilitate them to showcase and disseminate the latest progress in science and engineering. We also believe that it will facilitate bridging the technology gaps between industry and academia by building strong research and education linkages.

Finally, we gratefully thank our sponsors NICTA, Department of Electrical and Electronics Engineering (University of Melbourne), IEEE Victorian Section, Sun Microsystems, Melbourne School of Graduate Research (MSGR), Melbourne Engineering Research Institute (MERIT), Cloud Computing and Distributed Systems (CLOUDS) laboratory, and the Peer-to-Peer Networks and Applications Research (P2P) Group for their generous support to successfully organize this event.

IEEE Science and Engineering Graduate Research Expo 2009
The University of Melbourne, Australia

Landscape Visualisation Tools and Methods:

Choosing Preferred Landscapes

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***Abstract*— Making decisions on landscape futures is challenging to decision makers as land uses have differing, often conflicting objectives. Appropriate landscape management is especially important in areas dominated by production forests and a range of potential scenarios can be developed by applying different management practices, in varying spatial patterns across the landscape. This paper describes a software system – ScenarioChooser – which allows the public to compare and select their most/least preferred forest management options from a set of eight developed scenarios. The scenarios are represented by a description of the applied management techniques, quantifiable landscape outputs and 3D panoramic views from selected areas. The landscape scenarios preferred by the participants showed significant variation both in applied harvest system and in proportion of land made available to harvesting. Analysis of the system interaction log show patterns of use and the type of information that was important in the decision process.**

Forest management; landscape; scenario; visualisation; panoramas

I. INTRODUCTION

Landscapes reflect the multifunctional nature of land and the complex relationships that exist between society and the environment. Land management systems have evolved to provide resources to meet societal demand but within a human lifetime these practices can significantly change both the landscape and the relationship that people have with the affected land [1]. Land uses have differing, often conflicting objectives and making decisions on landscape futures is challenging to decision makers and compromises must be made between competing economic, ecological and social values. When dealing with competing criteria, land use decision-making is complex, made more so when we consider the spatial and temporal dimensions of the decisions [2]. Appropriate landscape planning is especially important in areas dominated by production forests, where the planning and allocation of land and the harvest method employed is critical to ensure an adequate and sustainable timber supply, an ecologically sound environment and a visually acceptable landscape for the public. In this environment, the type and intensity of harvest system applied, directly affects the quantity of timber product extracted, the underlying ecosystems and the visual appearance of the landscape [3]. A range of potential scenarios can be developed by applying different management practices, in varying spatial patterns across the landscape [4]. These scenarios can either be constrained or unconstrained by forest practices legislation and with the development of 'landscape outputs', the performance of these scenarios may be compared directly in terms of economic, ecological and visual acceptability. To evaluate the social acceptability, the implications of applying different forest management systems should be evaluated at a landscape level and the ScenarioChooser tool allows these management systems to be represented both visually and quantitatively in terms of timber output, natural environment and amenity, enabling participants to compare, contrast and select their most/least preferred scenarios. The visualised scenarios were a subset of forest management scenarios based on a study area located in Southern Tasmania. By recording the participants' interaction with the system, some insight may be gleaned into what factors were important in the participant's decision making process.

II. METHODS

A. Toolset Characrteristics

The project required development of an interface, termed 'ScenarioChooser' with following characteristics & functions:
(a) Operational simplicity.
(b) Clear presentation of scenario output data.
(c) Direct comparison of scenarios.
(d) Systematic scenario ordering based on landscape output.
(e) Method of recording preferred scenarios and interaction.
(f) Present data as text, 2D map and '3D' panoramas.

B. Interface Description & Development Process

Scenario Chooser Interface - A WEB based interface (Fig. 1) was developed, as the intended audience (public) were familiar with the required operational skills e.g. point & click, drag & drop. The interface was built from HTML and Javascript libraries to operate under the Mozilla Firefox™ (v 3.0.10) web browser using Apple Computer QuickTime™ (v 7.6.2) Javascript library as the application programming interface for the panorama control. The eight landscape scenarios were represented as 'tiles' that could be dragged into one of two 'view wells'. On placing a tile into a view well, the scenario description, summary output information and a panorama were automatically displayed. Additional scenario information was available via embedded HTML links, allowing the participants to compare and contrast two scenarios simultaneously. Participants selected their preferred scenarios by moving tiles into a series of ordered

This research is funded by an Australian Research Council Linkage Grant and by project partners Forestry Tasmania, Forest Practices Authority and Tourism Tasmania.

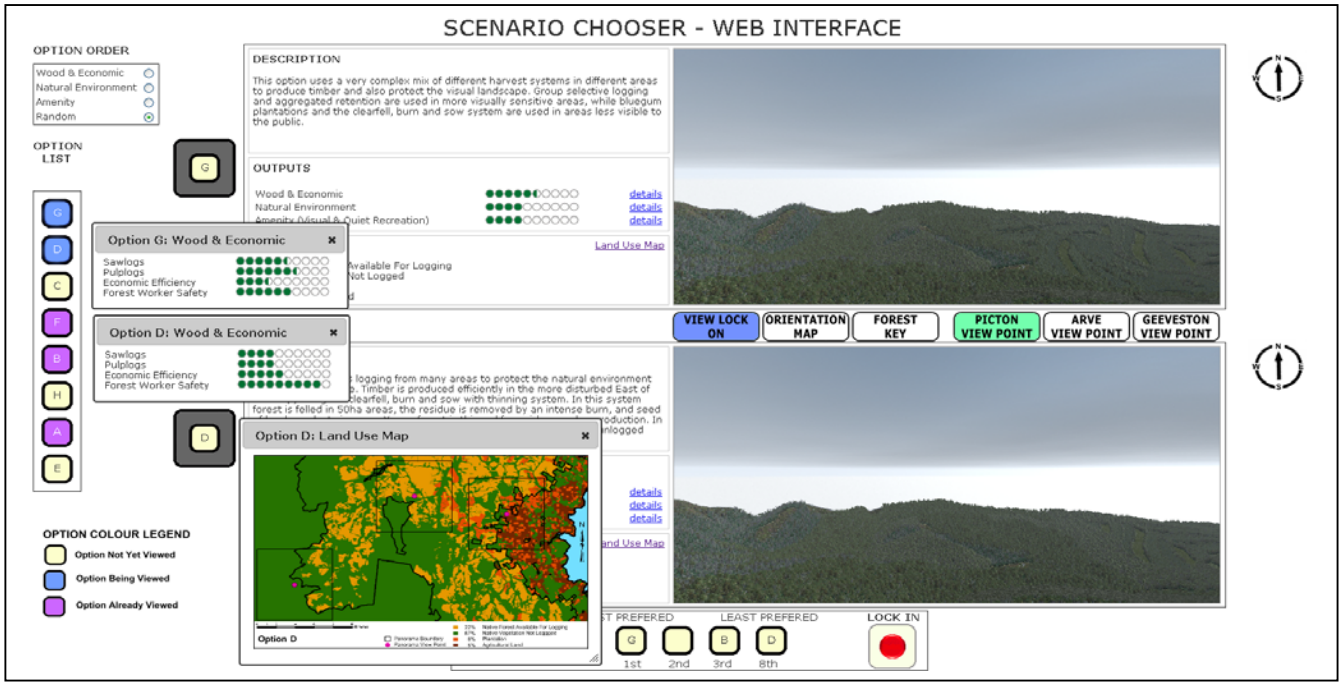


Figure 1. ScenarioChooser WEB Interface

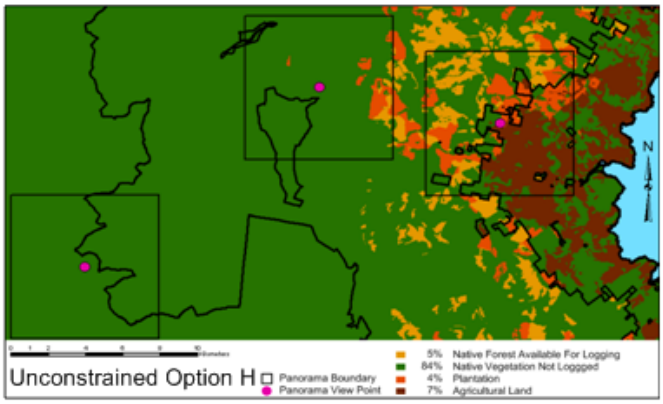
'selection wells' indicating 1st, 2nd, 3rd and 8th order preference.

All participant interaction and scenario selection was written to a time stamped event activity log. Thirteen future forested landscape scenarios were implemented (8 constrained, 5 unconstrained) with each scenario having three panoramic views. The panoramas used the same three geographic viewpoints across all scenarios, enabling direct visual comparison of the view scenes. In total thirty nine cylindrical panoramas were built using the commercial rendering toolset 3D Nature - Visual Nature Studio™ (v 2.86).

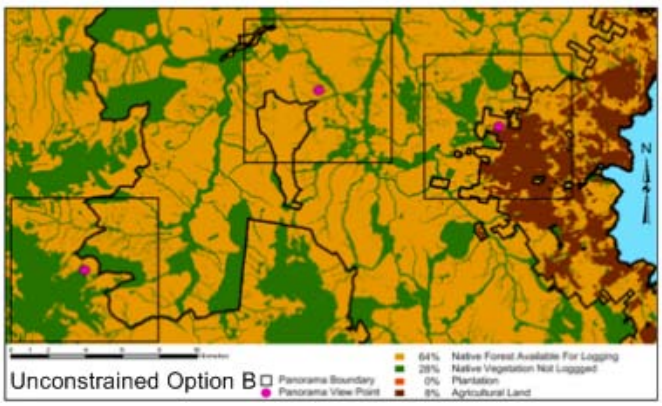
The landforms were represented by digital elevation models and the forested landscape by ecosystems developed to represent a particular overstory/understory type and density. The panoramas were presented as Apple QuickTime VR movies embedded into the WEB interface, allowing the participant to view landscapes by rotating the view scene through a full 360 degrees. All participant interaction with the WEB interface was written to an event activity log.

III. RESULTS

Trials were run in three locations, Melbourne, Hobart and Huonville, the latter two locations being physically close to production forests. Forty six members of the public took part in the study and all completed questionnaires evaluating both the scenario choosing process and the ScenarioChooser toolset. Initial analysis of the responses indicates that the ScenarioChooser interface performed well, with all participants finding the layout easy to understand and the interface elements simple to use. The thirteen scenarios were arranged into two groups of eight, with groups being randomly allocated to a participant. All participants viewed all eight scenarios in their group, and forty five were able to complete the selection task. The preferred scenarios had significant variation in the spatial distribution and type of applied harvest systems (Fig. 2).



Small Area Harvest Scenario



Large Area Harvest Scenario

Figure 2. Example of Selected Scenarios

The event activity logs were processed using the Python scripting language to produce a visual representation of the participants' session, illustrating the interaction with the separate elements of the ScenarioChooser interface (Fig. 3).

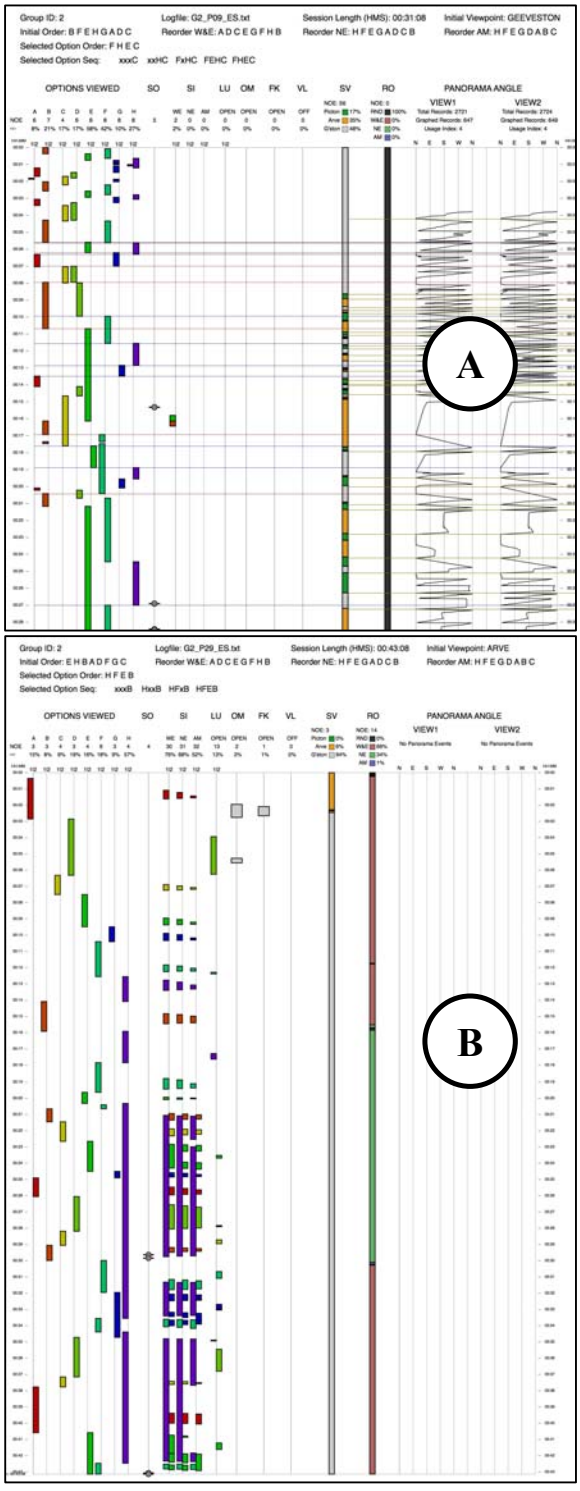


Figure 3. Example Participant Event Activity Logs

Analysis of these logs is ongoing, but initial inspection suggests different phases of interaction, (i) exploration of toolset, (ii) selection of scenarios and (iii) validation of selection. In each phase, participants used different combinations of the interface elements for different lengths of time. Participants also took different approaches to viewing and comparing scenarios e.g. systematic selection, random selection, repetition of viewing sequences, pair wise comparison or selecting a 'reference' scenario against which all others were compared. The type of information used by the participant in making their selection is also apparent. e.g. in fig. 3 log file A, there is extensive use of the panorama (PANORAMA ANGLE) and scene view (SV) elements but little use of the sub-indicator output elements (SI) which indicates that visual landscape representation was important to this participant. In contrast, fig. 3 log file B shows extensive use of SI elements but little use of scene view and no use of panorama elements, suggesting that descriptive elements were more important.

IV. Discussion & Conclusions

Appropriate landscape planning is important in areas dominated by production forests and making decisions on the most appropriate management approach is complicated due to competing often conflicting objectives of the decision maker. ScenarioChooser is an effective tool for use by the public in presenting, comparing and selecting preferred forest management systems. The information gathered from the system logs provide some insight into how the public use visually rich information to make decisions about forested landscapes and as such provides a basis for further interface development.

Acknowledgment

The author acknowledges the support of I. Bishop, Dept. of Geomatics, K.W. Williams and R. Ford, Dept. of Resource Management and Geography, University of Melbourne for providing inspiration and direction.

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Developing a virtual reality simulator for oral surgery training

A prototype based on fidelity requirements

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***Abstract*—Virtual reality (VR) has been attracting significant attention from the field of surgical training due to its potential to address several shortcomings of traditional surgical training methods. This demonstration presents a prototype VR haptic simulator for the training of technical skill in oral surgery. This prototype aims to teach dentistry students the core skill of differentiating tooth and bone when drilling - a skill utilised in many oral surgery procedures. The fidelity requirements of the prototype were identified by applying a structured empirical approach that has been developed as part of this research.**

Keywords-dental education, surgical training, dental drilling, virtual reality, surgical simulation, simulator fidelity, simulator development

I. INTRODUCTION

Competence in surgical psychomotor skills is a crucial skill for oral surgeons. Psychomotor skills are most effectively acquired by observation, practice and feedback[1]. However dental curricula include limited hands-on practice and as a consequence, the acquisition of practical skills occurs primarily during clinical practice, where students work with real patients. Virtual reality (VR) simulators with force feedback have shown great potential to improve surgical training by providing better extra-operative opportunities to practice [2].

One problem with many of the VR based training systems in surgery is that so far their development has been technology-focussed, rather than focussing on the skills that are to be trained and the needs of the trainees. VR simulators need not be perfectly realistic to support the development of the desired psychomotor skills [3][4]. In striving for perfect realism, unnecessary time may be spent simulating aspects of reality that are not important in learning, while other crucial aspects may be missed. To maximise training effectiveness and minimise development costs, training simulators should represent all crucial skill-related cues and responses in high fidelity. Information that is not crucial to the task or skill being taught can be simulated in low fidelity, and unimportant information may be omitted altogether.

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MUVES (Melbourne Univ. Virtual Environments for Simulation)
Melbourne Dental School

II. THE PROBLEM

To develop simulators that represent crucial skill-related cues in high fidelity, we first need to understand what aspects of the real surgical situation are important to the skill being taught. This is the central question of this work, and it is a question that has not been systematically explored in the field of surgery. Currently, most surgical simulators are not developed in a structured, methodical manner. Instead they are developed using trial and error with feedback from experts and users. This method is vulnerable to biases and may result in significant costs if many modifications are needed once the tool has been developed.

The overall aim of this research has been to develop a generalised structured methodology for identifying the fidelity requirements of haptic VR simulators for surgical training.

III. APPLICATION SCENARIO

Oral surgery was chosen as the application domain for this work. It was chosen because it includes some very common and highly invasive procedures (such as wisdom tooth extraction and dental implants), which are ideal candidates for simulation. While there are several dental drilling simulators being developed [5-9], very few cater for for oral surgery procedures.

The chosen training objective was to teach the skill of differentiating tooth and bone during drilling. To identify the requirements of a VR simulator to teach this skill, we designed and carried out an empirical study to identify the cues that dentists of different ability levels use to differentiate materials, and measured the forces applied during drilling [10-11]. Participant of different skill levels performed a representative oral surgery task on an ovine jaw attached to a tri-axial force sensor. Semi-structured interviews were used to examine the cues and factors affecting the performance of each participant. This study enabled us to identify which aspects of reality are important for training this specific skill, and how different cues are used during the development of this skill.

A prototype VR simulator is being developed based on our study results. Once this prototype is completed, it will undergo empirical evaluation to determine whether it has achieved adequate task fidelity, and whether the skills learnt in the simulator transfer to a real physical situation.

Figure1: PHANToM Premium 1.5 HF haptic device

Figure2: Simulator prototype in use.

The methods and techniques used to identify the requirements of the oral surgery simulator discussed above are being extended and generalised to form a methodology that can be used by VR developers to identify the requirements of other surgical skill training simulator.

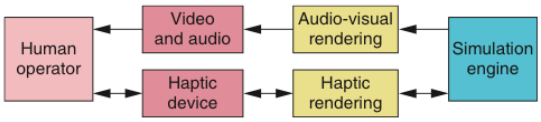

Figure3: Architecture of haptic VR simulator [12]

IV. Oral surgery VR prototype

This section describes the oral surgery prototype simulator that is the object of this demonstration. The first step in the development of this prototype was to examine the most prevalent cues used to distinguish tooth and bone in our empirical study.

A. *Overview of fidelity requirements*

The cues identified by our study as most important in distinguishing the boundary between tooth and bone were:

- Changes in material hardness;
- the position of the burr in relation to the tooth and the angulation of the burr;
- the anatomy of the area;
- changes in material colour.

Further qualitative analysis indicated that it is crucial to have a clear visual and tactile distinction on material boundaries. Thus we know that the oral surgery prototype needs to represent material hardness, anatomy and colour in high fidelity, particularly around material boundaries. Furthermore, the position and angulation of the burr as well as the removal of material needs to closely resemble reality.

B. *Implementation*

The hardware set-up consists of a PHANToM Premium 1.5 High Force haptic device (Figure 1). This device allows movement tracking with 6 DOF (X,Y,Z,roll,pitch,yaw) and force output with 3 DOF (X,Y,Z). It is capable of exerting 6.2N of sustained force and a maximum force of 37.5N. The haptic device is connected to a PC and a monitor. The monitor displays the visual model of a jaw being while the haptic device simulates the force feedback experienced as the jaw bone and teeth are drilled (Figure 2). A Magellan 3D mouse may be used to move and rotate the jaw model to the desired position. An infrared transmitter and active 3D shutter glasses can be used to obtain a 3D stereo view which allows for better perception of depth.

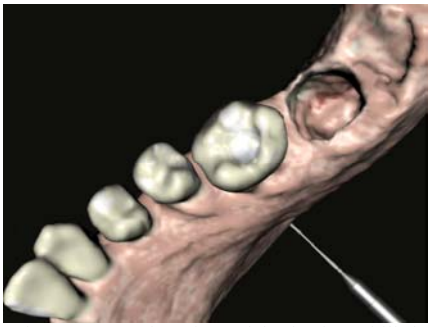

Figure4: Screenshot of a tooth having been drilled in the oral surgery simulator prototype.

Haptic and audiovisual rendering take place in two separate threads. This is because the haptic loop needs to operate at 1000Hz minimum to provide a continuous tactile feel, while the graphics loop only requires a minimum of 30Hz to provide a convincing animation. Figure 3 [12] outlines the architecture of the simulator.

The jaw model used in the prototype was created from patient CT data using semi-automatic region growing and thresholding. Each voxel in the thresholded CT volume is assigned an index number based on its material hardness as reflected in its Hounsfield value. Each index number corresponds to a particular material. Each material has two important properties, an RGB colour and hardness rating. These material properties are assigned to each voxel upon graphic and haptic rendering. Upon launch, the voxel volume is converted to an octree structure for haptic rendering [13], and the marching cubes algorithm is used to reconstruct the model's surface as it is drilled [14]. Haptic rendering uses a simple single-point spring model [12] with added vibration to create an approximation of the tactile sensation. Harder materials such as enamel require more force to be drilled and are removed at a slower rate compared to softer materials like bone. Figure 4 shows a screenshot from the simulation prototype.

V. Conclusion

An oral surgery prototype simulation has been developed based on a structured identification of the fidelity requirements of the training objective. This prototype is still incomplete and requires further refinement of the visual and tactile rendering around material boundaries to fulfill its objective of distinguishing tooth and bone during drilling. Once completed, the task fidelity and skill transfer achieved by the prototype will be evaluated. This evaluation will enable the identification of missing features subsequent improvement of the simulation. Future extensions may include the ability to use different types of drills, and the ability to extract a tooth.

ACKNOWLEDGMENTS

I thank Dr Richard Hall and Mr Hemang Rathod for their assistance in the development of the oral surgery simulation prototype. I thank Dr. Ed Kazmierczak, Dr. Linda Stern, Prof. Andrew Smith, Dr Lisa Wise, Mr. James Quealy and Dr Bruce Field for their valuable contributions to the theoretical and empirical aspects of this work.

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Megha Workflow Management System for Application Workflows

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***Abstract*—The Megha workflow management system (MWMS) is designed to execute scientific applications, expressed in the form of workflows, onto Cloud and Grid resources. Using MWMS, we execute three data-intensive applications: a) Image Registration (IR) workflow for functional Magnetic Resonance Imaging (fMRI), b) intrusion detection analysis using distributed data sources (ID), c) distributed Evolutionary Multi-objective Optimizations (EMO), on Clouds and global Grids. We also demonstrate the scalability of our system by executing thousands of jobs on limited number of Cloud resources. We use compute and storage services provided by Amazon for the executions of these applications. The primary objective of this demonstration is to minimize the execution time of the real-world applications by using MWMS**

Keywords: Application workflow, Cloud computing

I. INTRODUCTION

Increasingly, scientific and commercial applications are leveraging the power of distributed computing and storage resources. These resources are available either as part of general purpose computing infrastructure such as Clusters and Grids, or through commercially hosted services such as Clouds. Buyya et al. [1] have defined Clouds to be a type of parallel and distributed system consisting of inter-connected and virtualized computers. These computers can be dynamically provisioned as per users' requirements. Thus, to achieve better performance and scalability, applications could be managed using commercial services provided by Clouds, such as Amazon AWS, Google AppEngine, and Microsoft Azure. However, the cost of computing, storage and communication over these resources could be overwhelming for compute intensive and data-intensive applications. To manage tasks and data in Clouds by optimizing both time and cost is a challenging problem.

In our demonstration we use Megha Workflow Management system, a Cloud middleware for workflow applications, to schedule and manage the executions of three real world applications on Cloud resources. They are:

a) Image Registration (IR) workflow for functional Magnetic Resonance Imaging (fMRI) applications

b) Intrusion detection analysis using distributed data sources (ID)

c) Distributed Evolutionary Multi-objective optimizations (EMO)

By executing three different types of applications, we will show that MWMS is flexible and is capable of managing requirements of different real world applications. We also show that MWMS minimizes execution time of these applications by scheduling tasks dynamically.

We describe MWMS, Amazon Cloud resources and each of the above applications briefly in the following sections.

II. OVERVIEW OF MWMS

The Megha Workflow Management System [2] is a Cloud middleware that helps scientists to execute and manage applications, by expressing them as workflows, on Clouds and global Grids. It provides a Portal, which is the primary user interface for users to create, edit, submit and monitor applications on Clouds and Grids. The portal hosts a workflow editor, an application submission interface, application/ resource monitoring interface and application specific (e.g.IR, EMO etc.) pages. MWMS is designed to support an XML-based workflow language (xWFL). Users can define workflow tasks and dependencies through drag and drop facilities using the GUI based editor, without having to code the application in the XML format. The Megha Workflow Engine (MWFE) schedules the tasks in the workflow application through Cloud middleware services and manages the execution of tasks on them. The workflow-monitoring interface also provides a GUI for monitoring task status (e.g. ready, executing, completed). Resource monitoring interface provides both the static and the dynamic characteristics of resources being used by the application. The architecture of MWMS is depicted in Figure 1.

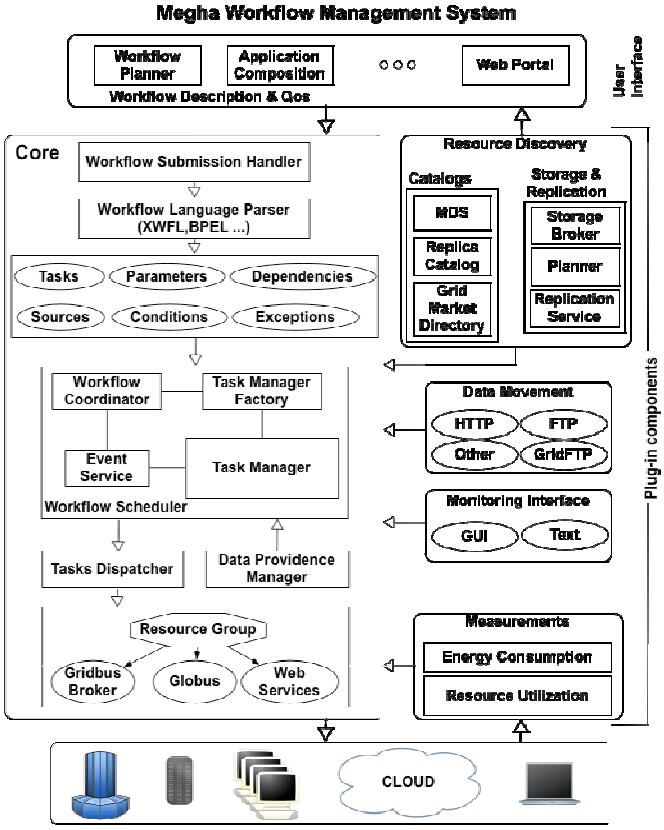

Figure 1. Megha Workflow Management System Architecture

MWMS has been implemented by leveraging the following key technologies: (1) IBM TSpaces for supporting subscription/notification based event exchange; (2) Gridbus Broker [3] for deploying and managing job execution on various middleware, including Aneka (a .NET based Cloud Computing Platform); (3) XML parsing tools including JDOM. In particular, MWFE uses services provided by the Gridbus Broker to manage jobs executing on Aneka.

III. MWMS ON AMAZON CLOUD SERVICES

We execute all the workflow applications on Amazon's Elastic Compute Cloud (EC2) [4]. EC2 provides direct access to virtual machine instances to its users. We use Amazon Simple Storage Service (S3) to store large sized files for easy and instantaneous access by EC2 instances. Both the Megha Workflow Management System and Aneka Enterprise Middleware were installed on instances of Amazon EC2. The deployment configuration includes 10 Linux (Ubuntu) instances for hosting MWMS and executing IR and ID applications. In addition, we instantiate 10 other Windows 2003 Server instances for executing the EMO application.

IV. SCIENTIFIC APPLICATIONS

We now describe the three applications mentioned earlier.

A. Image Recognition for fMRI Applications

Functional Magnetic Resonance Imaging (fMRI) is a non-invasive procedure that uses rapid MRI to measure changes in blood oxygenation in an active part of the brain. A typical fMRI experiment requires a multiple-stage process that begins with the preprocessing of an individual subject's raw data and concludes with a higher-level group statistical analysis. Such analysis procedures often draw upon hundreds or even thousands of images, which must be normalized to a standard/averaged image.

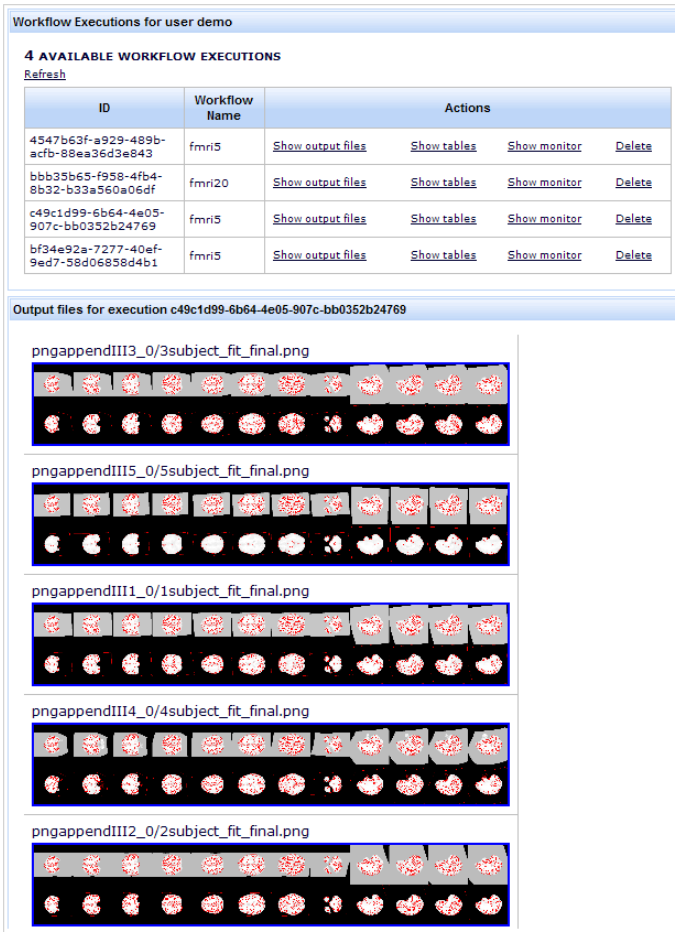

Figure 2. MWMS executing fMRI workflow application

We present this normalization procedure as a workflow. First, we create a population-based atlas from the anatomical MRI data. Each of the subjects is then registered to the reference image. We can combine both the registered image and the reference image on a single new image for the scientists to analyze the fit of each subject with respect to the reference image.

Our primary objective is to decrease the total execution time for large number of subjects used. We demonstrate that consistent and reliable results can be obtained within much shorter time by using resources provided by Grids and Clouds when compared to the conventional ways. Figures 2 and 3 depict the MWMS portal executing the IR workflow.

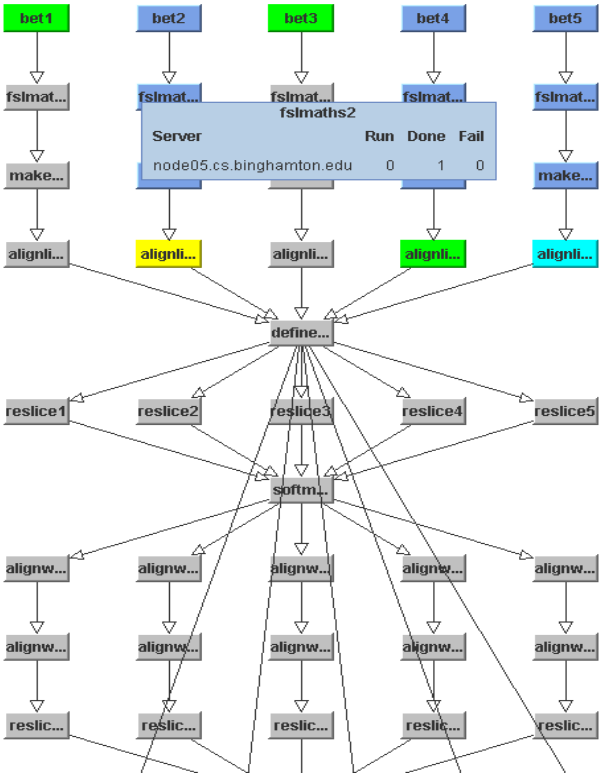

Figure 3. A snapshot of the fMRI workflow during execution

B. *Intrusion Detection using Distributed Data Sources*

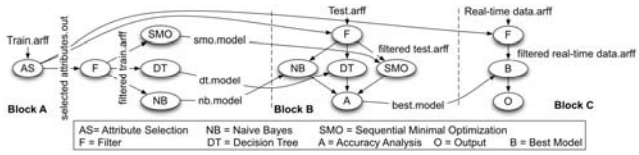

Figure 4. Intrusion detection workflow structure

Figure 4 describes the training, testing, and real-time processes labeled in the figure as Block A, Block B and Block C, respectively. The first step for training is to collect some training data, which can be the contents of IP packets, load on particular servers, logs generated by web servers and application servers or any other detail depending upon the environment. Collected data are then represented in a format that is supported by the data mining tool (in our case it is *.arff* format). The next task in training involves preprocessing the data, which includes data normalization, standardization and transformation, adding missing, values, etc.

Once we have the pre-processed data, we select a small set of features that are significant. This helps to improve the performance of the system as well as to improve accuracy. Finally, with the reduced training data (which have only a small number of significant features), we apply different algorithms to train corresponding models. Such algorithms include Naive Bayes Classifier, Decision Trees (J48), Support Vector Machines (SMO) and others.

C. *Evolutionary Multi-Objective Optimizations*

Evolutionary Multi-objective Optimization (EMO) is a technique based on genetic algorithms. Genetic algorithms are search algorithms used for finding optimal solutions in a large space where deterministic or functional approaches are not viable. Genetic algorithms use heuristics to find an optimal solution that is acceptable within a reasonable amount of time. In the presence of many variables and complex heuristic functions, the time consumed in finding even an acceptable solution can be too large. However, when multiple instances are run in parallel in a distributed setting using different variables, the required time can be drastically reduced. The EMO application as a workflow and its performance graph while running on Amazon is depicted in Figure 5.

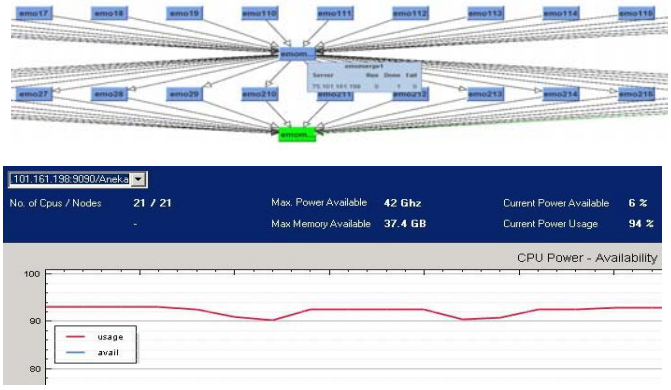

Figure 5. EMO workflow and real-time performance graph

ACKNOWLEDGMENT

We would like to thank Dr. James E. from the Department of Psychological and Brain Sciences at Dartmouth College, U.S.A for his contribution on the fMRI application; William Voorsluys, Mustafizur Rahman and Dr. Christian Vecchiola from the Department of Computer Science and Software Engineering at the University of Melbourne, Australia for their contributions on workflow portal, editor and Multi-Objective Optimizations applications.

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Service Oriented VoIP (SOVoIP):

A Universal Platform To Share Knowledge Beyond The Horizon

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I. Specific Problem and Application Scenario:

Voice over Internet Protocol (VoIP) consists of different communication services on the Internet. The main technical difference between conventional telephony and VoIP is that VoIP uses a packet switched network, the Internet, compared to traditional telephony's circuit switched network. Thus, VoIP enables cheaper or free communication by delivering its traffic via existing global network, the Internet and helps us to take our voice to the other part of the world. Skype, AOL, MSN and Yahoo messenger are good examples of current VoIP applications which enable voice, video and text messaging between peers. However, these applications are standalone, do not allow communication between them and most importantly they cannot extend their applicability beyond telephony and merge with other applications on the Internet. Thus we propose a service oriented VoIP architecture, Service Oriented VoIP (SOVoIP), which not only ensures inclusive convergence of Internet applications and telephony but also ensures Quality of Service (QoS) and support emergency services such as 000/ 911 call in IP network. An interoperability model between popular VoIP protocols Session Initiation Protocol (SIP) and H.323 is demonstrated in [2]. Thus, aim of SOVoIP can be seen as:

- To provide an infrastructure on the Internet in order to broaden the scope of Internet telephony from application to platform. Such platform will help us to share knowledge between organizations, cultures and research groups in order to provide better life to humankind.
- From technical aspect, as the implementation of SOVoIP is designed with web services technology, SOVoIP ensures universality for all the protocols both from telephony and Internet. Thus voice and data networks converge in its true sense.

II. Overall Architecture and Underlying Concepts and Technologies:

In SOVoIP, there are two types of nodes: Public Nodes and Client Nodes (Figure 1). A client node, where the VoIP software is installed, can be a PC or a handheld VoIP enabled phone. Public nodes, which are available on the network, have public IP addresses, and are managed by VoIP service providers.

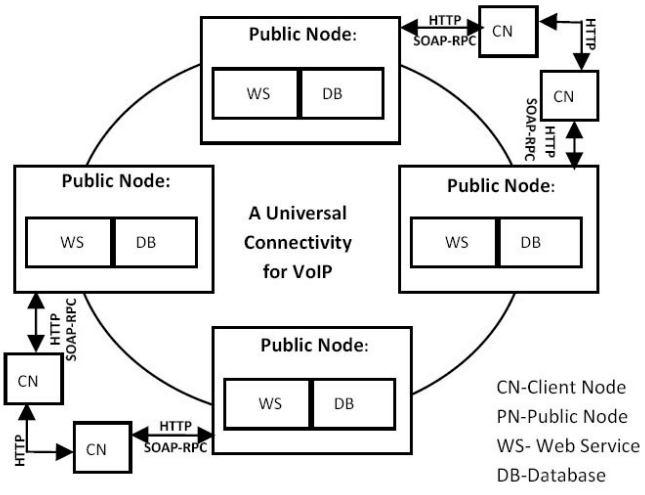

Figure 1. Web Service Based SOVoIP Architecture

Public nodes, deployed by VoIP service providers, provide a web service interface to clients. They are responsible for most of the data processing associated with VoIP connectivity. In addition to authentication and IP look up, these nodes are responsible for managing tasks such as NAT and firewall traversal and addressing the E911 problem. The concept of a public node is similar to a cell in a cellular network. Public nodes cover a specific area. For the ease of understanding, one public node can be considered to serve a particular post code. Public nodes have a local database which keeps information regarding clients assigned to its postcode. Public nodes can reach each other in p2p manner. They can provide proactive suggestion, if needed, regarding media codecs or network congestion in both sides, to the clients before call setup starts.

Client nodes connect to a web service at a public node for registration, authentication, user search and billing. Hence, data exchange between client nodes and public nodes use SOAP over HTTP. Each client node is associated with a public node that operates as the home node for the client. Home node for the client is selected based on the postcode information provided during first registration. All information related to a client is stored at the client's home node. During registration a client node shares necessary information with its home node such as IP and port. It may be necessary to share

Sun Microsystems, Inc. *(sponsors)*

the physical address as well, in order to provide better geolocation based services. Complete operational view of SOVoIP can be found at [1, 2].

Technologies used for development: NetBeans, JAVA, GLassFish and MySQL.

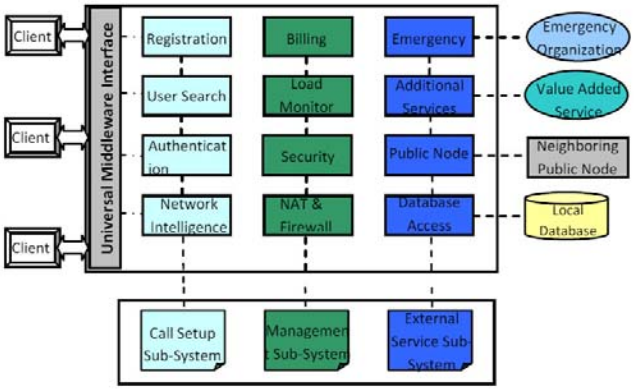

Figure 2. Architectural View of SOVoIP Middleware

Figure 2 shows the conceptual architecture of SOVoIP web services and interest of this proposal. The web service is divided into three functional subsystems: Call Setup Subsystem, Management Subsystem and External Service Subsystem in order to separate session related functions, managerial monitoring and access to external services respectively. The Universal Middleware Interface provides seamless connection to clients. Once any module within a subsystem is developed and tested it can be added to the web service transparent to clients. For example, value added services such as weather report and sports news can be added sequentially at different time without any architectural changes both for client and providers.

III. Expected Outcome and Impact of the Project:

To summarize the outcome of SOVoIP we point out the followings:

- Simplicity: No special hardware or software is required to install for SOVoIP.
- Geography: Internet host geolocation technology is associated with SOVoIP. Thus, it offers the opportunity to provide customize services based on user location.
- Extendibility: Compared to standalone VoIP applications, SOVoIP distinguishes itself with its service oriented vision which ensures the extendibility of the architecture.
- Thin Client: SOVoIP align with the notion "Network is the Computer". Thus it provides a thin client solution and takes the workload in the network.
- Semantic Web: SOVoIP is ready to embrace semantic web because of its simple underlying technologies such as SOAP, HTTP etc.
- Agent View: SOVoIP's ability to learn from the environment opens up the gate for agent technologies to integrate their knowledge with SOVoIP and transfer it to the people in need.
- Cloud Computing: SOVoIP's design is ready to embraces this new paradigm of cloud computing. It is because, like cloud computing, SOVoIP looks at infrastructure, platform and software as services.

IV. Screen Shot

Figure 3. Screen-Shots

Acknowledgment

This project is supported by SUN Microsystems. We would also like to thank M.J.Arif, author of [1] [2] for his guidance.

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Establishment of a Collaborative Virtual Environment for Knowledge Transfer Between Farmers and Scientists:

Using Mobile as The Extension of The CVE

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***Abstract*—the research has developed a Collaborative Virtual Environment (CVE) to facilitate the knowledge transfer between local farmers and scientists. The CVE provides a three dimensional computer interface, where scientists and local famers are able to access the same scenario, and transfer knowledge, no matter how far away they are. Moreover, a mobile application used to capture on-site image has also been developed to assist local farmers to transfer knowledge with scientists. Through this application, scientists can receive the first-hand information of the farmlands, meanwhile local farmers can obtain on-site support from distant scientists.**

Keywords-Collaborative Virtual Environment; agriculture; mobile application; knowledge transfer;

I. INTRODUCTION

CVEs have been proved to be useful in different kinds of field, such as online gaming, surgery and education [1][2]. But its usage in the field of knowledge transfer seldom has been explored, especially for agricultural sciences. The advantages of CVE, such as being capable of providing a collaborative working platform for users and simulating different kinds of scenarios, might be able to benefit the knowledge transfer for agricultural sciences.

Scientists and local farmers play the major roles in the knowledge transfer of agricultural sciences. With the development of information technologies, local farmers are much easier to access to scientific knowledge than before [3], meanwhile scientists are distributing their knowledge much faster through internet, instead of organizing courses and teaching on the site. However, the local farmers obtaining knowledge does not mean they fully understand and are able to take appropriate action. Therefore, face-to-face meeting on the site with the knowledge owner would possibly solve the issues. But it would cost too much and the knowledge could not distribute speedily. And even though the knowledge owner can teach local farmers and strategy planners on the site, the different education backgrounds of users would cause varying degrees of understands. To solve this issue, simulations of future scenarios have been employed by other scholars to facilitate users' better understanding. In this regard, this research has developed a CVE, where scientists and farmers can transfer the knowledge, despite the barriers of distance and different education backgrounds of users.

After demonstrating the knowledge transfer features of the CVE to some scientists and local farmers, the researcher found that using the computer interface at home can not satisfy farmer's requirements on being provided a virtually on-site support from scientists. In this regard, the research has developed a mobile application, through which farmers are able to collect first-hand data on the site and send them to the server, meanwhile scientists are able to track the location of the on-site data in a virtual environment, and transfer knowledge to the farmers based on a geo-referenced knowledge database.

II. THE BASIS OF THE CVE

In order to develop a user-friendly and sustainable knowledge transfer platform, researcher has interviewed some scientists and local farmers to conclude the requirements of the users. According to the requirements, a series of features have been developed based on a mature CVE called SIEVE(Spatial Information Exploration and Visualization Environment), which is produced by CRCSI, and has been proved to be a useful decision-making CVE and simulation platform through some tests in Victoria, Australia, cooperated with Department of Primary Industries [4].

A. Introduction of SIEVE

SIEVE is made up of SIEVE builder and SIEVE Viewer. SIEVE builder is used to create 3D visualization scenarios based on certain GIS data, such as DEM and Vector data (land use polygon file in shapefile format) [5]. SIEVE Viewer is used to view the 3D scenarios, and also can be set up as a scenario server, through which other SIEVE viewers are able to login, and look over the same scenarios.

B. Knowledge to be transferred

The knowledge to be transferred comprises two parts:

From scientists to local farmers: the knowledge is concluded as a series of dataset, which are based on the research of scientists. Relying on the comprehensive spatial databases and related agricultural models, scientists analyse the current condition of the farmlands, and predict the future of

them. Afterward, they used SIEVE Builder to produce the current scenario and prediction scenario, and distribute to the farmers.

From local farmers to scientists: the experienced knowledge of local farmers is not ignored in this case. Local farmers are able to provide on site information or data including photos, soil condition (humidity, pH, and fertilizer type), to scientists to assist scientists to analyse the problems of certain areas and complement the knowledge database they master.

III. DESIGN OF THE CVE

The figure 1 shows the layout of the proposed fully functional CVE.

In Melbourne:

In order to transfer some knowledge with the form of large files, such as photos, researcher set up a FTP Server in Melbourne to manage the upload and download of them. For storing other knowledge, such as vector data of land use, species condition and soil condition, a spatial database is hosted in Melbourne as well. Object database is used to store the 3D objects, such as trees, animals, and infrastructures. And researcher can build up different scenarios according to the users' requirements (the SIEVE builder can also be used by trained scientists).

In farmlands:

Besides viewing the virtual scenarios of there farmlands through the SIEVE Viewer, local farmers are also able to provide knowledge on the site using SIEVE Viewer, even a mobile.

At this stage, researcher has developed an interface within SIEVE Viewer to upload and download photos, which are marked with upload date, location, and description. Additionally, a mobile application used to take a photograph on the site, then complement it with photo description, and send to the FTP Server, subsequently update the spatial database with a new record of on site photo with information of owner, date, location and orientation. The application of the mobile is developed on iPhone.

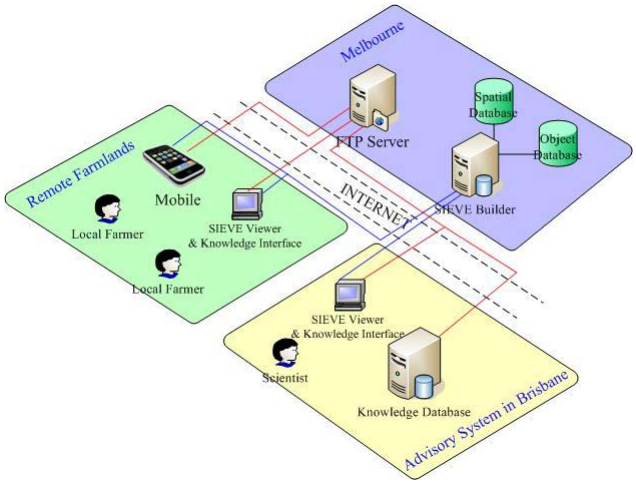

Figure 2. *layout of the fully functional CVE*

In Brisbane:

Either local farmers or the scientists are able to launch a collaborative virtual on-site meeting distantly. They will log in the same scenario through SIEVE Viewer (if local farmers launch the meeting on the site, and without laptop supported, they can use the iPhone as a communication tool). Then local farmers either upload the photos through the SIEVE Viewer or take a photo on the site using iPhone, at the same time, scientists are able to view the photos of the specific location within SIEVE Viewer, and analyse the conditions of the specific points of the farmland, under the support of the knowledge database.

The interfaces of the iPhone application and the SIEVE Viewer are showed in figure 2.

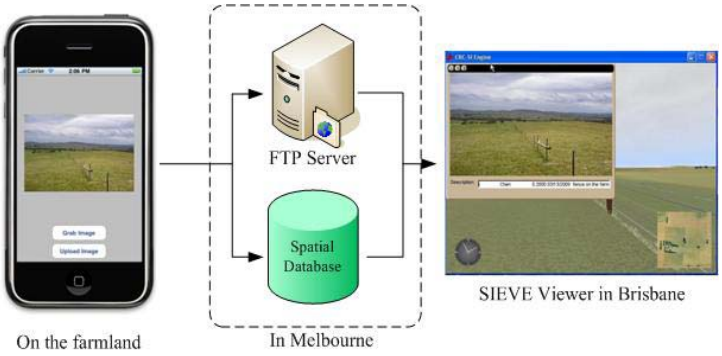

Figure 1. *Interaction between iPhone and SIEVE Viewer*

IV. CONCLUSION AND PROSPECT

Through this CVE knowledge transfer platform, scientists and local farmers are able to virtually work together, which saves both of them large quantity of time and money. Additionally, the scientists can complement their knowledge with the first-hand data, meanwhile local farmers can master the knowledge in a easier understandable form (3D visualization). This synergistic virtual working environment can improve the distribution of the latest knowledge, and better assist farmers to receive the help from scientists and manage their farmlands, which are more and more facing the threads of climate change and different diseases.

Besides exchanging photographs using iPhone, there are more potential of the mobile platform can be explored in the future, such as obtain data from spatial database on the site. Moreover, a more sophisticated and flexible database structure is the other attempt for the future, based on which scientists are able to update their data to the spatial database and knowledge database hosted in the server side., in order to enable the farmers and other scientists to access and share the up-to-date knowledge database.

ACKNOWLEDGMENT

The Cooperative Research Centre for Spatial Information (CRCSI) is funding the research. SIEVE mentioned in the paper is owned by CRCSI.

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Protein Structure Prediction:

Clustering of Memetic Algorithm in Protein Structure Prediction

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***Abstract*—This project proposal introduces clustering as a tool to improve the effect of recombination and incorporate niching in memetic algorithm to find protein structure prediction. Our novel memetic algorithm [1] deals with modified fitness function and schema preservation technique to find optimum protein structure. Still due to the effect of genetic drift it sometimes seems to be stuck in local minima. Efficient clustering of the population can overcome this drawback.**

Keywords-memetic algorithm; clustering; Protein structure prediction

I. BACKGROUND

Next to water, protein is the most plentiful substance in your body. Proteins are composed of small units. These units are the amino acids. There are about 20 different amino acids which are commonly known. Each different protein is composed of various amino acids put together in varying order with almost limitless combinations. Most proteins are large molecules that may contain several hundred amino acids arranged in branches and chains. Proteins have many different functions in our bodies. By studying the structures of proteins, we are better able to understand how they function normally and how some proteins with abnormal shapes can cause disease.

But a protein can have an astronomical number of folds. Even a small protein of 50 amino acids long could have so many folds in fairly simplified model that, if a powerful computer can find out 200 folds in one second then it would take more than 6 years to find all the folds. Among all the folds only the lowest energy fold is the native structure of the protein and protein needs to fold its native structure to perform its function in living beings. In nature, protein is folding to its native structure everyday within seconds. So our challenge is "*Nature does it everyday, can we?*"

II. AIM AND SIGNIFICANCE

The *aim* of this project is to develop an effective and efficient process to find protein structure from a given sequence of amino acid. We will be having amino acid sequence from *Protein Data Bank* (PDB) then our project will show the native structure for the given sequence in an efficient way which will not take so long.

There have been researches going all over the world using computation approaches. Two of the main streams are worth mentioning here. One is IBM has made world's fastest parallel computer, *Blue Gene*, which is being used to study protein folding. Other is the world's most powerful distributed computer is being used by Pande Group at Stamford University called *Folding@home*.

After these much effort from all over the world the total number of protein structure known from the available PDB sequences is sightly more than 2% (according to 2008's statistic). So, any contribution to the main stream of research, would be the goal of this project and it is worthy of research. As we have time constraint, so we have set some project goals –

- Develop an efficient fitness function incorporating domain knowledge
- Develop an efficient local search for memetic algorithm that identifies meme correctly
- Extend memetic algorithm to distribute in subsections to multiple grid and combined their output in main grid
- Extend this project to higher resolution model

III. METHODOLOGY AND SCREEN-SHOT

This project first tests its efficiency on the basis of benchmark protein sequences. Then it will determine the structure of unknown protein sequences from Protein Data Bank (PDB). Our Sequence Conversion Toolkit (SCTK), Figure 3, will convert PDB sequences to your program required formate and pass it to the Core program. The result generated by the Core program will be shown graphically by our Protein Drawing Toolkit (PDTK), Figure 4, and comparison analysis is made afterwards. This high level overview is shown in Figure 1. Detail segmentation of research problem with implementation perspective is shown in Figure 2.

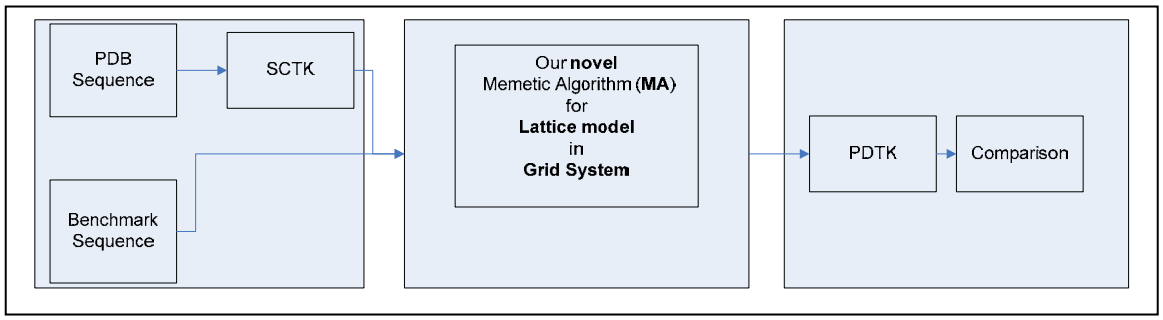

Figure 1 High level conceptual diagram of the project

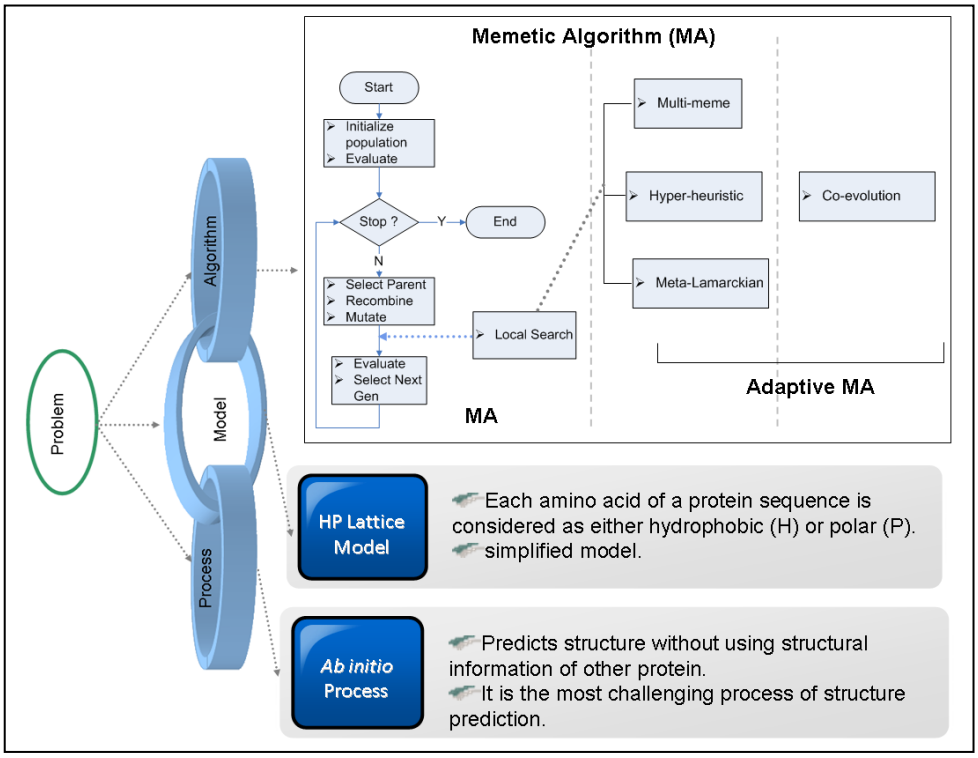

Figure 2 Architecture of the Core part of the project

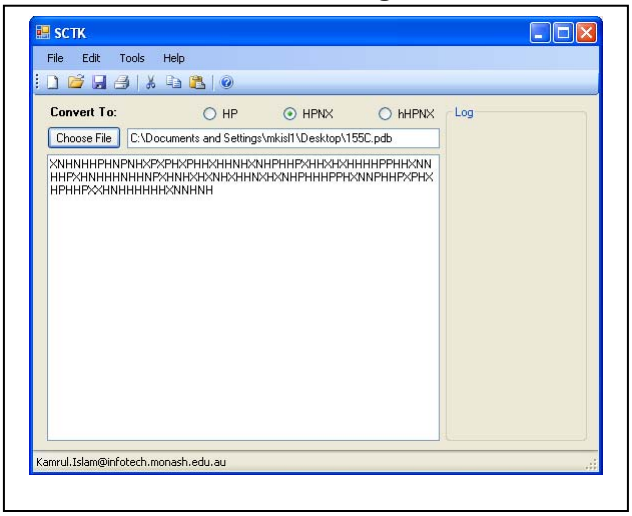

Figure 3 SCTK

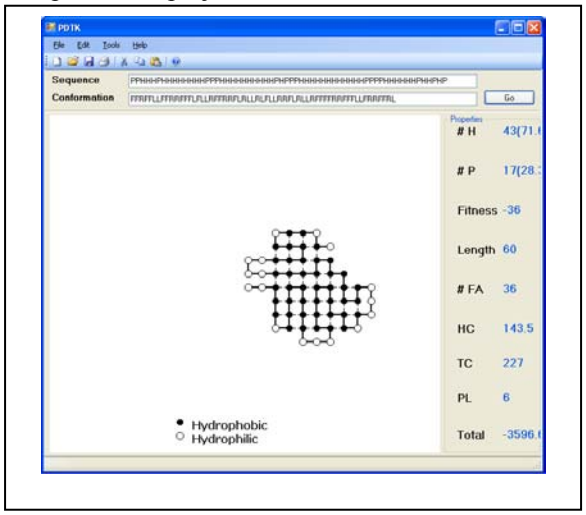

Figure 4 PDTK

Memetic algorithm which is a powerful combination of genetic algorithm and local search is the key technique that has been used for the project. Our modified fitness function characterizes the domain knowledge perfectly for protein structure problem in lattice model [1]. Our novel technique for finding schema (meme) has shown significant success in the area of combinatorial problems [1]. Monash Computer Grid and VPAC Grid are being used for this project so far.

Clustering will be applied in each generation and memetic algorithm will be applied on each of the clusters so that they evolve separately. This will eliminate the problem of symmetry. This method will ensure the algorithm to search different stable subpopulation as well as faster convergence.

IV. Project Outcome

Following benefits and outcome are expected.

- Novel memetic algorithm for PSP including novel fitness function and meme generation technique.
- Memetic algorithm for gird and parallel computing.
- Success of this project will lead to tremendous expansion in drug discovery.
- This project may lead to multi disciplinary collaboration and application for large grant.

V. Conclusion

Clustering in memetic algorithm for protein structure prediction is first attempt to be used in this area of research.

Acknowledgment

Associate Professor Manzur Murshed, Head of Gippsland School of Information Technology, has helped this project with necessary guidance and equipments. This project has won "Award for outstanding contribution" in 2009 Higher Degree by Research both from Gippsland Poster Exhibition and Monash Poster Exhibition.

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Meeting Application Constraints Efficiently by Deploying Cloud Resources On-demand

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Abstract—**Cloud computing and Infrastructure-as-a-Service providers, such as Amazon Elastic Computing Cloud (EC2), have paved the way towards computing as a utility. The integration of the cloud providers with in-house infrastructure can be used to support on-demand resource provisioning, providing elasticity in modern applications, and making dynamic adaptation of the service capacity to variable user demands. Cluster and grid computing environments are two examples of services which can obtain a great benefit from these technologies. In this work we aim to propose resource provisioning policies for applications which cannot finish within their deadline using current resources.**

Keywords-Cloud Computing; Market-oriented Scheduling;QoS Constrains.

I. INTRODUCTION

As more complicated and resource consuming applications are emerging, the need for deploying more resources is rising. Technologies that can provide and manage resources for such applications are becoming more essential. Although recently Cloud computing [1] sounds promising in providing illusion of "infinite resource" for user applications, the challenge ahead will be making efficient provisioning policies for such applications to take the advantage of public Cloud providers, organizational resources, along with resources from other organizations. Intelligent decisions made by these policies can result in large benefits in overall throughput.

The advances in virtual machine and network technologies has resulted in appearing commercial providers, which offer numbers of resources to users, charging in a "pay-as-you-go" fashion. As the provided resources are on a "Cloud" whose physical infrastructure is unknown to the users; it is called "Cloud Computing". This new paradigm for the provision of computing infrastructure on the network (IaaS) has reduced the capital expenditure for infrastructure and management. Amazon Elastic Compute Cloud, or as it is known "Amazon EC2", is the most famous IaaS provider which is considered the pioneer in the Cloud computing era.

Resource provisioning policies for applications in an environment which has the potential of leasing from Cloud while it has access to local resources brings significant challenges for resource managers. One challenge is how to take the advantage of public Clouds to reinforce organizational computational power on-demand. In one hand, there are applications that usually have some QoS constraints in terms of deadline, cost, or specific number of resources which local infrastructure alone cannot satisfy them. On the other hand, public Clouds are not costless and charge users based on the amount of their usage (usually in an hourly basis) from different resources such as CPU power, storage, bandwidth, etc. Therefore, in these circumstances the challenges are:

a) When is it necessary to ask public Clouds to aid local resources?

b) What is the optimal number of virtual machines should be created on a public Cloud to be able to satisfy the user QoS constrains?

Market-oriented computing [2] considers computing resources in economic terms in a way that deploying resources implies paying to resource providers for utilizing the computing resources. Market-oriented scheduling policies enable both resource consumers and suppliers to maximize their utility and profit.

Gridbus Broker [3] is a system that mediates access to distributed resources running diverse middleware. It is able to interface with various middleware services, such as PBS, Condor, and SGE. The Broker has equipped by market-oriented scheduling strategies which consider differing objectives namely, time and cost optimization. It maps jobs to the appropriate resources to meet these objectives.

In this contribution we try to propose policies for the aforementioned challenges. More specifically, the policies lease virtual machines from cloud provider when it predicts that it cannot meet the deadline. The number of leased virtual machines depends on the budget provided by the user. These policies have been implemented in the Gridbus Broker.

II. PROPOSED SOLUTION

In this section we propose our solution for satisfying user deadline when the deadline could not be met by relying just on local resources. As mentioned before, our solution tries to reinforcing local infrastructure processing power by deploying resources from commercial cloud providers in exchange of a fee. Fig. 1 depicts a brief and high level view of the proposed policy.

The proposed solution has been implemented in Gridbus Broker. There are several reasons that motivated us to use Gridbus broker for the integration of Cloud resources with other grid, cluster, or even personal computers resources.

First of all, Gridbus broker has proved performance for running different types of applications such as Bag-of-Tasks (BOT) and Parameter Sweep Application (PSA), Workflows, and data-intensive applications in real environments [3]. Secondly, Gridbus broker is highly extensible for supporting any kind of middleware. Third feature of Gridbus broker is being able to schedule tasks based on user QoS needs, such as deadline, cost or both. The last but not the least, is that Gridbus broker has implemented based on Market-oriented resource management idea, which its time has finally come with the emergence of commercial Cloud providers. More specifically, Cloud providers, such as Amazon, charges user for computational power as well as storage and bandwidth. Gridbus broker, however, consider costs of all of these items.

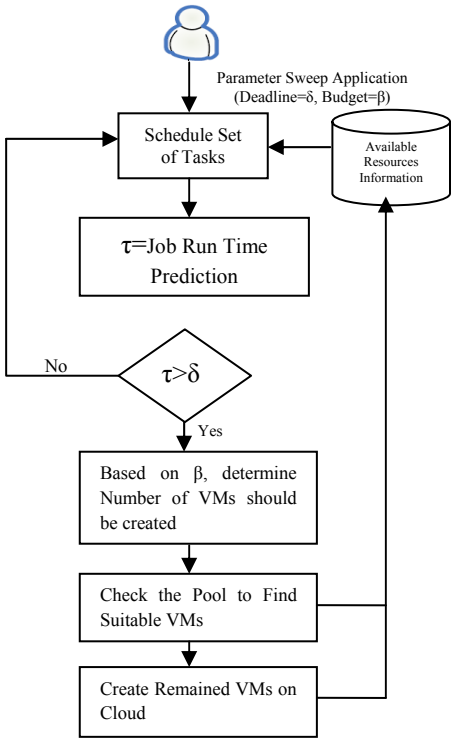

Figure 1. Flowchart of the proposed policy.

Changes were required to allow the broker to create virtual machines on Amazon EC2 on demand. This has been done by developing a new actuator for Gridbus broker and changing the way users are charged in Gridbus broker. Connecting to Amazon EC2 has been using Amazon Web Services (AWS). Moreover, implementing the above policy would need changes in the scheduler part of the broker as well as making another part for managing pool of hired virtual machines.

III. EXPECTED OUTCOME

The expected outcome of the proposed system is showing how using public Clouds computational capabilities helps to meet QoS constrains needed by a high performance application. Reinforcing local resources power is done through hiring optimal number of virtual machines from the Cloud provider and considers the budget available for the user.

In my demonstration I will use real parameter sweep application (such as PovRay [4] which is an image rendering application). The demonstration would be in two different scenarios. In the first scenario, I will show that if the application could be finished without extra resources in its deadline, the broker would not hire any virtual machine from Cloud providers.

In the second scenario, I will show how PovRay can be finished in its deadline by hiring proper amount of resources from Amazon, while the same application could not be finished in the deadline without cloud resources.

Fig. 2 and Fig. 3, show the way cloud resources are declared in the context of Gridbus Broker; and a PovRay application running on both local and Cloud resources respectively.

```
<service type="compute" cost="5.0 " mappingID="remote">
    <compute firewall="false" middleware="fork" >
    <fork hostname="snowball.cs.gsu.edu" />
    </compute>
    </service>
<service type="compute" cost="10.0" mappingID="amazon">
    <compute middleware="EC2" >
    <EC2>
    <hostname>ami-dfbb5ab6</hostname>
    <minInstance>1</minInstance>
    <maxInstance>2</maxInstance>
    <instanceType>m1.small</instanceType>
    <availabilityZone>us-east-1a</availabilityZone>
    </EC2>
    </compute>
    </service>
```

Figure 2. Sample Service Description File provided by the user to Request Cloud Resources.

Figure 3. A screenshot of the Gridbus broker running parameter sweep application on Cloud resources along with the usual resources from other providers.

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Drought Forecasting: A Case Study within the Yarra River Catchment in Victoria, Australia

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Abstract — **Early forecasting of future drought conditions during continuing dry periods can improve the water resources management strategies to combat against draught related issues. In this study, a draught forecasting tool is developed and presented that comprises of two main components namely: Aggregated Drought Index (ADI) and Drought Forecasting Model (DFM). The ADI has been developed by applying Non-linear Principal Component Analysis (NLPCA) on several draught related hydro-meteorological variables whereas DFM is developed by using Artificial Neural Network (ANN). The ADI has been compared with and found to be better than two widely used indices namely Deciles (used in Australia) and SPI (used in most parts in the world). The DFM shows that it is capable to provide an early indication of drought conditions which will certainly improve the water resources management strategies during the drought periods.**

Keywords - drought; drought forecasting; water resources management; Yarra River Catchment.

I. INTRODUCTION

Drought is a complex natural phenomenon and it has significant impacts on several water resources management systems including river systems. Early indication of future drought conditions has great importance for water resources managers to assist in identifying strategies for preventing river level dropping to an unsafe level. Therefore, the aim of this study was to develop a drought forecasting tool which will help to the water resources manager for better management of water resources. In this study, a drought forecasting tool has been developed and presented. It consists of two components, one is Drought Index (DI) development and other is development of a Drought Forecasting Model (DFM).

Development of an appropriate DI is the first component of a drought forecasting tool in this research project. Typically, a DI is expressed by a numeric number and it is a function of a number of hydro-meteorological variables such as rainfall, temperature, streamflow, storage reservoir and amongst others. A number of DIs have been developed around the world including widely used Deciles [1] and Standardized Precipitation Index (SPI) [2] based on rainfall variable. Some of the researchers well justified that the reliance on rainfall as the single variable in the DI formulation does not reflect the wide spectrum of drought related conditions. This is because drought depends on numerous factors, such as water supplies and demands, hydrological and political boundaries and antecedent conditions. Therefore, Non-linear Principal Component Analysis (NLPCA) [3] was used is this study to develop an Aggregated Drought Index (ADI) by considering all significant hydro-meteorological variables which effects on drought. The application of NLPCA in ADI development captured the combined effect of the nonlinear hydro-meteorological variables. The ADI results were compared with Deciles and SPI to justify the ADI technique.

The second component of the drought forecasting tool in this study is the development of a DFM. A number of existing statistical time series models have been examined in finding out the possibility of their adaptations in this study. In recent decades, Artificial Neural Network (ANN) has shown great ability in modeling and forecasting nonlinear and non-stationary time series in hydrology and water resources engineering due to their innate nonlinear property and flexibility for modeling. Therefore, this numerical approach was used in this study for the development of a DFM.

II. STUDY AREA AND RESEARCH APPLICATION

During the period of drought, the pressure upon supply of water resources to licensed users and to maintain adequate flow in the existing river system become more intense within the Yarra River catchment in Victoria, Australia. Therefore, the Yarra River catchment is considered as the case study for this research project.

III. DATA SOURCES AND PROCESSING

Data for this study were collected from Melbourne Water Corporation (i.e., streamflow and storage volume data), Bureau of Meteorology (i.e., rainfall data), and SILO database (www.bom.gov.au/silo) (i.e., evapotranspiration data). Soil moisture measurement data were not available, and therefore a two-layer water budget model of Palmer [4] was adopted in this study to determine the soil moisture content in the catchment. The data ranged from 1960 to 2008 (49 years) were used in this study which were available for all variables used in the ADI development.

IV. METHODOLOGY

A. Drought Indices

As mentioned earlier, the ADI was developed by using NLPCA. The NLPCA method is similar to linear PCA method where linear PCA was performed on the transformed variables instead of the original variables. For further computational details of NLPCA, the reader is referred to [3]. Principal Components (PCs) and Eigenvectors were generated through NLPCA. Eigenvectors derived through NLPCA are unit vectors (i.e., magnitude of 1) that establish the relationship between the PCs and the transformed data:

$$Z = QE \tag{1}$$

where, Z is the n x p matrix of PCs (i.e. uncorrelated components), Q is the n x p matrix of transformed variables, E is the p x p matrix of eigenvectors, p is the transformed variables, and n is the number of observations.

The ADI was considered as the first PC (PC1), normalized by its standard deviation:

$$ADI_{i,k} = \frac{Z_{i,1,k}}{\sigma_k} \tag{2}$$

where, $ADI_{i,k}$ is the ADI value for month k in year i, $Z_{i,1,k}$ is the PC1 during year i for month k, and σ_k is the standard deviation of $Z_{i,1,k}$ over all years for month k.

The ADI utilizes only the PC1 because it explains the largest fraction of the variance described by the full p-member, standardized data set. Since PCs are orthogonal vectors, it is not mathematically proper to combine them into a single expression [5]. Considering all 12 months, PC1 which is generated through NLPCA, described an average of 60% of the data set variance in this study. Once the computations of ADI values were completed for each year and each month, they were combined and reordered into a single time series in chronological order. The ADI thresholds values were calculated using the empirical cumulative distribution function of non-seasonal ADI for the catchment. Low thresholds values were used to classify the drought conditions.

The Deciles and SPI computations was relatively simple. In Deciles, long-term monthly rainfall records on a non-seasonal basis were first ranked from highest to lowest to construct a cumulative frequency distribution. The distribution was then split into ten parts (tenths of distribution or deciles) based on equal probabilities. Lower Deciles values used as the thresholds for defining drought conditions. In SPI, first the long-term monthly rainfall record on a non-seasonal basis was fitted to a probability distribution. The cumulative probability is then transformed into a normal distribution so that the SPI mean and variance for the location and long-term record is zero and one respectively. Similar to the ADI and Deciles, low SPI values used as the thresholds values for defining drought conditions.

B. Drought Forecasting Model (DFM)

The ANN is an information processing approach that resembles the structure and operation of the brain. This approach was used in developing a DFM in this study. An overall architecture of the DFM is shown Fig. 1.

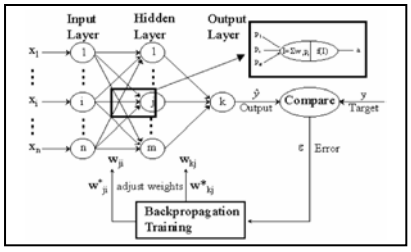

Figure 1. Architecture of a feedforward three-layer ANN

To forecast the future values of the ADI, the inputs to the networks are represented by various combinations of their present and past values with different time lags. The full time series of developed ADI (1960-2008) was divided into three parts; training (1970-2000), validation (1960-1969) and testing (2001-2008, most critical part of the time series data). All input values were standardized to range between 0.1 and 0.9 to avoid the flatspots during the training process. The selection of the number of neurons in the hidden layer was done by trial and error process. In the output layer, a range of forecasting lead times from 1 to 12 months were tested. Because it is the short to medium-range forecast that are critical for drought preparedness. Finally, to optimize the network, widely used feed forward back propagation algorithm was used in this study. The performance of the networks was evaluated using RMSE and MAE.

V. RESULTS AND DISCUSSIONS

A. Aggregated Drought Index (ADI)

The ADI time series was constructed for the period from 1960–2008 to characterize the magnitudes of various droughts is shown in Fig. 2. Different levels of drought severity are presented with the horizontal dotted lines, while the vertical windows represent various historical droughts. It shows that the historical droughts occurred in Victoria, Australia in 1967-1968, 1972-1973, 1982-1983, and 1997-1998, 2002-2003, and 2006-onward were well detected by the ADI.

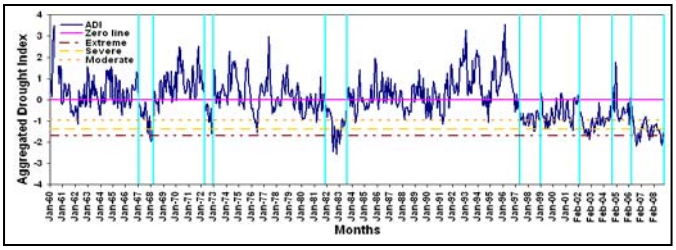

Figure 2. ADI time series

A comparative study was carried out on ADI with Deciles and SPI to justify the appropriateness of the ADI application for classifying droughts conditions. The chronological comparisons of ADI with Deciles and SPI are shown in Fig. 3 and 4 respectively. It can be seen from Fig. 3 and 4 that the historical droughts were detected more clearly with ADI, followed by SPI and Deciles. ADI has smooth transitional

characteristics during droughts, and in and out of droughts. Therefore, the ADI is more robust than the Deciles and SPI.

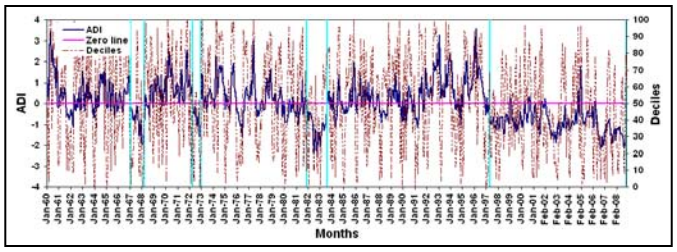

Figure 3. ADI and Deciles time series

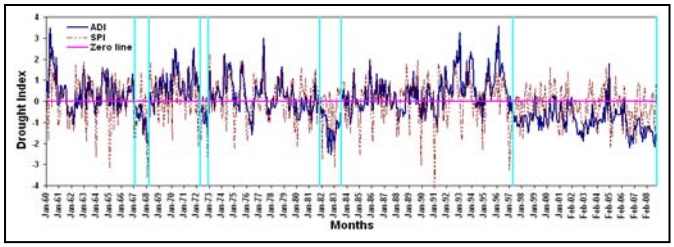

Figure 4. ADI and Deciles time series

B. *Drought Forecasting Model*

In the development of DFM, the best model was found in this study consists of five neurons in the input layer, two neurons in the hidden layer, and six neurons in the output layer. The model was tested for the time lag of up to 12 months. However, the best model showed that it can forecast the ADI values up to six months ahead. The time series of the observed and forecasted ADI values obtained from the best model is shown in Fig. 5.

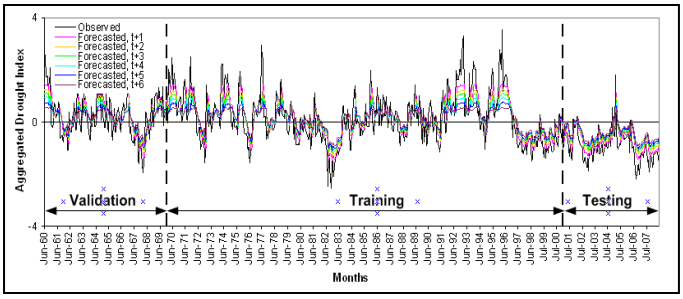

Figure 5. Comparison of observed and forecasted ADI time series

The best model performance with *RMSE* and *MAE* values for up to six months ahead drought forecasting are presented in Table 1 and 2 respectively. Both tables show that the *RMSE* and *MAE* are increases when time lag is increases. The better forecasting capability shows when the time lag is smaller.

TABLE I. ROOT MEAN SQUARE ERROR (RMSE) VALUES

	t+1	*t+2*	*t+3*	*t+4*	*t+5*	*t+6*
Training	0.66	0.75	0.79	0.82	0.84	0.87
Validation	0.64	0.68	0.67	0.70	0.75	0.80
Testing	0.55	0.63	0.69	0.79	0.82	0.87

TABLE II. MEAN ABSOLUATE ERROR (MAE) VALUES

	t+1	*t+2*	*t+3*	*t+4*	*t+5*	*t+6*
Training	0.52	0.59	0.63	0.64	0.66	0.68
Validation	0.54	0.56	0.57	0.58	0.63	0.64
Testing	0.42	0.51	0.56	0.64	0.67	0.72

VI. CONCLUSIONS

Drought forecasting is an important issue to the water authorities to plan ahead for the management of water resources in the river systems during continuing dry climatic situations. In the context of drought forecasting issue, defining drought conditions have been also a challenging task among the drought researchers and managers as it depends on many hydro-meteorological variables. Many argue that drought is just deficiency in rainfall and could be defined with the rainfall as the single variable. Others believe that rainfall based drought indices are not strong enough to define the wider drought conditions and have proposed that the drought should be defined with a number of hydro-meteorological variables which play significant roles in drought incidence. In this study, an Aggregate Drought Index (ADI) was developed by using Non-linear Principal Component Analysis (NLPCA) to investigate its appropriateness in describing historical droughts conditions based on water deficiencies within the hydrologic cycle. The Yarra River catchment in Victoria, Australia used as the case study in this study. Based on the developed ADI, a Drought Forecasting Model (DFM) was developed by using Artificial Neural Networks (ANN) technique. The DFM shows good agreement in forecasting ADI values up to six months ahead. The outcome of this study can be useful to the water resources managers for better management of water resources within the Yarra River catchment in Victoria, Australia. Similar approach can be adapted in the other catchments which will provide significant environmental benefit to riverine ecosystems.

ACKNOWLEDGMENT

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Harvesting Bandwidth for Real-Time Traffics in Cognitive Radio Networks

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Abstract— **Multimedia traffic demands high bit rate with minimal delay. However, the uncertainty in channel availability and hostile environment in CRN may limit the throughput of real time applications. In CRN, it is true that channel availability is time varying and by continuous switching among different channel may gives us the continuity of communication. At the same time CRN is not interference free network. Delay is induced due to interference, channel unavailability when moving to another channel and channel switching time. On the other hand, high bit rate is susceptible to channel fading. When there is an opportunity to send data due to absence of primary user, we need to maximize the opportunity by exploiting fading dynamics. Along with that, to maintain QoS requirements like delay and throughput, admission control and priority scheme need to be applied. The proposed research will address these issues to support the real time traffics.**

Keywords-Cognitive Radio, spectrum mobility, orthogonality, Markov Decision Process.

I. INTRODUCTION

Cognitive Radio Network (CRN) will dictate the wireless network for the next decade since it radically changes the communication concept. CRN is already being considered as the candidate for the 5th Generation of Wireless Communications. Cognitive radio arrives with its intrinsic challenges to get rid of spectrum scarcity and underutilization [1]. The concept of CR is to use the left over space (called 'white space' or 'spectrum hole') of primary user (PU) by secondary user (SU). Three core issues that strengthening the footprint of CRN concept and they are: 1) current fixed spectrum allocation policy 2) spectrum utilization inefficiency and 3) new wireless application soaring against finite radio spectrum. In [2, 3], Markov decision based approach are studied but they did not investigate how to find out optimum time slot duration, how to deal with network heterogeneity and channel fading. [4] developed a queuing model but lacking suitable prediction scheme to achieving orthogonality among PUs and SUs..

II. NETWORK MODEL

The components of CR networks are depicted in Fig 1 where CRN and legacy networks are co-exists. Here, PU has priority to use the channels at any given time. SUs are co-operatively sensing the operating frequency spectrum of legacy systems and decision is taken by CRN base station for suitable channels which will lead to minimum collision among PUs and SUs.

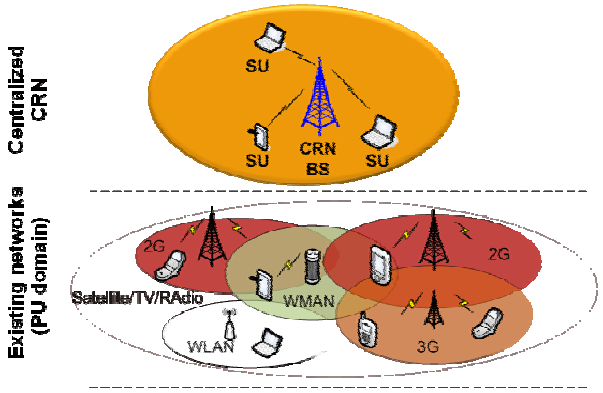

Fig.1. CRN network model

We are considering operating channels which are a collection from heterogeneous networks like 2G, 3G WLAN, WMAN, TV networks.

III. PROBLEM STATEMENT

In CRN both PU and SU coexist where PU has priority over SU in accessing the wireless medium. SU will opportunistically use the spectrum hole which is left by the PUs as shown in Fig 2. So, interference is the obvious phenomenon in this overlay architecture.

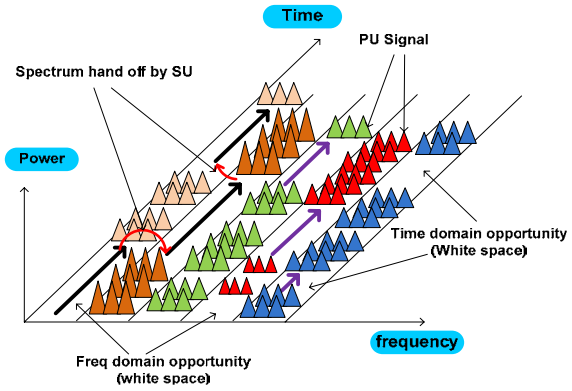

Fig.2. Opportunistic use of spectrum

Orthogonality in time domain among PUs and SUs can be achieved by modeling PU activity so that interference level is within sustainable limit. In case of multiple users, it is the responsibility of the CRN base station to allocate suitable spectrums through spectrum mobility scheme in a dynamic manner to maintain seamless communication. When there is some opportunity to utilize the unutilized space, the fading behavior of the wireless channel may reduce the bit rates. So, How to support real-time transmission in presence of continuous switching, interference and fading in CRN are the investigation areas.

IV. METHODOLOGY

Two things that can help to achieve better spectrum utilization and orthogonality between PU and SU are: 1) Sensing and 2) behavior prediction of PU. Till date, most of the researchers' interests were in physical layer for how to sense the spectrum efficiently. Now, researchers' attention shifts from purely detecting the presence of a PU by sensing to its behavior prediction. Solution decomposition for the mentioned problem is as below:

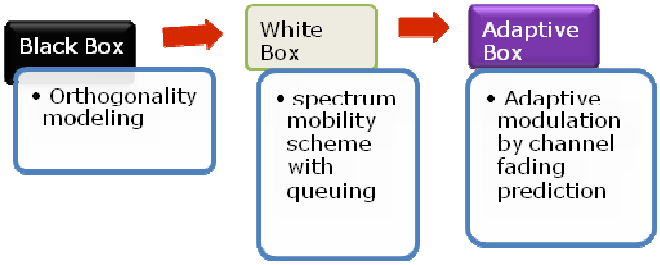

Fig.3. Solution decomposition

In principle, black box will model the white space or primary user traffic where we do not have any control or information over primary network. White box will model the secondary user traffic by queuing, accepting or rejecting a new request and by guiding secondary terminals to use the best available frequency. Adaptive box will exploit the fading dynamics so that system and user throughput maximized.

A. Black Box

How to achieve orthogonality between PU and SU and better transmission throughput – is the objective of this section. To achieve this, prediction of suitable and better channel is inevitable before transmission and following are the components for modeling the PU activity with Markov Decision Process (MDP):

1) PU ON-OFF model

In this model, PU traffic can be modeled as two state ON-OFF processes where ON (busy/'1') state represents the period used by PUs and OFF (idle/'0') state represents the unused periods as shown in the below figures:

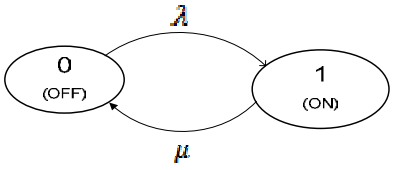

Fig.4a. Transition rate diagram

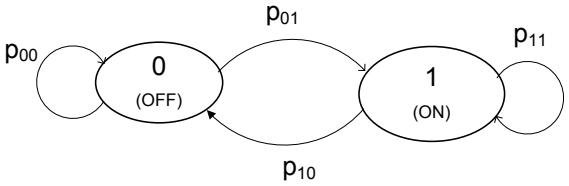

Fig.4b. Transition probability for PU users

Holding time in each state is exponentially distributed with mean $1/\lambda_i$ and $1/\mu_i$ for channel *i*. We have proposed observation history based transition probability which is substantially different from standard MDP, is coined as Modulated MDP (MDP).

2) Reward/Regret history of channel

A successful transmission is ended with rewards and unsuccessful transmission is ended as regrets. Reward/Regret unit track all the decisions taken by the MDP unit and provides feedback to optimize channel parameters.

B. White Box

Spectrum mobility procedure helps the SU to release the current channel and find suitable channel to resume its transmission. A suitable resource allocation is required to achieve fairness among the SUs. Since PU has the pre-emptive priority, a pre-emptive resume priority (PRP) M/G/1 queuing network is suitable for queue management with admission controller.

C. Adaptive Box

Channel state/quality is time varying due to multipath fading, Doppler and time dispersive effects introduced by wireless propagation. We are considering a Rayleigh fading channel, as an example is provided in Fig 4.

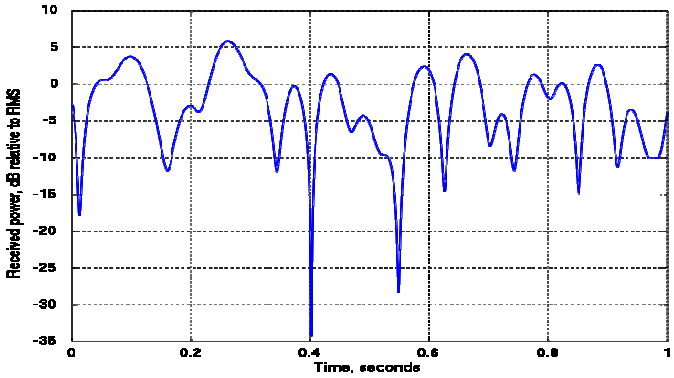

Fig.5. An example of Rayleigh fading channel

In this channel model, SNR is partitioned into finite number of intervals and Finite State Markov Channel can be exploited to achieve adaptive modulation and coding.

D. Overall Solution Architecture

Considering the cross layer approach, an overall architecture is proposed to support the video traffic like H.264.

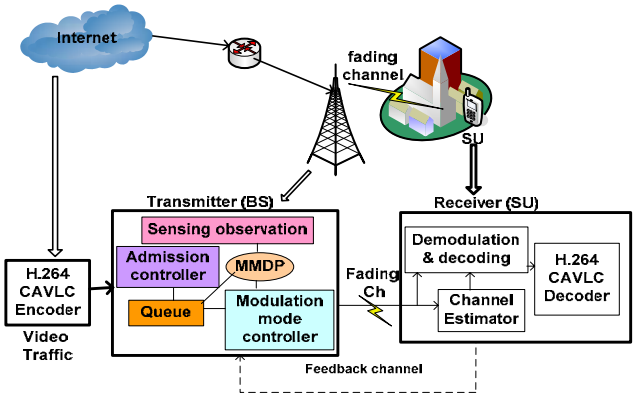

Fig.6. wireless communication combined with queuing, fading and Adaptive Modulation & Coding

V. OUTCOME

The performance of prediction accuracy of channel selection due to PU behavior considering wireless link is perfect is carried out in MATLAB.

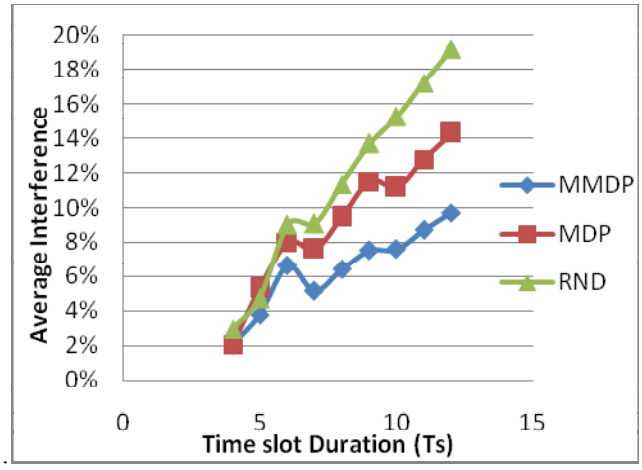

Fig.7. Interference vs Time slot duration

Fig.7 gives a comparative result in particular PU traffic condition where T_s varies gradually and interference recorded. A preliminary study reveals that our MMDP approach perform better than other standard MDP and random (RND) selection scheme. For further analysis, our next effort is to implement our solution architecture in widely use ns-2 network simulator.

VI. SIGNIFICANCE

A. Research Perspective:

Our research will deal with the following areas which are crucial to assess the wide applicability of CRN:

- ✓ harvesting bandwidth by primary user activity modeling
- ✓ Maximizing system and user throughput by exploiting fading dynamics
- ✓ Achieving constrained solution that will tolerate by primary networks

B. Application Perspective:

- ✓ Emerging Applications : Sensor Network, Multimedia surveillance, Personal tele-health care, Jam proof military application, Emergency communication in disastrous environment
- ✓ Existing Applications: Extra bandwidth for crowded PDAs, Laptops etc.

VII. CONCLUSIONS

CRN arrives with its intrinsic challenges which are still in rudimentary state and our effort is to give the mathematical shape of these challenges for its wide applicability.

ACKNOWLEDGMENT *(HEADING 5)*

I would like to thanks Gippsland School of IT, Monash University and my supervisor Dr. Manzur Murshed for his excellent guidance and encouragements.

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Modelling the Impact of High Strength Sewage on Septicity Occurrence in Existing Sewer Network

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Abstract— **Implementation of water saving practices like wastewater re-use and water demand management is considered to offer benefits in terms of water savings. However, these practices could have implications on the operational performance of downstream infrastructures like sewer network. High strength sewage will be the outcome of implementing those practices and it might increase septicity that leads to material corrosion and odor problems. This study is mainly aimed to investigate the impact of high strength sewage on septicity in existing sewer networks. The aim of this research will be obtained by, firstly improve the current state of the hydrogen sulphide production model followed by simulation of sewer model. Based on an extensive literature review, this paper first outlines the wastewater characteristics from greywater re-use, urine separation and water demand management. Then, the component to enhance the current state of septicity model will be briefly described.**

Keywords: ***wastewater re-use, water demand management, high strength sewage, septicity***

I. INTRODUCTION

There is an increasing interest in the implementation of water saving practices such as reuse of domestic wastewater, water demand management. These practices are considered to offer benefits in terms of water savings. However, the introduction of these practices could have implications on the operational performance of downstream infrastructures such as sewer network.

The major source of inflow to sewer networks is from domestic wastewater therefore the water saving practices in domestic catchments would affect sewage quantity and quality in sewer networks. High strength sewage and lower discharges will be the outcome of the implementation of those practices. Higher pollutant concentration in sewage and lower discharges increase biochemical transformations that can result in septic conditions; releasing gas that can be the cause of corrosion and odor problems (septicity).

Some studies have discussed the impact of domestic catchments practices to the occurrence of sediment deposition in sewer network. However, there are no studies have been done on their impact on the septicity. It is caused by the fact that the current modeling tool for septicity is less accurate. The sulphide build-up/septicity model was introduced by the WATS model (Wastewater Aerobic / Anaerobic Transformations in Sewers) [14], however, the WATS model simulates the sulphide build up only during steady state flow conditions. In contrast, sewer systems are dynamic systems which are expected to lead to large temporal variations in sulphide production that cannot be predicted using the steady-state approach.

This research is mainly aimed to investigate the impact of high strength sewage on hydrogen sulphide production (septicity) in existing sewer networks. Since the current state of hydrogen sulphide production modeling is still under the speculation; one of the first steps towards achieving the above aim will be to improve the current state of the hydrogen sulphide production model.

II. WATER SAVING PRACTICES

Many big cities in the world have changed their wastewater management for new area development into local wastewater reuse and tighter water demand management. This practices currently widely implemented in the City of Melbourne [3].

A. Greywater Re-Use

Greywater re-use is an alternative strategy for reducing water consumption associated with the toilet and outdoor use. Greywater is wastewater from domestic application other than from toilet. Domestic appliances in residential properties that produce greywater are the bath, shower, washbasin, kitchen sink, dishwasher and washing machine.

According to the study, the average concentration and volume of greywater produced during each appliance usage was used to calculate pollutant load contributions [13]. However, for WC wastewater, the pollutant load from excreta was used as the basis for calculating the contribution to domestic wastewater. With the assumption that all greywater produced from each domestic application is re-used, therefore, the sewer discharge is mainly from toilet use (excreta, water flushing and urine). Table 2 summarizes the pollutant loads related to excreta discharged into the sewerage system/head.day. To provide an estimate of pollutant load from the WC arising from urinal and faecal use, the values of pollutant load/hd.d were multiplied by factors of 0.6 and 0.8

for urine and faeces, respectively. These calibration factors accounted for the fact that many household members are at work most of the day, therefore they use toilets outside the catchments area.

TABLE I. GREYWATER WATER CONSUMPTION AND WASTEWATER CONCENTRATIONS [13]

Appli-ances	Water Consumption			Wastewater quality			
	Per use (l)	*Freq (/d)*	*Total (l)*	*BOD (mg/l)*	*COD (mg/l)*	*SS (mg/l)*	*Amm. N (mg/l)*
Bath	74	0.25	18.5	190	350	120	1.6
Shower	36	0.28	10.1	190	350	120	1.6
Washing basin	3.7	2.9	10.7	235	400	150	0,6
Kitchen sink	6.5	1.98	12.9	680	1150	720	5
Dish washer	30	0.18	5.4	1040	1000	440	4.5
Washing machine	90	0.16	14.4	280	725	190	0.55

TABLE II. POLLUTANT LOADS DISCHARGED TO SEWER [13]

Item		BOD g/hd.d	COD g/hd.d	Amm. N g/hd.d	TKN g/hd.d
Faeces	Total	11	23	0,2	1.25
	Discharged to sewer	8.8	26.4	0.16	1
Urine	Total	10	16	6	13
	Discharged to sewer	6	19.6	3,6	7.8

B. Urine Separation

Urine separation is the diversion or urine into a separate water stream generally collected on-site. As urine is the major nitrogen source in wastewater, this method has the impact of reducing the nitrogen load to the sewer system. From total amount excreted in faeces and urine, urine accounts for approximately, 80% of the total excretion of nitrogen, 50% of phosphorus and 70% of the potassium [2], [8], and [9].

The separation of urine may offer several benefit to agricultural sector and also water saving sector. With regard to water-flushed urine separating toilets, trials in Europe have shown that since it only requires 0.1-0.3 L of water to flush the urine (about 10% of the usual low flush) and design of the bowl enables a 2-6 L flush for the solids, there is a significant saving in flush water [6].

C. Water Demand Management

Water demand management is becoming an important policy and planning objective in many parts of the country because available fresh water supplies are insufficient to meet the anticipated needs of growing urban centers. One of the cities that have implemented water demand management is northern California. Household water use was reduced from 30 to 55% and it has been reported that reduction in waste water flows parallels reductions in water use [4].

Water demand management in northern California showed that reduction of household and industrial water use will result in a decrease in wastewater flows and an increase in the strength of the wastewater. Experience of 14 northern California treatment facilities shows that wastewater flows were reduced 15 to 16% after implementation of water demand management; average waste water flows were reduced from 371 to 284 1/cap-d for a 24% reduction. Concentrations of BOD and TSS generally increased as wastewater flow decreased [4].

III. SEWAGE GENERATOR MODEL

Sewage generator model is a model used to estimate the sewage quality from each household appliance. Household appliances that produce sewage include the WC toilet for excreta flushing (blackwater) and a wide range of appliances that produce greywater, including the bath, shower, washbasin, kitchen sink, dishwasher and washing machine. Sewage from these appliances was characterised by the frequency of each usage, water consumption, and the pollutant loads and/or sewage concentration. This approach is used to produce discharge data and pollutographs for the different appliances which were subsequently combined to simulate the total sewage produced by each household. In this model no attempt was made to simulate biochemical or physical changes in concentration due to the storage of greywater or process inside the piping system. Eventually, the output of sewage generator model can be used as the input for sewer model.

IV. SEWER NETWORK MODEL

A. Sewer Modelling Approach

In modeling, there are two processes to be considered, they are (i) transport processes and (ii) transformation processes (Fig.1).

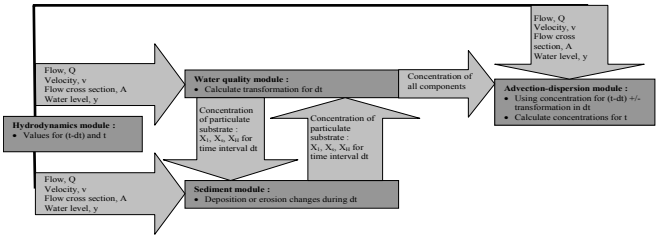

Figure 1. Schematic representation of the modelling approach [1]

Transport processes include the water flow (hydrodynamics); the advection-dispersion of dissolved and suspended (conservative) substances; and the deposition and re-suspension of particles. Transformation processes cover the physical and biochemical processes related to the quality of the pollutants [1].

B. WATS model

The transformation of sulfate compounds model was introduced using empirical equations. However, the empirical equations are unable to deliver a sufficient degree of accuracy

since they were designed and developed for a limited range of sewer conditions [7]. The development of the sulphide build-up module was then enhanced by the WATS model (Wastewater Aerobic/Anaerobic Transformations in Sewers) [10], [14]. The WATS model simulates those chemical and biological transformations and associated transport processes that take place in sewer networks. The WATS model was designed for steady state conditions because the WATS model only focused on dry weather problems where the biochemical transformations are most significant [15]. In contrast, sewer systems are truly dynamic systems. Wastewater flows through sewer networks are known to vary greatly over time, resulting in varying hydraulic retention times (HRT) for wastewater in sewers. These dynamic factors are expected to lead to large temporal variations in sulphide production that cannot be predicted using the steady-state approach.

C. SWMM 5.0 (Storm Water Management Model)

The EPA Storm Water Management Model (SWMM) model is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. SWMM tracks the quantity and quality of runoff generated within each subcatchment, and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period that comprises multiple time steps. The EXTRAN module does add dynamic wave routing capability, but this software still does not include the simulation of water quality transformation [12].

V. FUTURE WORK

The initial step for this research will focus on water transport and mixing of plugs followed by transformation process. The existing models that will be used to achieve the purpose of this study are the SWMM model for describing the unsteady state conditions and as previously mentioned the WATS model for describing the hydrogen sulphide transformations. After built the model, the next step will be calibration and validation of the model by using the data that is collected in small domestic catchments. The Genetic Algorithm (GA) optimization techniques will be used for calibration of the modified model because GA is the most extensively techniques and is known to be efficient and robust model calibrating algorithm [11].

The water saving practices scenario and the variables in sewer network will be developed after the model has been calibrated and the result is satisfying. Changes in contaminant load will be based on scenarios for greywater treatment, urine separation and water demand management. The wastewater servicing scenarios above will be simulated by varying the volume of wastewater discharges to sewer network, the amount of water reduction and different location point of discharges within the sewer network. A domestic sewage generator model will be used to obtain the sewage characteristics from water saving practice. The output of domestic sewage generator model will be used as the input for 'Enhanced' model.

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Reliable and energy efficient backup Clustering scheme for wireless sensor network

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***Abstract*— One of the major challenges in wireless sensor networks (WSN) is to meet the energy constraint of its sensor nodes while ensuring reliability of the system. Clustering is an effective self-organization approach to offer energy-efficient communication for WSNs. However, energy of a sensor node dynamically decreases when it plays a role of a cluster head. As a result some nodes die faster that shorten overall network lifetime and reduce reliability. Existing clustering techniques even with backup cluster head consumes huge energy due to frequent re-clustering and inefficient backup cluster head selection and switching. In this paper we propose a new approach for backup cluster head scheme to reduce the frequency of re-clustering and thus to increase the network lifetime. We introduce the selection of an optimal set of backup cluster heads from the cluster member nodes and the calculation of their optimum switching time. To evaluate the efficacy of the proposed scheme we extend the HEED clustering protocol to backup cluster head.**

Keywords- Wireless sensor networks, backup cluster head, reliability, energy consumption, network lifetime.

I. INTRODUCTION

Wireless Sensor Network (WSN) has emerged as an active research area mainly due to its potential of numerous cutting edge applications. The primary tasks of a sensor node within a WSN are sensing, data processing and communication. In WSN, spatially distributed autonomous tiny devices (nodes) collaborate to monitor physical or environmental phenomenon such as temperature, lighting, sound, vibration, pressure, motion and pollutants at different locations. In many applications, nodes are deployed in a remote and harsh environment or in disaster areas where recharging would be expensive and time consuming or even impossible.

Since the energy required for transmitting data is always higher than computation, it is advantageous to organize sensors into clusters [1]. In clustering techniques, a subset of nodes becomes cluster head (CH) nodes that receive data from a group of nodes, and process and transmit them to the base station, or to another CH in the case of a multi-level network.

Although clustering can reduce energy consumption, its main problem is that energy consumption is concentrated on the CHs. The CH nodes deplete energy faster than non-CH nodes as they need to perform more tasks like data aggregation, compression and encryption before forwarding data. Moreover, due to the multi-hop routing nature of a sensor network, the nodes along the routing paths tend to have heavier workload and consequently deplete their energy faster than other nodes. Therefore, periodic re-clustering is introduced to select a new set of nodes with higher residual energy to act as CHs [1][3]. However, CHs spend energy at different rate due to unequal cluster size, node density and random distribution of nodes. Even though healthier nodes exist in a cluster, sometimes a node having less energy continues to serve as a CH till its death or before re-clustering takes place in the network. The inefficient and excessive usage of energy by certain nodes often causes energy imbalance in a cluster. As a result, some CHs may face faster death. Frequent failures of CHs demand frequent re-clustering incurring large re-clustering overhead of energy.

Many WSN applications are critical in nature, where the data loss can not be tolerated such as chemicals leakage and sudden rise of temperature in industry, abnormal reading of medical devices attached to the patient's body, and detection of enemy operation etc. Therefore, these applications demand a reliable network. Sudden break down of a CH due to energy depletion disconnects the cluster from the whole network resulting loss of sensed data. Moreover, the sensing operation of the whole network remains suspended during re-clustering. Consequently, reliability of the entire network decreases drastically.

To solve the energy consumption problem of the clustering protocols and to provide a greater fault tolerance from a CH break down situation, backup or proxy node has been proposed [6][10] which assumes the role of the current CH. However, the effectiveness of [6] is limited due to exploiting the average remaining energy of all nodes in a cluster to bring the proxy node in the place of a CH. Single and double backup CH concept introduced in [10] has shown that it could improve data transfer reliability in exchange of network lifetime.

Efficient use of energy is one of the recent challenges in clustered WSN. Much of the research [1-7][10] has attempted to overcome the challenges in reducing energy consumption and extending system lifetime through cluster based routing techniques. However, none of these approaches could improve network lifetime and reliability simultaneously [8].

To address this major issue, in this paper we propose a new technique for selecting an optimal set of BCHs for a particular

cluster based on the residual, average reachable, and switching energy, and energy for data aggregation and communicating other clusters (inter-cluster) or the BS.

The remainder of this paper is organized as follows. Section II presents a survey on related works. In section III we address the problem statement which discusses the clustering problems and sensor network energy model. The proposed backup clustering protocol is presented in section IV. Section V shows simulation setup and Section VI describes performance evaluation. Finally concluding remarks and directions for future work are provided in Section VII.

II. RELATED WORKS

A clustering refers to a grouping of sensor nodes that are usually within a geographic neighbourhood to form a cluster which is managed by a CH. A number of energy-efficient hierarchical clustering algorithms have been proposed in the literature to prolong the network lifetime [1-5]. Heinzelman et al. [1] introduced a clustering technique called low-energy adaptive clustering hierarchy (LEACH) for mainly periodical data gathering applications. To distribute energy consumption over all nodes in the network, LEACH uses randomized rotation of CHs. The TDMA time schedule is adopted between the CH and the member nodes to avoid collision, and the base station communicates the CHs by CDMA schedule. Each CH assumes direct communication to the base station. Random selection of CHs incurs faster death of some nodes and consequently, their frequent failures result in large re-clustering overhead. It generates clusters based on network size and does not work well in dynamic network. In [2], the authors proposed distributed algorithms for organizing sensors into a hierarchy of clusters to minimize the energy spent in communicating information to the sink. However, minimizing the total energy consumption is not equivalent to maximizing coverage time, as the former criterion does not guarantee balanced power consumption at various CHs [12].

Younis and Fahmy proposed Hybrid Energy Efficient Distributed clustering (HEED) [3] which does not make any assumption about the network such as its density and size. Every node runs HEED individually. At the end of the clustering process, each node either becomes a CH or a child of a CH. The initial probability for each node to become a tentative CH depends on its residual energy, and final CHs are selected according to the intra-cluster communication cost. HEED terminates within $O(1)$ iterations, and achieves fairly uniform distribution of CHs across the network. However, HEED has not addressed the situation where the CH nodes die, which renders data loss [10]. Also clusters generated by HEED are not well balanced and the cluster topology fails to achieve minimum energy consumption in intra-cluster communication [13].

In EECS [4], a distance-based cluster formation method is proposed to produce clusters in unequal size. Clusters farther away from BS have smaller sizes, thus some energy could be preserved for long-haul data transmission to BS. However, CHs are chosen here based on only residual energy and less energy consuming inter-cluster multi-hop communication technique is not considered. Energy-efficient multi-hop routing protocol for wireless sensor networks (EEMR) [5] presented an uneven clustering mechanism and inter-cluster multi-hop routing selection. Clusters which are closer to the base station (BS) have smaller cluster size than those farther from the BS, thus they can preserve some energy for the purpose of inter-cluster data forwarding. EEMR improves the network lifetime over HEED. However, uneven cluster size consisting of nodes with different residual energy can cause energy imbalance in the cluster resulting faster die of some nodes.

PEACH (Proxy-Enabled Adaptive Clustering Hierarchy) [6] selects a proxy node which can assume the role of the current CH during one round of communication. PEACH uses healthy nodes for the detection and management of any CH failure. Although the protocol claims improvement in network lifetime over LEACH, it couldn't extend the lifetime until the first node falls. Energy-driven adaptive clustering hierarchy (EDACH) [7] proposes a new approach which evenly distributes the energy dissipation among the sensor nodes to maximize the network lifetime. This is achieved by replacing the CH having low battery power with a proxy node and forming more clusters in the region relatively far from the BS. However, more clusters formed far from the BS rather increases energy consumption with the single hop communication required to reach the BS. In both PEACH and EDACH, authors used a threshold value to determine when the current CH becomes obsolete. However, the calculation of the threshold value as an average energy consumption of all CHs of the network is not an effective approach, as all clusters do not spend energy at equal rate.

Hashmi et al. proposed [10] to reduce the loss due to the failure of a CH in any existing clustering protocol by selecting a backup CH for those CHs whose residual energy level are close to deplete their energy and are expected to die before the next rotation. They achieved more data transfer reliability by reducing data loss only due to the death of CH nodes. For this they used single and double backup CHs. This scheme could increase data transfer reliability to some extent, however, in [10] it was reported that this decreased the network lifetime compared with LEACH.

III. PROBLEM STATEMENT

A. Clustering Problems

The main objective of clustering-based sensor networks is affected due to the overhead incurred in the clustering process. Let T_C be the clustering time of the whole network and T_N be the network operation time. The lifetime of a sensor network is $n(T_C + T_N)$, where n is the number of re-clustering process runs until either first or all nodes die. In the entire lifetime of a network, the clustering process spends a total time of nT_C. We can reduce n, by reducing the frequency of re-clustering. Therefore, it is necessary to optimally select a set of BCHs for a particular cluster and switch them with the current CH according to their optimum switching time so that both reliability and network lifetime increases simultaneously. For

this we also need to rank the selected BCHs of a particular cluster so that they can take over the job of the relevant current CH sequentially. This will increase the effective network operation time by reducing the clustering overhead. In this paper we have assumed that the energy depletion is the main cause of a node failure. If a node continues its role as a CH for a long time, it will eventually loose its precious energy faster than its member nodes.

In a cluster-based multi-hop WSN, CHs play roles such as data sensing, aggregating and routing. Malfunctioning of some CHs due to power failure can cause significant topological changes and might require rerouting of packets and reorganization of the network. Switching the cluster head role also affects the other CHs in the network that use the CH which has been recently replaced to forward packets toward the BS through multi-hop communication. Thus, enhancing data reliability through seamless network operation is essential for WSNs.

B. Sensor Network energy Calculation

Let N be the total number of nodes in the network and K be the total number of clusters in the network. E_{da} be the 1-bit data aggregation energy. If l_1 be the data receiving rate (Bit/sec) from member nodes, l_2 be the data receiving rate (Bit/sec) from M number of multi-hop nodes and l_3 be the data aggregated from member nodes and multi-hop nodes, according to the energy model **Error! Reference source not found.**, energy consumed by a CH can be calculated as follows:

E_{CH} = E(Receiving member node data) + E(Receiving multi-hop data) + E(Aggregating data of CH's own, member nodes and multi-hop nodes) + E(Transmitting aggregate data to BS/CH)

$$E_{CH} = l_1\left(\frac{N}{K}-1\right)E_{elec} + l_2 M E_{elec} + \left(l_1\frac{N}{K} + l_2 M\right)E_{da} + \left(l_3 E_{elec} + l_3\varepsilon_{mp} d^4_{CH,CH/BS}\right) \quad (1)$$

Energy consumed by non-CH node,

$$E_{non-CH} = l_1 E_{elec} + l_1\varepsilon_{fs} d^2_{non-CH,CH} \quad (2)$$

Distance between non-CH and CH ($d_{non-CH,CH}$) is small and hence data transmission is dependent on the free space ε_{fs} channel model. Whereas, distance between CHs and CH to BS ($d_{CH,CH/BS}$) is large and hence data transmission is dependent on multipath fading ε_{mp} channel models **Error! Reference source not found.**.

IV. PROPOSED BACKUP CLUSTERING PROTOCOL

A. Protocol Operation

In this section we propose a new backup clustering scheme considering the residual energy (E_{RE}), average reachable energy (ARE), switching energy (E_{SW}), sensing energy (E_S) energy for aggregating data (E_{da}), and energy spent to communicate the other CHs (inter-cluster communication) or the BS. ARE of a node represents the expected intra-cluster communication energy consumption if that node is selected as a CH. Therefore, ARE will enforce the selection process to elect a node as a BCH, which will minimise the intra-cluster communication cost. A CH selects a set of BCHs just after the formation of that cluster. To do this, CH uses E_{SW}, *and* E_{RE} and ARE of each member nodes, that are obtained during their time of joining. Current CH also calculates the optimal switching time based on nodes' E_{RE}, E_{SW}, E_S and energy consumed by a CH (E_{CH}), which includes energy for data aggregation and transmitting data to the BS, and all energy required for intra and inter-cluster communication. Then it initiates the switching operation by sending a single update message. The sequence of protocol operation can be described as follows:

1. Current CH optimally selects and ranks a set of BCHs from all member nodes and calculates their optimal switching time.
2. At its switching time, current CH chooses the first BCH from its ranked set of BCHs and broadcasts the BCH information by a single update message.
3. All member nodes of that cluster update their current CH information on receipt of the update message.
4. All the member nodes of that cluster including the CH to be replaced join the new CH as its member nodes.
5. Other relevant CHs of the network update their multi-hop routing table on receipt of this update message.
6. Newly selected BCH takes over the role of the CH to be replaced and forwards its aggregated data to the same node as was done by that CH.
7. Newly selected BCH is removed from its set and CH switching process continues until either next round of re-clustering or any more BCH does not exist.

Fig.1 shows the BCH switching process. Here, node 2 hands over the CH role to node 4.

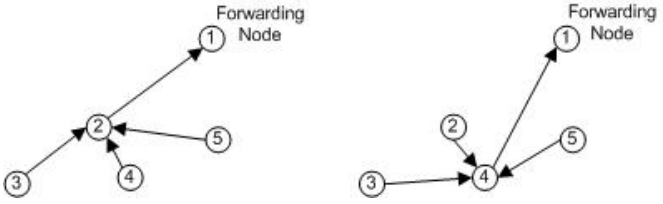

Fig. 1 Switching to backup cluster head.

It is less likely that all clusters in the whole network will start CH switching operation at the same time. Rather only the CH, which reaches to its threshold energy (switching time), triggers the switching process. Although CH switching operation takes place in one cluster, regular network operations in the other clusters remain unaffected. The switching operation takes quite short time compared to the time needed for re-clustering as illustrated in Fig. 2. Thus the protocol considerably reduces re-clustering frequency.

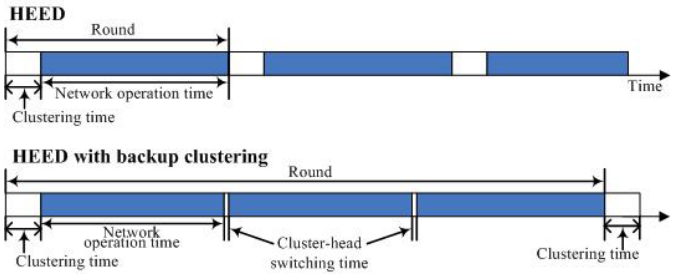

Fig. 2 Time line of HEED with backup clustering.

VII. CONCLUSION AND FUTURE WORK

In this paper, we propose an optimal backup cluster head scheme where the role of cluster head rotates among selected member nodes within the cluster for balanced energy dissipation. This scheme reduces energy consumption and time needed for frequent re-clustering and thus enhances the network lifetime and reliability. We combine rotation of CH role among nodes of a cluster with a suitable clustering algorithm. Simulation results confirm that by rotating the CH in cluster-based networks, the network lifetime can be increased and the network reliability can be improved as compared to those networks not using CH rotation or using existing backup cluster head selection scheme such as [10]. Entire network re-clustering is not only a resource burden on the nodes, it is often very disruptive to the on-going operation. However, in backup clustering scheme sensed data of a particular cluster may be lost during its switching operation, however, rest of the network continue its regular data sensing and transmission operation. Therefore, our proposed scheme helps better monitor the field by avoiding loss of important data from the sensor.

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Power and Performance Efficient Resource Management in Cloud Computing

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Abstract — **Power-efficient resource management is essential for Cloud computing environments to facilitate reduction of operational costs and CO_2 footprints. This work proposes an architecture and a heuristic for continuous optimization of allocation of virtual machines (VM) leveraging several power-saving techniques. Three stages of optimization are presented and detailed description of the first stage is given. The goals are to improve utilization of physical resources and decrease power consumption and the impact on the environment of modern virtualized computing environments, while meeting performance requirements defined by Service Level Agreements (SLA).**

Keywords – Energy efficiency, power consumption, resource management, carbon dioxide emissions, performance constraints, SLA, Cloud computing, virtualization.

I. INTRODUCTION

In recent years, the demand for computational power continues to rapidly grow [1]. In conjunction with advancements in microelectronics it leads to creation of large-scale data centers built upon computing resources packed with high density [2]. Such infrastructures may dissipate enormous amount of electrical power, which requires cooling system consuming approximately the same amount of energy as the infrastructure itself to maintain its operation [3]. However, the cost of electricity consumed by both computing resources and cooling system can exceed the cost of hardware in few years. Moreover, data centers often have to be built being able to serve peak loads, which results in low average utilization and, thus, extra expenses on over-provisioned capacity. Except high establishment and operational costs, there are other important problems, which are consequences of inefficient resource management and high power consumption. Insufficient cooling system in addition to overloaded resources may lead to overheating, which in turns reduces system reliability and devices lifetime. Furthermore, carbon dioxide emissions harmfully influence the environment implying the greenhouse effect. To address these problems, new power efficient resource management strategies have to be developed.

II. THE PROBLEM DESCRIPTION

With the emergence of virtualization technologies and Cloud computing paradigm [4], services can be consolidated as virtual machines (VMs) on smaller number of physical computing nodes. Such consolidation allows improving utilization of resources and decreasing power consumption by switching off idle nodes. Another advantage of virtualization is performance isolation between applications running at different VMs. But for the reason of consolidation, VMs may share resources leading to potential violation of performance isolation. Cloud computing model stipulates strict Quality of Service (QoS) provided for customers, therefore, Service Level Agreements (SLA) can be defined as providing as much resources as requested initially for a VM at any moment. This work is proposed based on Cloud computing model, which entails the following characteristics.

- Underlying hardware is presented by large-scale data centers, which may comprise several heterogeneous clusters.
- Multi-user multi-application environments, which means mixed workloads (web-applications, HPC, etc.).
- "Hard" SLA, which may vary for different applications.
- On-demand resources provisioning on pay-as-you-go bases.

In this work the problem of power and performance efficient resource management in the described environments will be investigated and addressed by development of mechanisms for continuous optimization of VMs allocation and appropriate adjustment of resource power states. The following requirements are essential for a viable solution.

- The optimization algorithm must be decentralized and parallel to eliminate a single point of failure (SPF) and allow scalability.
- The algorithm must be fast to be able to quickly respond to changes in workload.
- The approach must leverage virtualization technologies.
- The approach must guarantee meeting QoS requirements for each application.
- The algorithm must be independent of workload type to be able to perform efficiently in mixed-application environments.

monitoring of node's resource utilization, appropriate resizing of VMs and applying DVFS, soft scaling and power-saving

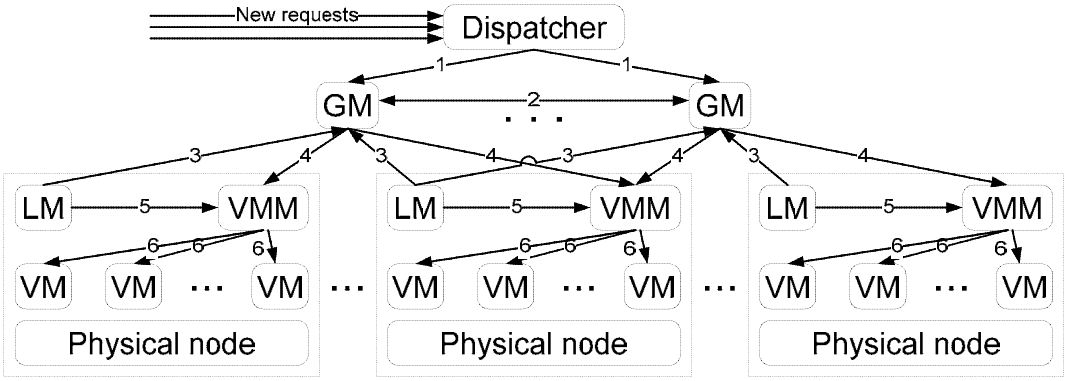

Figure 1. Architecture diagram. GM — global manager; LM — local manager; VMM — virtual machine monitor; VM — virtual machine. 1 — dispatching new requests for VM provisioning; 2 — data propagation between global managers; 3 — sending data about resource utilization and VMs to migrate; 4 — migration commands; 5 — commands for VM resizing and adjusting of power states; 6 — VM resizing, scheduling and migration actions.

III. The Solution Architecture

To achieve reduction of power consumption a combination of the following techniques will be applied.

- Dynamic Voltage and Frequency Scaling (DVFS) — intentional decreasing of CPU performance according to current utilization to reduce consumed power.
- "Soft" scaling — emulation of hardware scaling by scheduling capability of virtual machine monitor (VMM) [5].
- VM resizing and consolidation — logical resizing of amount of resources allocated to a VM according to current utilization and packing resized VMs to less number of physical nodes [5, 6, 7].
- Power-saving states of nodes — switching idle nodes off or putting them to sleep / hibernate modes [8, 9].

Allocation of VMs will be optimized continuously in three stages. At each time frame at the first stage allocation of VMs to physical nodes will be optimized according to current utilization of three resources: CPU, RAM and network bandwidth. Optimization of disk storage is not required as centralized Network Attached Storage (NAS) is assumed to be used to allow live migration of VMs. The next stage is thermal optimization, which means that current temperature of nodes will be considered during allocation decisions. The aim is to avoid "hot spots" by reducing load of overheated nodes and, thus, decrease error-proneness and cooling system overloading. The last stage is optimization of virtual topologies created by intercommunicating VMs. Network communication behavior of VMs will be observed and considered during reallocation in order to reduce data transfer overhead and network devices load.

Current work is conducted on the first mentioned stage. The architecture of the system is tiered comprising local and global managers (Fig. 1). Local managers reside on each node as modules of VMM. Their objective is to perform continuous states. Activities of different local managers are not supposed to be synchronized implying decentralization.

Local managers maintain two kinds of utilization threshold for each resource: minimum and maximum of allowed utilization. If utilization goes bellow minimum threshold for all resources, VMs have to be migrated in order to minimize a number of nodes under load. If maximum threshold is exceeded, local manager chooses which VMs to migrate to another host in order to decrease resources usage and, thus, prevent performance loss. Local manager chooses VMs with highest potential utilization growth, which can be determined as lowest usage of initially requested amount of resource. The thresholds can be set statically or dynamically according to a particular set of VMs allocated to a node. For example, the smaller average relationship between utilization and amount of resource requested initially for a VM, the lower maximum threshold should be set to reflect high potential growth.

Local managers provide information about utilization of resources and VMs chosen to migrate to global managers. They apply distributed version of heuristic for semi-online multidimensional bin packing problem with variable bin sizes and prices to optimize placement of VMs: consolidate VMs from underutilized nodes and place VMs chosen to migrate from overloaded nodes. Such approach allows reallocation of only required number of VMs leading to reduction of migration overhead. To reduce the number of unproductive migrations local managers apply statistical filtering on utilization data. New requests for VM provisioning are processed by global managers in a similar manner. Most of nodes are kept switched off, whereas some temporary nodes are in sleep / hibernate mode (with less transition time) to make system be able to rapidly respond to load peaks.

IV. Expected Outcome and Impact of the Project

Completion of the project implies development of efficient algorithms, implementation as modules of VMM and VM manager and extensive experimental evaluation of the system. The system must satisfy Cloud computing requirements to be

suitable for applying in real-world environments. As it is difficult to conduct experiments on a real large-scale Cloud computing testbed, the system will be evaluated by simulation with real-world workload traces using CloudSim framework [10], which is aimed at targeted environments. Besides reduction of operational and establishment costs the project has social significance as it decreases carbon dioxide footprints and energy consumption by modern IT infrastructures. The project will contribute to the knowledge of resource management in Cloud computing and facilitate future development of power and performance efficient computing environments.

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A Market-Based Meta-Scheduler for Utility Computing on Grids and Clouds

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***Abstract*—*As users increasingly require better quality of service from infrastructures such as Grids, resource management scheduling mechanisms have to evolve in order to satisfy competing demands on limited resources. Traditional algorithms are based on system-centric approaches which do not consider user requirements and interests. These system-centric approaches for scheduling user applications aims to maximize system performance and thus do not consider user utility. Most importantly, these traditional techniques do not perform effectively when the demand for resources surpasses the supply. Therefore, we propose a complementary approach which uses basic economic and market principles to help allocate limited resources more efficiently and fairly by balancing supply and demand. This requires good valuation schemes for both grid resources and user applications. In this work, we design valuation and allocation mechanisms for mapping jobs with Quality of Service (QoS) requirements to heterogeneous grid resources. Finally, we propose a Meta-Broker framework for Grid Market to realize these scheduling strategies with different objectives*.

I. Specific Problem, Application Area, Project Requirements

Cloud and Grid computing provide many advantages at local level and national level, creating a viable infrastructure where IT services can be distributed as new utility [2]. During the last few years, many commercial resource providers such as Amazon and Google have started their utility computing services to provide High Performance Computing (HPC) Infrastructure on demand. Similarly, the use of HPC infrastructure to run business and consumer based IT applications has increased rapidly. This is evident from the recent Top500 supercomputer applications where many supercomputers are now used for industrial HPC applications, such as 9.2% of them are used for Finance and 6.2% for Logistic services [1]. Thus, it is desirable for IT industries to have access to flexible HPC infrastructure which is available on demand with minimum investment. Utility computing paradigm such as Clouds and Grids promises to deliver highly scalable and cost effective infrastructure for running HPC applications. Hence, the scientific and industrial communities have started to use these commercial infrastructures which can scale up based on their demand, rather than maintaining their own HPC infrastructure.

Traditional HPC scheduling systems and algorithms are based on system-centric approaches which aim to maximize system performance and thus do not consider parameter such as application's execution cost. Most importantly, these traditional techniques do not perform effectively when the demand for resources surpasses the supply. Therefore, we propose a complementary approach which uses basic economic and market principles to help allocate limited resources more efficiently and fairly. Current work in market based approaches, such as Tycoon and Bellagio use one sided auctions which are based on the budget of consumers neglecting other application requirements. Moreover, the coordination between different user based brokers such as Gridbus Broker and Nimrod/G will be a challenge because of the conflict to gain access of best resource in terms of performance and cost. Thus, we propose a market based meta-scheduler for Cloud/Grid Market where all HPC users and resource providers get matched. This exchanger can coordinate the global demand and can decrease the unnecessary contention at the cheaper resources. To make this market place a reality, in this project we have to design:

a) Scalable meta-scheduler algorithms 1) which can keep track of dynamic change in cloud offerings by cloud providers 2) which match provider and consumers according to their interests 3) which do fair allocation to users and providers 4) which maximize utility of both users and providers
b) Scalable Implementation of Cloud Exchanger and evaluate using real application and cloud infrastructures.

II. Solution Architecture, Concepts and Technologies

The main components of Grid/Cloud Market (Figure 1) are following:

- **Global Information Service (GIS) and Resource Catalogue -** support resource discovery and availability.
- **Reservation Service:** Interact with local scheduler of resource site to do the advanced reservation

which assures the availability of resources at the right price & time.

- **Pricing System** – keeps update of current service prices for usage of compute resources.
- **Meta-Broker (Meta-scheduler)** – provides the interface between resources and end-user. It has responsibility to match user application with appropriate resources. It will be integrated with various economic models.
- **Accounting System** - presents and reports on usage of compute resources. It also calculates money that needs to be charged from user based on these usage reports.

To allow negotiation of Market with different user based brokers such as Gridbus Broker, and resource schedulers such as Maui, Grid Market has a web server interface which will be implemented using JAX-WS API. For, first step, we intend to add a web service client in Gridbus broker and Aneka enterprise cloud. This client will allow both of the middleware to use Market services. To ensure reliable service of Grid Market, we intend to use persistent database such as Hibernate/Mysql for saving periodically market state.

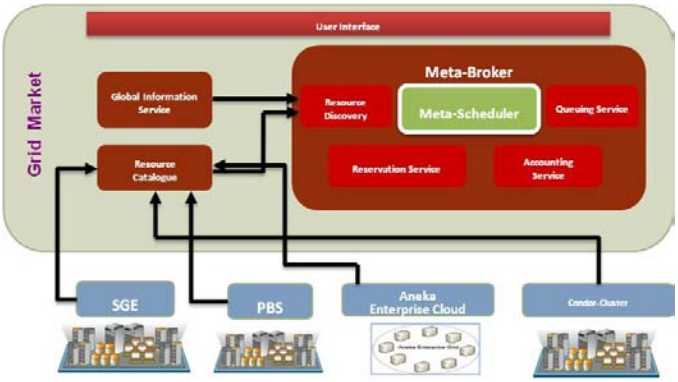

Figure 1. Grid Market Architecture

III. Expected Outcome, Impact of Project & Deliverables

Expected outcome of this project will be a meta-scheduler with capability of maximizing fairness among its participant and simultaneously maximizing their profit [3][4][5]. We believe that such a system will have a deep economic impact on current IT industry by easing access to cheap resources on demand, which can results in economy of scale for IT needs of small and medium enterprises. Moreover, our system will also help many scientific research organizations which cannot buy high cost super computing infrastructure which is needed for time consuming scientific applications. Grid Market like applications can accelerate research advancements by providing access to cheap computational power.

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Bioactivce Paper:

Stability, Activity and Deposition

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***Abstract* —** *Bioactive papers and paper diagnostics are getting a reality for their low cost, selectivity and application flexibility. Critical is the stability and reactivity of bioactive papers that need to be shipped and stored. This study quantifies the stability and reactivity of enzymatic bioactive papers.*

The thermal stability, reaction kinetics, functionality and selectivity of bioactive enzymatic papers were investigated. The thermal stability and reactivity of enzymes adsorbed on paper was measured using a colorimetric technique quantifying the intensity of the product complex. The enzyme adsorbed on paper retains its functionality and selectivity. Adsorption of ALP on paper decreased the enzymatic reactivity up to 3 orders of magnitude and improved the thermal stability up to 2-3 orders of magnitude compared to the same enzyme in solution. Complex patterns of enzymes and protein were ink jet printed on porous substrate using to demonstrate the feasibility of thermal ink jet printing as a robust process for biosurface engineering. Paper and inkjet printing are ideal material and process to manufacture low cost – high volume bioactive surfaces.

Keywords-biosurface engineering; bioactive papers; bioassyas; paper diagnostics; ink jet deposition; protein; enzymes

I. INTRODUCTION

The high cost and the limited availability of tests and application devices often restrict the benefits of many breakthroughs in biotechnology, medicine and environmental science. There is a high need for low cost bioassays, in health and environmental diagnostics. Disposable materials can be very useful for medical or environmental purposes. Routine bioassays for the early detection of cancers and genetic conditions, for daily tests to monitor diabetes, and for instant water analyses of heavy metals and microbial activities are a few of the potential applications of disposable bioassays.

The successful commercialization requires bioassays and bioactive surfaces to be low cost, which is best achieved through high volume manufacturing and with commodity materials. . Printing is a high speed technology, able to deliver patterns of materials such as functional fluids at an exceptional accuracy. Recent developments in bio-interface engineering have shown ink jet printing as a promising method to create biomolecular patterns onto surfaces [1, 2]. Ink jet is a non-contact printing technique, which can print biomolecules with high resolution: 20-40 μm reduces cross contamination. Ink jet printing is a digital technique and the result is highly reproducible [3]. Peptides, enzymes and cells have also been printed under laboratory conditions using a variety of technologies including inkjet printing [4, 5]. On the other hand, paper, a non-woven made of cellulosic fibres, is highly wettable when untreated, easy to functionalise and engineer, biodegradable, sterilisable, biocompatible and cheap. It has long being used for analysis in chromatography [6, 7]. Also, thin coatings of polymers and inorganics can easily be achieved through standard wet-end addition, surface sizing, coating and other surface treatments common to the industries. This suggests that paper is a natural material of choice for the production of disposable bioassay devices and bioactive surfaces. However, the biotechnology industry has a limited understanding of the effect of paper structure and chemical composition on the biomolecule functionality.

Enzymes are model biomolecules of choice for a fundamental study because of their stereospecificity, wide range and availability. Understanding the effect of adsorption on the enzyme secondary and tertiary structure, its functionality, stability and the selectivity of substrate recognition is critical for engineering biocatalysis. This knowledge can later be applied to other biomolecules. Few scientific studies have described the immobilization of enzymes on paper. Among those are paper strips indicators for sea food freshness using two enzymes (xantine oxidase and nucleoside phosorylase) [8], and bioactive paper to monitor alcohol content in the breath using alkaline oxidase (AOD) [9]. However, there is little fundamental understanding on the effect of surface property on biofunctionality. Chen et al. investigated by AFM the effect of surface wettability on enzyme loading (candida antartica lipase B CALB) [10].

The concept of paper bioassays is to rely on paper for the transport of fluids samples, biomolecule detection/reaction, and the communication of the event in a single step process. Whitesides pioneered paper microfluidic systems by developing hydrophobic barriers on paper [11, 12]. The pattern accuracy and manufacturing efficiency of microfluidic papers can be improved with plasma treatments or inkjet printing [13].

The first requirement of a bioactive paper is to retain the functionality, reaction rate and selectivity of its immobilized biomolecules. The second is to provide good biomolecule stability. The objective of this study is to measure the potential of paper as stable support for the immobilization of enzymes required for catalytic and diagnostic applications. Alkaline phosphatase (ALP) and horseradish peroxidase (HRP) were the enzymes selected for their stability and their wide range of applications.

In the first part of the study, the reaction kinetics of ALP adsorbed on paper is measured and modelled. In the second, a complete enzymatic pattern of HRP is printed by ink jet printing on paper. It is the objective of the study to engineer fully bioactive and stable enzymatic papers.

II. Methodology

A. Immobilize Enzymes on Paper

The enzymatic paper formation technique is shown in Figure 1. Experimental details, surface profile analysis and histogram distribution of gray values are described elsewhere [14].

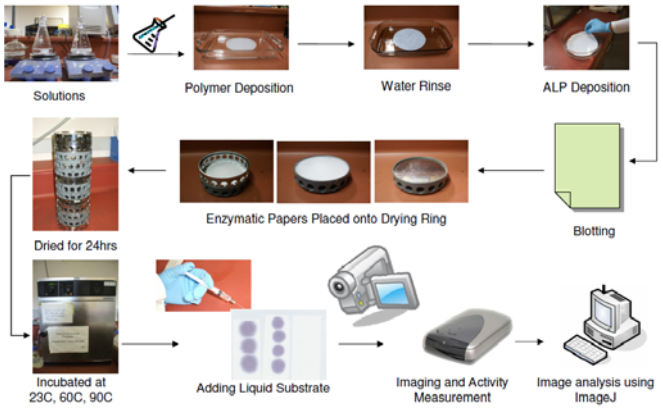


Figure 1 *Experimental system to prepare enzymatic papers*

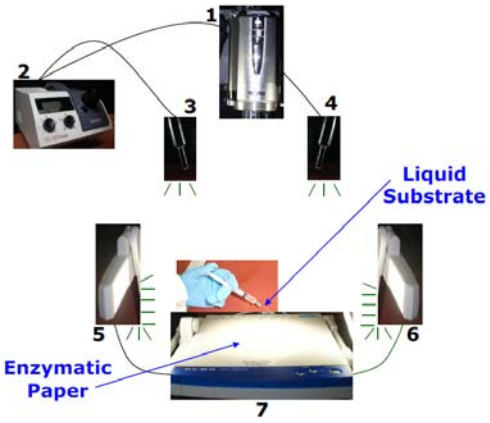


Figure 2 *Experimental setup to study reaction kinetics on papers*

B. Image Capturing and Activity Measurement

The reaction kinetics images were captured using a standard video camera along with two sets of lighting (Figure 2). The enzymatic reactivity data were converted using Prism Video Converter v 1.27 and VirtualDub-1.8.8. The deactivation images were scanned at 1200 dpi using a standard scanner (EPSON PERFECTION 2450 PHOTO). The images were analyzed using ImageJ software (ImageJ 1.41o). ImageJ calculates the gray values of RGB images. For any selected area, the ImageJ software calculates the weighted average gray value within the selection, which can be related to the activity of enzymatic paper.

C. Bio Printing

A basic Canon inkjet printer (Pixma ip4500) and ink cartridges (CLI, Y-M-C-BK, PGBK model) were reconstructed to print the hydrophobization solution and the HRP-enzyme solution on paper. A paper-based microfluidic pattern was created using the method describes elsewhere [13]. Different patterns of Horseradish peroxidise (HRP) enzyme and Albumin-FITC protein were printed. Details of printer modification, bio ink formulation and printing technique are discussed elsewhere [3].

III. Results and Discussion

A. Activity of Enzymatic Papers

Liquid substrate system 5-bromo-4-chloro-3-indoxyl phosphate/nitroblue tetrazolium (BCIP/NBT) was applied on the alkaline phosphatise (ALP) enzymatic paper samples and allowed the enzyme-substrate (E-S) reaction proceed to completion. The activities of enzymatic papers were calculated from the weighted mean grey value of the captured images. Figure 3 and Figure 4 show the colorimetric evolution of enzymatic reactivity of ALP papers as a function of time. Pictures of product colour formation on ALP enzymatic papers are shown in Figure 3.

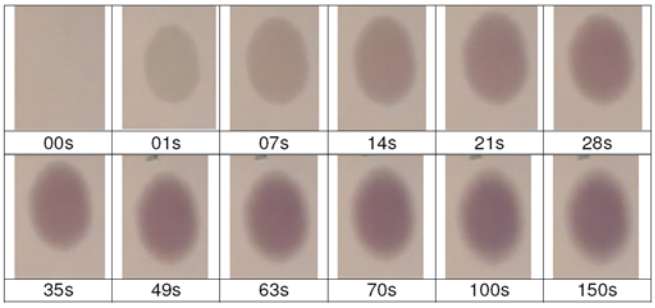
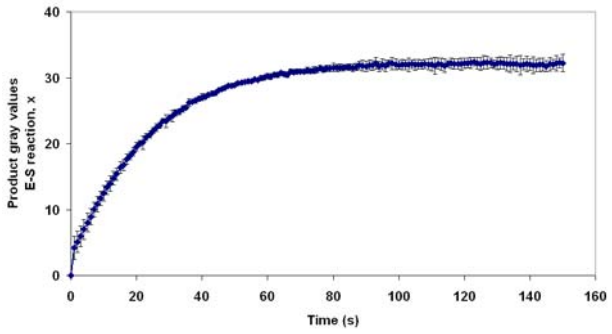
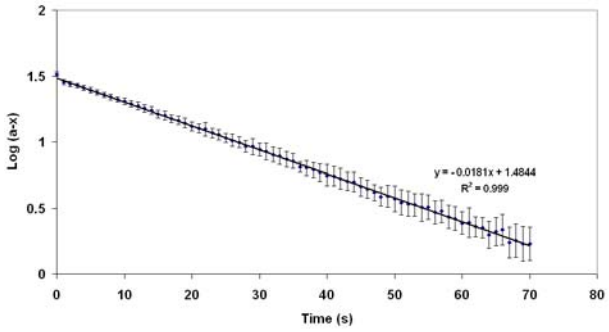


Figure 3 *Product formation on ALP enzymatic paper at different time. The blue purple colour reveals the enzyme-substrate (ALP-BCIP/NBT) reaction*



(a)



(b)

Figure 4 *Reaction kinetics of ALP enzymatic papers. (a) RGB gray value of product concentrations as function of time (b) reactant concentration as a function of time in semi-log scale. Reaction follows 1 order reaction kinetics.*

Figure 4 illustrates the reaction kinetic model of ALP enzymatic paper. The product colour intensity (x) was found increasing upto first 40 sec. After that the colour changing became slow and gradually approached to saturation (Figure 4a). Figure 4(b) shows that E-S reaction on ALP enzymatic paper follows the first order reaction kinetics. The reaction rate constant (k) for ALP enzymatic paper was found 150 hr^{-1}. However, the rate constant of ALP hydrolysis mechanism in buffer is 30-118 s^{-1} (≈ 108 - 425 $\times 10^3$ hr^{-1}) [15, 16]. Therefore, *the ALP enzymatic activity was found 3 orders of magnitude faster in solution than that on paper.*

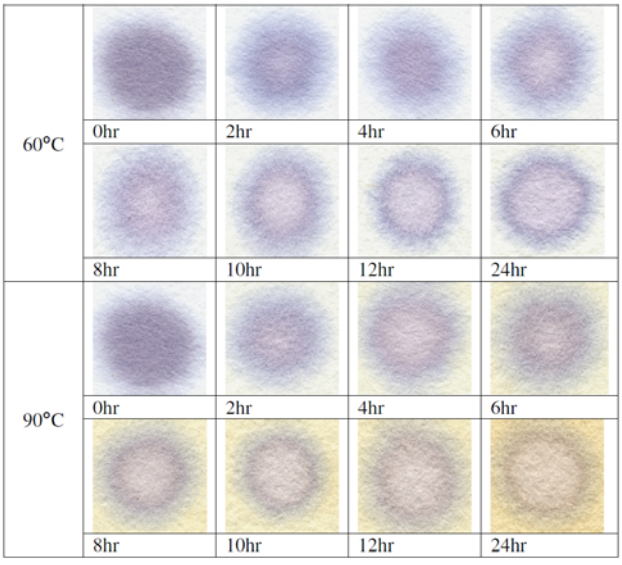


Figure 5 *Aging of ALP enzymatic paper treated at 60ºC and 90ºC for various periods. The blue purple colour reveals the E-S (ALP-BCIP/NBT) reaction*

B. *Deactivation of Enzymatic Papers*

Enzymatic paper samples were aged at different temperatures for various periods. After applying the liquid substrate to the aged enzymatic paper and letting the enzyme-substrate reaction proceed to completion, the paper samples were scanned. The relative activities of enzymatic papers were calculated from the weighted mean gray value of the scan images. Pictures of ALP enzymatic papers heated at 60°C and 90°C for periods up to 24 hrs are shown in Figure 5. Figure 6 show the colorimetric evolution of ALP enzymatic paper aged at different temperatures as a function of time. Paper yellowing is becoming visible for papers treated at the higher temperature and longer periods (≥4 hr) which is addressed else where [14].

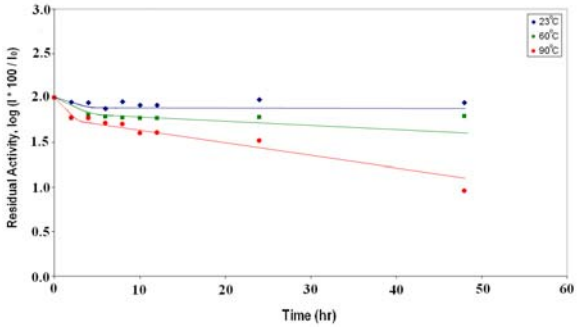


Figure 6 *Residual activity of ALP enzymatic papers at different temperature. I_0 = gray value at '0' hr and I = gray value at 't' hr.*

The deactivation model is described elsewere [14]. The deactivation rate constants of ALP on paper were found 2-3 orders of magnitude smaller than in water [14]. The activation energies 'E' of ALP deactivation process on paper surface were found to be 16.74 kJ/mol for phase-1 and 42.09 kJ/mol for phase-2, respectively. Fadiloglu et al. (2006) reported the 'E' of ALP deactivation in buffer is 97.2 kJ/mol. 'E' of enzyme deactivation on paper is much smaller than in buffer: 2-5 times smaller for ALP [14]. *This indicates that enzyme deactivation in solution is more temperature sensitive than that on paper. From the deactivation model it is found that ALP enzymatic papers remain bioactive for 22 days at room temperature or 4 months refrigerated.*

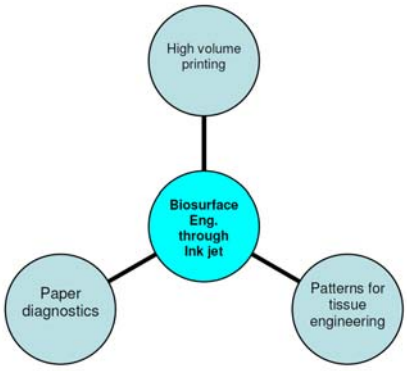


Figure 7 *Prospects of Biosurface Engineering through Ink Jet Printing*

C. *Ink jet Deposition on Porous Substrate*

Figure 7 demonstrates potential applications of ink jet deposition of bio inks in three major categories: a) large volume printing which can be useful to develop bioactive paper towels that signal bacterial contamination; b) printing paper micro-fluidic to develop diagnostic devices; and c) printing gradients of trophic/tropic factors can serve as driving force for cell growth or migration for tissue regeneration (Figure 7). Figure 8 shows different patterns ink jet printed on

porous substrates: paper and bio-degradable polymer (PCL-scaffolds, a nano-fibrous biodegradable polymer) to demonstrate the potential application in medical and environmental purposes (Figure 8). Characterizations of printed patterns are discussed elsewhere [3, 14].

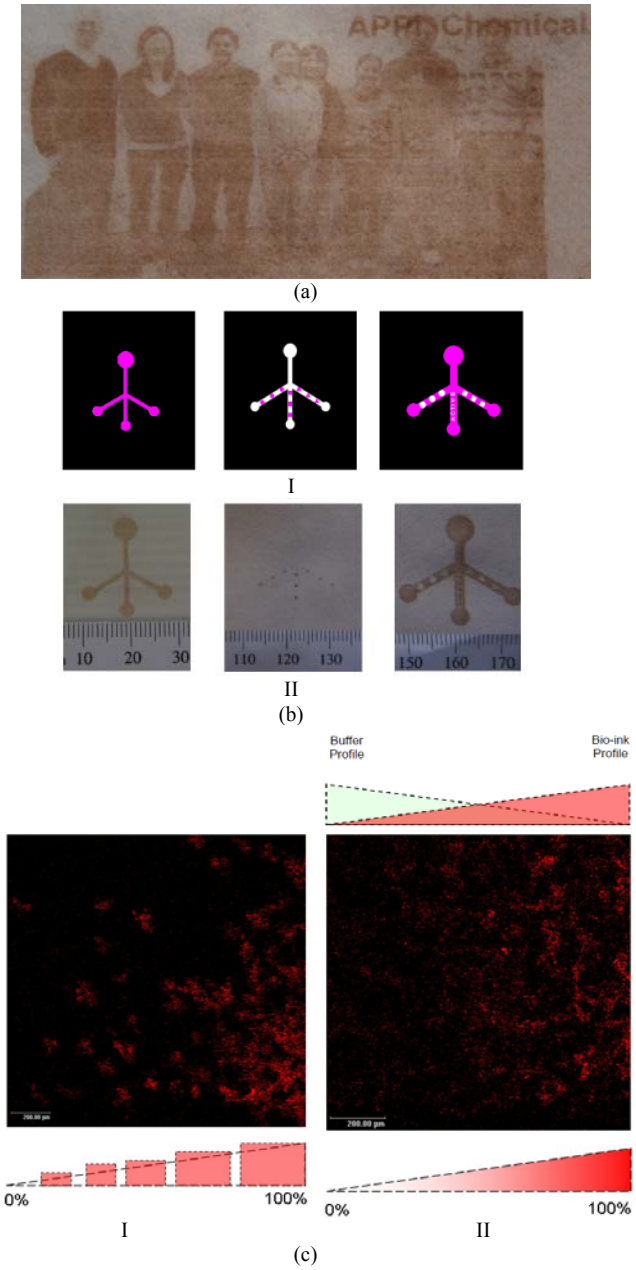


Figure 8 *Printed Patterns using Ink Jet Printing. (a) Research group picture (14.5cm×10.5cm) obtained using HRP followed by reaction with DAB; (b) paper-based diagnostic devices: HRP was printed inside the hydrophilic channels and a drop of DAB was deposited in the collector which react with HRP and reveal exact position and activity of HRP; (c) Protein (Albumin-FITC) gradient was printed on PCL-scaffolds. Two inks system (Tris buffer and Albumin-FITC) provides smoother gradients.*

Conclusion – *The activity and thermal stability of enzymatic papers were quantified using a colorimetric technique measuring the colour intensity of the product complex. Enzymes adsorbed from solution onto paper and dried remain functional and exhibit strong activity and selectivity. Adsorption onto paper increases the enzyme thermal stability by two to three orders of magnitude and decreases the activity about three orders of magnitude compared to the enzyme in solution. Complex patterns of enzyme and protein were printed on paper by modifying a common thermal inkjet printer. Enzyme sustained the printing thermal and shear stress and remained bioactive. This demonstrates that bioactive paper has exceptional potential for low cost, high flexibility diagnostic and industrial application.*

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