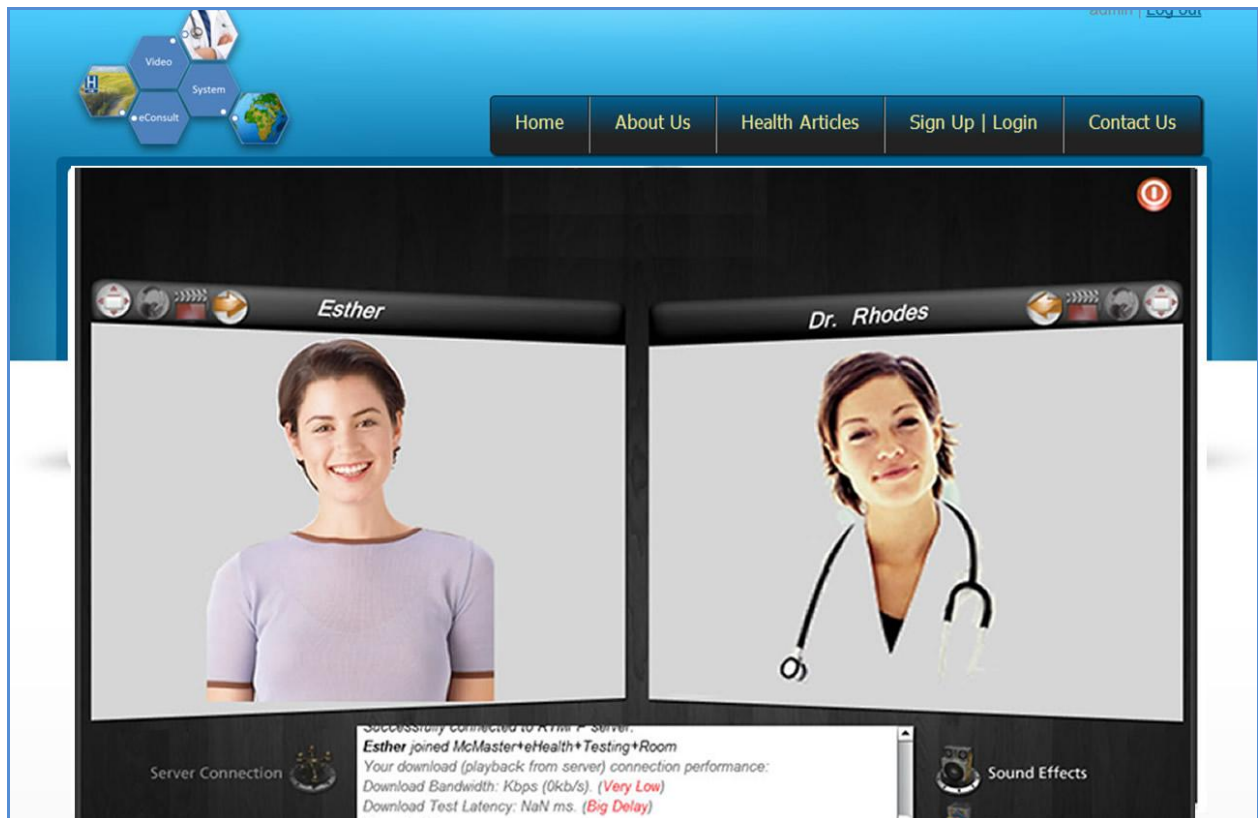


Design and Evaluation of a Two Way Interactive Video eConsult System (TWIVES): A Web-Based Care and Continuity Solution



Design and Evaluation of Two Way Interactive Video eConsult System (TWIVES): A Web-Based Care and Continuity Solution Enabling Secure and Private Patient-Provider Connections When Mobility is Limited or Commuting is Not an Option

By

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A Thesis

Submitted to the School of Graduate Studies

In Partial Fulfillment of the Requirements

For the Degree

Master of Science eHealth

MASTER OF SCIENCE eHealth (2012) McMaster University
Hamilton ON

TITLE: Design and Evaluation of Two Way Interactive Video
eConsult System (TWIVES)

*A Web-Based Care and Continuity Solution Enabling
Secure and Private Patient-Provider Connections when
Mobility is Limited or Commuting is not an Option*

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NUMBER OF PAGES: 159

ABSTRACT

This thesis reports on the development of a Two Way Interactive Video eConsult System (TWIVES), a telemedicine application for the continuity of care in rural communities, remote areas, and in developing countries. In developed countries like Canada, there has been much development of complex telemedicine solutions that may not be suitable for rural communities in developing countries. TWIVES can be a useful alternative when mobility is limited, the patient is disabled, or commuting is not an option for the patient. This system is both easy and inexpensive to use, and operates well in the low bandwidth Internet connections available in these areas.

In his article “The role of cost in telemedicine evaluation” Fuhmei Wang stated that an increase in the provision of telemedicine services can significantly improve a population's health status. According to Laurent Elder and Michael Clarke, sufficient evidence has been generated from work carried out by the International Development Research Centre (IDRC) partners and others to show that implementing telemedicine and e-health applications can have many benefits, including direct benefits to patients. TWIVES aims to facilitate an environment where users can securely request medical consultations from healthcare providers at distant locations, thereby saving time, money, and providing patients access to medical expertise that would otherwise not be available. TWIVES also introduces the concept of web-based submission of requests, replacing the existing traditional method of telephoning to arrange personal face-to-face appointments.

Video conferencing solutions abound in the marketplace. However most of these solutions are not designed with healthcare in mind, especially with respect to privacy issues that are critical in healthcare. To address these concerns, TWIVES is deployed on two different servers – one for Content Management and the other for Video Streaming. This separation comes with

many advantages and makes it possible for other applications to easily integrate with it and eliminates the need to maintain multiple profiles and databases.

To ensure privacy and security, user logon information is protected by employing salted and hashed password protection techniques on the Content Management side. A hash is a mathematical function that is simple to perform in one direction, but very difficult to reverse. Salting adds another layer of protection by including a string of random characters to the passwords before they are hashed, so that each one has a unique hash. To further ensure security and privacy, the video content resides on another secure server that is not connected to the Content Management server. Information exchange between the two servers is configurable to flow through a Secure Sockets Layer (SSL) connection. SSL is a cryptographic protocol for encrypting information over the Internet.

TWIVES is a proof of concept (POC) designed and built with the Drupal framework, with particular attention paid to access control and user management, content management, custom search, private messaging and file sharing, request management, and real time video consultation. This thesis explain the purpose and features of TWIVES, its interfaces, what it can do, the constraints under which it must operate, and how it will react to external stimuli.

Future full scale development would allow the solution to be deployed on a live server and enable an evaluation and analysis of bandwidth constraints and healthcare logistics to be conducted on its use in a developing nation environment.

ACKNOWLEDGEMENT

This work would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in its preparation and completion.

First and foremost, my utmost gratitude to Dr. Norm Archer, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject. Sir, I will not be discussing 10 ideas at once with you in a while.

Dr. Ann McKibbon, Director of the M.Sc. eHealth Program, who always says something that makes me think about “stuff” differently;

Dr. Ruta Valaitis and Dr. Emil Sekerinski, for their unselfish and unfailing support as my dissertation advisers;

Ms. Fariba Rawhani, Senior Vice President – Development and Delivery at eHealth Ontario, for making her scarce time available to me as a member of my thesis committee;

My colleagues and staff in the M.Sc. eHealth Program for all the support, the use of facilities and consultations - also those books on application development came in handy!

Last but not the least, my family and the one above all of us, the omnipresent God, for answering my prayers; for giving me the strength to plod on despite all odds - thank you so much Dear Lord.

Kenneth Chinenyeze Nwosu

DEDICATION

I wish to dedicate this thesis to my late mother, Rita Osinachi Nwosu, because of whose prolonged illness, I got involved in eHealth. *Mama udo diri gi!*

&

My one and only sister, late Esther Nkiruka Onwenu (nee Nwosu), who took time off school to play mother to me; nurtured me to health after the Biafran War and never stopped believing in me. Though you left this life early you will forever be remembered. *Nwanne oma m, ekele kwara m gi!*

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CHAPTER 1

1 INTRODUCTION

Many rural and remote regions around the world have chronic shortages of doctors and other healthcare providers. Producing more physicians and expecting the excess to spill over from the cities into rural and remote areas has been shown to be ineffective in solving the rural medical workforce shortage (Strasser et al., 2009). According to the World Health Organization, these shortages are critical, especially in developing countries of sub-Saharan Africa (WHO, 2006).

Shortages of healthcare providers suffered by rural and remote communities, especially in developing countries, are usually the result of internal emigration to urban centers, brain drain to other countries, diminished workforce productivity, and population growth (Ehman & Sullivan, 2001). Existing medical and nursing schools in these areas cannot train enough workers to keep up with increasing demands for healthcare services. As a result of this, community health workers are armed with inadequate training, limited medical supplies and the necessary support to provide primary care services to the population. “Task shifting”, which involves the transfer of primary care roles from professional health workers to community health workers is prevalent in these settings and is considered to be a more efficient use of available human resources to improve the health of millions at reasonable cost (Mit, Rony, & V., 2008).

In Ontario Canada, the Ontario Telemedicine Network (OTN) has been very successful at reducing the need for remote patients to travel to access specialists (OTN, 2012c). However, OTN generally has knowledgeable nurses

and physicians to be with the patients at the times of their appointments online.

There is a need for a solution that patients, in rural and remote areas, where there are no such OTN facilities, can use to connect with healthcare providers, preferably through a bandwidth-light video link over the Internet, from their homes. This is quite different from current OTN services which connect physicians in an urban area to a community health center in a remote region presently delivered through OTN Telemedicine Studios located at health centers and hospitals requiring travel for participants.

TWIVES is an application that takes care of the need identified in the paragraph above: It delivers a web-based video consult application for rural and remote care that allows a patient to connect with clinicians without the need to visit an OTN-like facility. TWIVES offers a cost effective solution that patients can potentially use from the comfort of their homes and does not depend on elaborate hardware and specialized software. This in essence removes the need to commute from rural and remote communities to cities or facilities, for consultations. With a simple Internet device, community health workers who are registered with TWIVES, as well as enrolled patients, can connect with and access the services of healthcare providers at distant locations for delivery of care.

With recent developments in wireless systems and the ubiquitous penetration of mobile technologies, it is now possible for healthcare providers at distant locations to see, discuss, and evaluate patient issues virtually and inexpensively. Patients who live in remote regions could get consultations from a family doctor or specialist remotely, eliminating expected waiting time at hospitals and the costs and delays of travel.

In a developed country like Canada, TWIVES could also be useful to patients with limited mobility, as exemplified by Jane Doe in Section 1.5.1, as well as those who do not have much disposable income. For example, in their report titled “A Portrait of Poverty - Living on Social Assistance in Hamilton”, the Homelessness Initiative Campaign for Adequate Welfare (2003) posited that the levels of assistance provided through both Ontario Works and the Ontario Disability Support Program are not enough to provide for the basic necessities of life. According to Lightman et al (2005), the maximum Ontario Works payment for single people is CAN\$520 a month, for single parents with a child younger than one, \$957, and for couples with two children the new ceiling was \$1,250. For such people (depending on the location of patient and healthcare provider), travelling to see a physician could be difficult, as the cost of public transport alone would be difficult to manage, given their meager monthly stipends.

Video conference software and services have improved drastically over the last few years; some of the popular commercial solutions, as gathered from the Video Conferencing Software Guide website, are shown in Figure 1 below (Video-Conferencing-Software-Guide, 2011). TWIVES can be compared to the myriad of videoconferencing solutions available in the market today like Skype, GoToMeeting, Webex and FaceTime from Apple.

Until recently Skype was the most popular videoconferencing solution (Unuth, 2007). However, there have been concerns about its encryption methods and therefore suitability for healthcare applications. According to a team of researchers led by Benoit Dupasquier of Queen's University of Belfast in the UK, communication within Skype could be recovered with up to 83% accuracy under certain conditions. The service encrypts conversations, but that encryption provides users a false sense of security (Dupasquier, Burschka, McLaughlin, & Sezer, 2010).

FaceTime is a videoconferencing solution that runs on Apple products like iPhone 4 or later, iPad 2 or later, iPod touch (4th generation) and Mac with Mac OS X Lion (Apple, 2010). The FaceTime protocol is not open, but is based partly on a number of open industry standards. However, FaceTime is not currently supported on any non-Apple devices. Moreover, the majority of users targeted by TWIVES may still be using PC instead of Mac computers. According to a study conducted by Canalis in 2010, there are 89.2% of PC users compared to 10.8% of Apple/Mac (Yau, 2011).

| NAME | INSTANT RECORD | MAC COMPAT. | PARTICIPANTS | PRICE | VOIP |
|---|----------------|-------------|--------------|-------------|------|
| GoToMeeting Video Conferencing | Yes | Yes | Up to 15 | \$49/Month | Yes |
| Webex Video Conference Software | Yes | Yes | Up to 25 | \$59/month | Yes |
| Megameeting.com Review | No | Yes | Up to 50 | \$349/Month | Yes |
| Fuze Meeting Software Review | No | Yes | 15 Max | \$29/Month | No |
| Lifesize.com HD Teleconferencing | No | Yes | 4 Max | \$22,836 | Yes |
| Nefsis Conference Tool Review | Yes | Yes | 10 Max. | \$500/Month | Yes |
| Work Space 3D by Tixeo.com Review | No | No | 30 Max | \$86/PP/PM | Yes |
| MeetingPlace by Vmukti.com | Yes | No | N | Depends | Yes |
| Voxwire Meeting Room Review | Yes | Yes | Up to 20 | \$39/month | Yes |
| RHUB Turbo Meeting Review | Yes | Yes | Up to 10 | \$995 | No |

Figure 1: Commercial Videoconferencing Solutions

Although FaceTime seems popular among users of Apple products, it may not be suitable for the segment of the society that TWIVES is targeting. FaceTime over a cellular network requires iPhone 4S or iPad (3rd generation) with cellular data capability and FaceTime is not available in all countries.

In addition to the high cost of using these systems, they are designed to store the transaction information at the server of the service provider. This is not acceptable in healthcare where the need to maintain patient privacy is of utmost importance. TWIVES targets patients in remote regions of the world who may not have the means to subscribe to these services even if they could afford it - online payment for goods and services is yet to be widely adopted. Even with Internet-able consumers, current online payment options are not widely available due to legal and systemic limitations (Hartley, 2009).

TWIVES is also designed to be used as a last resort application for patients in developed countries who for any reason could not leave their location in order to keep an appointment with their healthcare provider. In Canada, a physician would be unlikely to agree to use the system for more than follow-up (where the specialist or general practitioner had actually examined the patient initially). But TWIVES could be used by patients who for any reason at all cannot leave their locations (i.e., due to heavy snow storm, physical immobility, etc.).

Such a patient would log into TWIVES, and the system would send an email to whomever the patient needs to contact. The patient would then call the office of their healthcare provider and inform them of the email that was sent. The email contains a link which the provider clicks on to open the consult window that the patient has set up. And because it is by invitation only, only the provider and the patient would have access to the online room.

1.1 Overview

Telemedicine has been used for many years to support doctors in the developing world (Wootton, Vladzimirsky, Zolfo, & Bonnardot, 2011). According to Bashshur, (1995), if telemedicine can bring quality health services to isolated and underserved populations at a reasonable price, the benefits will far outweigh the initial capital investment as well as the cost of operations. The cost of sending patients to referral hospitals has been estimated to be 10–100 times higher than using telemedicine, due to the travelling and accommodation costs and missed income during the time of absence from home (Krüger & Niemi, 2012).

While there is a substantial body of work showing that telemedicine has been used in the developing world in broadly similar ways to its use in industrialized countries (Bonnardot & Wootton, 2010), it has been used primarily for educational and clinical purposes. Moreover in developing countries, clinical applications are predominantly asynchronous in nature and are used to obtain second opinions by those working in a wide range of medical and surgical fields, including general practitioners. Most of the systems often use ordinary email for obtaining specialist advice from other consultants or colleagues in other countries (Bonnardot & Wootton, 2010). For example, the results of medical specialist consultations sampled from several rural clinics located throughout India indicate that remote expert opinions can improve the speed and accuracy of diagnosis (Amble, Comparini, Kumar, Dahlgren, & Lurie, 2004).

The purpose of this thesis is to explore the possibility of creating a very low-cost videoconferencing solution that could be used by community health workers and patients in these settings to connect to healthcare providers, fully managed and maintained by the communities, thus facilitating a sense of

ownership and empowerment in rural and remote communities (Krüger & Niemi, 2012).

1.2 Research Question

The research question to be addressed by this thesis is: Given the significant cost associated with the setup of telemedicine networks, how feasible is it to develop a web-based solution for community health workers and patients in rural and remote areas, including developing nations, in an environment of low speed Internet connections, limited infrastructure, and relatively small budgets for eHealth systems?

TWIVES was developed as a Proof of Concept (POC) to answer the above question. This development involved the design and development of TWIVES, based on the Drupal Framework. The design covers: access control and user management, the deployment of a full Content Management System (CMS), custom search functionality, and the ability to generate relevant reports. TWIVES was also evaluated for bandwidth constraints at low speed Internet connections.

1.3 Background

Telehealth and telemedicine are often used interchangeably in medical literature. Telehealth can broadly be defined as the use of information and communications technologies to deliver health information and services over both long and short distances (Fiona, 2001).

According to Shreveport (2011), telemedicine is the delivery of healthcare and the exchange of healthcare information across distances. The American Telemedicine Association defines Telemedicine as the use of medical information exchanged from one site to another via electronic communications

to improve patient health status (ATA, 2011). Telemedicine encompasses diverse varieties of services delivered to the patient and includes the whole range of medicine: diagnosis, treatment of diseases, continuing education of healthcare providers and consumers, and research and evaluation, performed when distance is an issue (Cipolat & Geiges, 2003). Sorrells-Jones et al (2006) further added that videoconferencing, transmission of still images, patient portals, remote monitoring of vital signs and continuing medical education are all considered part of telemedicine and Telehealth.

The roots of telemedicine can be traced back centuries when medical care was limited to the radius in which the physician was available (Edwards & Halawi, 2007). The earliest objective of telemedicine was to assist in the delivery of healthcare to persons geographically remote from physicians or a medical center. As a result, distance between patient and physician played a significant role in driving the cost of healthcare and the volume of healthcare delivery. This meant that patients and providers had to be co-located for care to be delivered. Hence, healthcare was limited by the need to relocate people and equipment, the distances involved, and the speed of information transfer.

The term telemedicine is a relatively recent one; it was first used in 1970 (Stanberry, 1998) leading to the common misconception that it refers to a technological advancement of the late 20th century. In fact, medicine has long made use of various communication technologies; in the broadest sense, telemedicine consultation dates back to the invention of the telephone and radio. Current telemedicine systems originated from developments in the manned space-flight program and separately from the pioneering efforts of a few physicians using off-the-shelf commercial equipment.

One of the first efforts to overcome time and distance barriers was telemetry research and development (R&D) undertaken by the National Aeronautics and

Space Administration (NASA) in its manned spaceflight program (Zundel, 1996). Demonstrating that physiological functions for astronauts in space could be monitored successfully by physicians on earth, NASA's scientists, engineers, and contractors developed sophisticated biomedical telemetry and telecommunications systems for biomedical applications (R. Bashshur & Lovett, 1977).

Telemedicine is being utilized by health providers in a growing number of medical specialties, including but not limited to dermatology, oncology, and radiology, surgery, cardiology, psychiatry and home health care (Chowdhury, Kabir, Ashrafuzzaman, & Kwak, 2009). Fuhmei Wang (2009) stated in his paper "The role of cost in telemedicine evaluation" that the implementation of the telecommunications healthcare system led to an increase in the confidence of physicians and patients and has assisted medical personnel in rural areas as they practice medicine and in ensuring the quality of medical care. Also, according to Urquhart et al, telemedicine is a cost-effective and efficient way to follow up with patients who have undergone surgery, with significant convenience and financial benefits for the patient and healthcare system (Urquhart, Antoniotti, & Berg, 2011).

Modes of Telemedicine Applications

There are two modes of telemedicine operations - store & forward and real time (J. C. Lin, 1999). "Store and Forward" proves to be very efficient in cases where immediate response is not required and applies where the patient and specialist doctor do not have to be present at the same time.

When using Store and Forward mode, patient information is gathered and stored electronically. Specialists can then either log into the system upon the receipt of a notification, for instance, or simply receive a copy of the information by email. The specialist could reply using any suitable media

including email, fax or phone, after analyzing the patient's information and medical records.

Real time telemedicine requires the presence of both parties at the same time (Kale, 2010) and a reasonably high bandwidth communication link between them. Video-conferencing equipment is one of the most common forms of technologies used in real time telemedicine. Real time telemedicine can work in a more efficient way for psychiatry, internal medicine, rehabilitation, cardiology, pediatrics, obstetrics, gynecology and neurology (Ullah, Khan, Sultana, & Kwak, 2009).

Applications of Telemedicine Tools

Many of the references in the medical literature describe projects developed to promote remote consultation and diagnosis via various forms of telecommunications. Way back in 2004, under the Canada Health Infostructure Partnership Program (CHIPP) program, Health Canada supported the development of an interactive videoconferencing network in the Témiscamingue area that linked patients in remote locations and at the residential Centre with physicians in the Centre's emergency department. The project was intended to improve health services in this area, which is a remote region in Quebec (Berube, 2004). According to the Berube, though it was thought to be unlikely that telemedicine services could be adopted in the near future at Pavillon Duhamel, this project led to the development of networking with the Ordre des infirmières et infirmiers du Québec [Quebec Order of Nurses] and the Collège des médecins du Québec [Quebec College of Physicians].

The potential applications for telemedicine encompass the entire field of healthcare, involving a range of providers from general practitioners and specialists in hospitals and research and teaching institutions. Telemedicine

also provides access to medical care in underserved areas; highlighted in the following are a few of the many projects reported in the literature, beginning with the earliest reference located.

Telemedicine in Underserved Regions

Compensating infrastructural deficits related to geographical location is one of the central goals of telemedicine. Many of the first pilot projects in telemedicine were conducted in remote areas with inadequate healthcare access. Telemedicine enabled people in rural areas, conflict and crisis areas, the “Third World”, and on airplanes and boats to be cared for and treated by medical facilities located far away (Norton, Burdick, Phillips, & Berman, 1997; Schmid-Grendelmeier, Masenga, Haeffner, & Burg, 2000).

Critical Care

A 1977 article (Grundy et al., 1977) described how telemedicine was used to solve problems related to the scarcity and poor distribution of specialists in critical-care medicine. According to the authors, an intensive care specialist provided daily consultations to patients in a small private hospital using a two-way audiovisual link with a large university medical center. The project showed that routine consultations in critical care can be provided using an audiovisual link, which is superior to the telephone for these consultations; telemedicine can be a valuable educational resource that can influence the process and probable outcome of patient care.

Moreover, telemedicine can serve as an important link between a small hospital and a large medical center, favorably influencing the quality of critical care of the small hospital.

Home Monitoring

Home monitoring via telephone and television allows doctors to observe the patient's vital signs such as heart rate, respiration rate, blood pressure, and even blood chemistry of patients using transdermal patches that are readily available. Some communities have been experimenting with "lifeline" programs, in which the elderly or disabled wear a panic-button device that automatically summons emergency help when activated. Pacemakers and cardiac-monitoring devices also are being tied into sophisticated communications equipment to transmit vital data (Michaels, 1989). Another clever innovation is the "wanderer" device, which, hooked to confused patients with diagnosis like Alzheimers, Acquired Brain Injury (ABI), degenerative diseases of the brain or confusion, alerts staff at a facility or home when these patients wander outside (Wilkinson, 1987).

Mobile Telemedicine

Mobile telemedicine refers to telemedicine applications in which the participants are mobile and not in proximity with each other. Rather than using stationary equipment, portable communication devices such as mobile laptops, tablets, personal digital assistants (PDAs) and mobile phones are used for healthcare service delivery. Mobile telemedicine can be used to monitor patients at home and during transport, to provide care to patients who are travelling, and in disaster areas. During transport, for example, mobile telemedicine enables paramedics to send vital patient data ahead to the receiving hospital.

There have been a small number of studies on PDA and mobile phone use in telemedicine. Lin et al (2004) describe a system that uses PDAs to provide continuous monitoring of patients during transport within a hospital.

Physiological parameters such as ECG (Electrocardiogram) traces, heart rate, and blood pressure are measured and transmitted from a PDA in real-time through a WLAN (Wireless Local Area Network) to a central unit, from which medical personnel can continuously monitor the patient's condition. A related study described a system that comprised of cardiac event loop recorder and a smartphone gateway, setup by the patients themselves at their homes, that enabled their care providers to provide remote noninvasive cardiac diagnostic services (Sparkes, Valaitis, & McKibbon, 2012).

In a recently published study, (Hsieh et al., 2004) reported the successful use of mobile phones to triage plastic surgery candidates with finger injuries. Transmission technologies and end devices are continually evolving. A satellite terminal can be used for connections at distances that are kilometers apart, and Bluetooth over shorter distances (up to 100 m). Clinical images can also be transmitted to computers via mobile devices using infrared, USB, Bluetooth, or wireless local area network (WLAN) technologies (Braun et al., 2005).

In the 1990s, the standardized Global System for Mobile Communication (GSM) was introduced (Stanberry, 2000). With its low rate of data transmission (9.6 kilobits/sec), it barely allowed transmission of images of sufficient quality. The potential uses in telemedicine of GSM, especially considering related costs, were consequently limited (Y. H. Lin et al., 2004). The newer General Packet Radio Service (GPRS) technology, with a transmission capacity of 50 to 100 kilobits/sec (kbps), provides full Internet access for a mobile phone connected to a handheld computer. The mobile standard of the third generation, Universal Mobile Telecommunication System (UMTS), has a transmission capacity of 384 kilobits/sec and the expanded High Speed Downlink Packet Access (HSDPA) protocol currently allows a maximum transmission rate of 3.6 megabits/sec (mbps). This means that the quality of mobile communications is now approaching that of land lines.

1.4 Telemedicine in Canada: Ontario Telemedicine Network (OTN)

OTN is one of the largest telemedicine networks in the world, helping to deliver clinical care and distance education among healthcare providers and patients using live, two-way videoconferencing systems and related diagnostic equipment. OTN offers a full range of telemedicine services, including videoconferencing, web conferencing, store forward and most recently, Telehomecare (OTN, 2012a). According to OTN's website, OTN recently completed a Telehomecare pilot involving more than 800 patients with one of two chronic diseases - Congestive Heart Failure or Chronic Obstructive Pulmonary Disorder (OTN, 2012b).

OTN's types of installations tend to be expensive. They require special (often customized) hardware deployment and significant bandwidth to operate. Moreover, there is the added need for someone with expertise at the local site to operate the system, work with the patient, and interact with the specialist at the central site. These clearly are not at all suitable for home healthcare support.

TWIVES on the other hand is a system that overcomes the cost and other limitations of the OTN system. Users only need to have regular internet access to fully utilize TWIVES. Moreover, users of TWIVES do not require any special technical knowledge and do not incur any extra costs through the use of the system.

1.5 Objectives of TWIVES Telemedicine Tool

Technological innovations in healthcare, assessments of home-based telemedicine and correlative policies are driven by economic and technological criteria that emphasize cost reduction and technological efficiency (Bauer,

2001). TWIVES is a tool that uses telecommunications and information technology to provide healthcare services (Finkelstein, Speedie, Lundgren, Demiris, & Ideker, 2001) and can be extremely beneficial for people living in rural areas, remote regions and developing countries.

By the use of Mobile Internet Devices (MID), care workers, for example, can connect to clinicians within the system to facilitate the delivery of patient care. The solution eliminates the need to travel to urban-based specialists or general practitioners for basic consultations and follow up visits. Patients could connect remotely with a healthcare provider from home or by visiting a community health center that has Internet access.

Typical TWIVES User Sequence Diagram

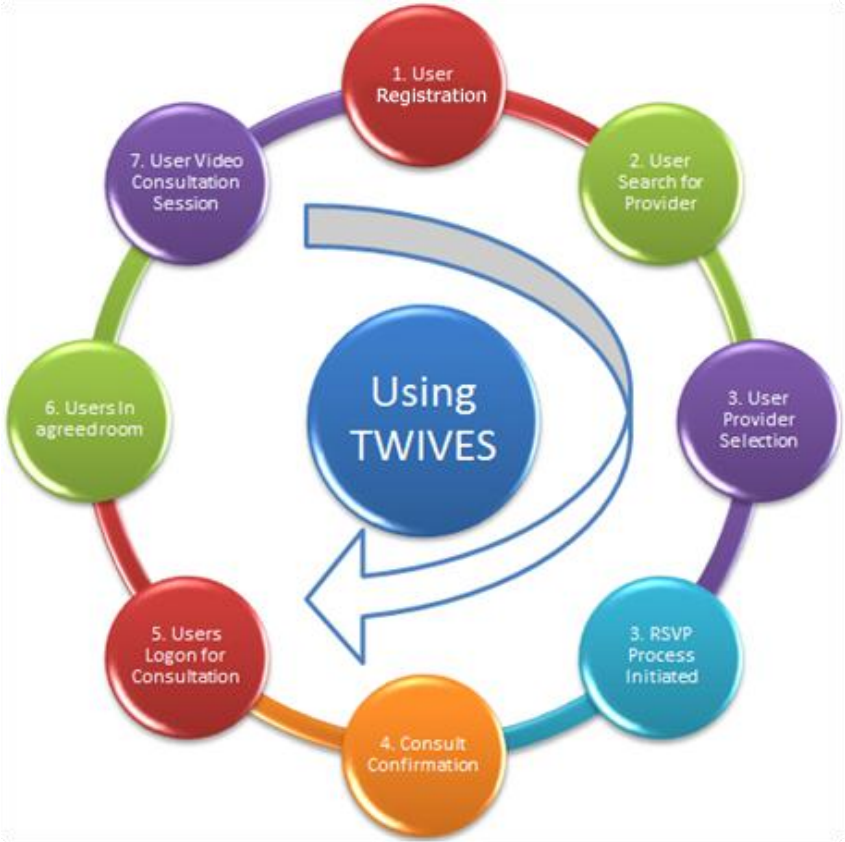


Figure 2: Typical User Registration and Consultation Process

A user is identified as anyone who uses TWIVES: a patient, a clinician, a health support worker, or a care-giver. With TWIVES, users are identified as patients, health support workers, or healthcare providers. For RSVP (Répondez, S'il Vous Plaît) management, the invitation can flow from patient/support worker to provider or vice versa.

Every user has to be registered within the system to use the service. However due to the fact that the providers are the sought-after group, there is a functionality for completing the registration process for them by a systems manager or administrator, where necessary. The registration process has in-built user-management functionalities that enable a systems administrator to enable or disable users (patients and providers). A user could be disabled for a number of reasons including “shopping around” within the system (in the case of a patient), false claims, misrepresentations (in the case of providers) or any other type of fraudulent activities. The framework that the system runs on is robust enough to handle special and specific configurations for the effective management of the patient-provider interactions. For example, it is possible to require that provider and patient must have connected prior through a face to face consultation. During registration, users identify the user group they intend to be associated with. This is to ensure that consultations occur between patients and providers and not between patients or between providers, which is not the intention of this system design.

Figure 2, above, shows how users move through the system once they are registered. The registration process itself is very simple and requires the provision of a valid email address, a unique username and a password. The system uses the email address to initiate the validation process for each user, which may include the direct contact of all newly registered users by system managers before activating their accounts, which introduces a time lag

between registration and the use of the system. The system can also be set to automatically process all users in which case it uses a workflow script to initiate and complete the user validation. In this case, there is no time lag between registration and the use of the system.

Storyboard - Jane Doe

Jane Doe is a 23 year old diabetic woman who lives in a remote area in Northern Ontario. She has limited mobility and moves around either with crutches or in a wheelchair. She was involved in a car accident in Toronto and was treated by a specialist during her hospital stay in Toronto. Upon discharge, she returned home to Northern Ontario but requires follow up appointments with her specialist in Toronto. After the eight hour drive from Northern Ontario, she has on two occasions missed her 30-minute appointment with her specialist, due to traffic. The long drive has also had detrimental effects on her condition. It would be beneficial if Jane Doe could find an alternative way of consulting with her specialist without commuting to Toronto.

The nearest telemedicine center in her region also requires a one hour drive and the setup and booking is an additional challenge. Jane Doe would benefit from a web based video consultation system that she could access from the comfort of her home as shown in Figure 2. TWIVES offers such a solution: easy to use, web-based, and accessible from the patient's home.

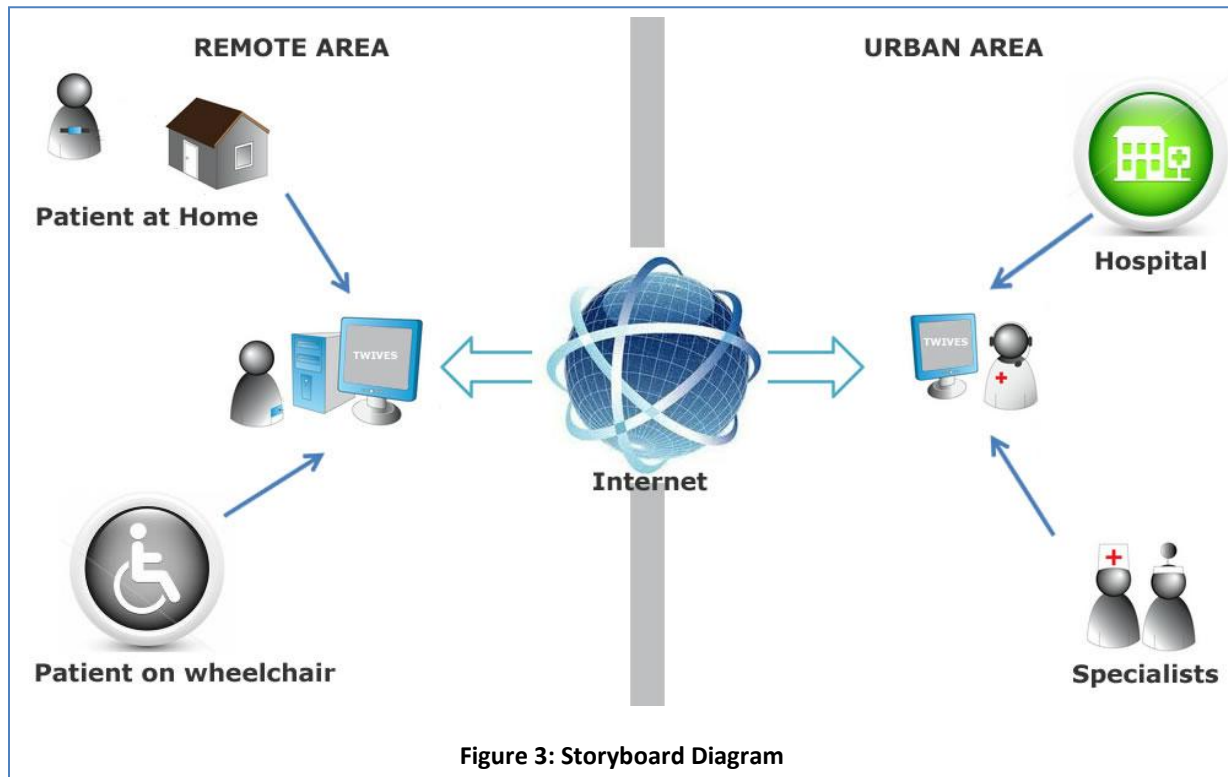
Storyboard - Flow of Events

Registration

Jane Doe goes to the home page of TWIVES and registers with a username, which can be her existing email address and a password. The system sends a confirmation email to Jane's inbox with a link that requests confirmation that Jane owns the email account. This confirmation completes the registration.

Search for Health Care Provider

Jane Doe can now search for the name of her health care provider on the system to book an appointment. Naturally, the specialist would have to be enrolled in the system by registering, just as Jane did above.



RSVP

Jane Doe's search finds her health care provider in the system. She clicks on the specialist's name to reveal a page where she can "invite" the specialist for a consult. The specialist can accept or reject the invitation and can also suggest a new time if there is a conflict. Jane Doe and the specialist will use the Messaging Center to communicate and agree on a date and time for the consultation.

Video Consult

On the agreed day and time of the appointment, Jane Doe and the health care provider will each click on the link provided in the RSVP confirmation email. They both enter a virtual room for the video consultation which can be recorded for documentation purposes. After the session, they both log off and the room becomes inactive. The room may be reactivated for re-use if the need arises. However, once the session is closed, it cannot be recalled by hitting the back button.

Follow Up Sessions

Jane Doe and the health care provider can use the Message Center to schedule their next appointment and the system sends out a confirmation email for any further consults.

Summary of Flow of Events

- i. Patient registers online by using a valid email address
- ii. Patient logs into the system and searches for health care provider by keyword or name
- iii. Health care provider matching keyword or name are displayed
- iv. Patient selects the right physician
- v. Patient sends an invitation to physician's office requesting an eConsult session
- vi. Health care provider's office accepts the invitation
- vii. Health care provider's office and patient use messaging to agree on time and date
- viii. Health care provider's office and patient receive email confirmation
- ix. Patient and health care provider log in at agreed time for consultation

- x. Patient and health care provider can use text chat, audio and video during the consultation
- xi. After consultation, the session is closed and session-variables are destroyed
- xii. Consultation information is stored in secure server.

The above process could work in a developing country, since the primary means of communication are email and phone; these are already used extensively in these countries. Also nuclear families still exist in most developing countries and, therefore, it is very possible for patients to solicit the help of family members in the setup of the consultation. Moreover, the patient still has the option of visiting the local community health center where the healthcare support worker on duty can help set up a session for the patient.

CHAPTER 2

2 UNITED NATIONS MILLENNIUM DEVELOPMENT GOALS AND TELEMEDICINE TOOLS

In 2000, the UN Millennium Declaration was signed by 189 countries, and translated into eight Millennium Development Goals (MDGs) for development and poverty eradication (UN, 2000). These goals are shown in Table 1 below and three of them are directly related to health. The ambitious nature of these goals—which are supposed to be achieved by 2015—coupled with concern about the massive health challenges being faced by the world's poorest countries, has led to a growing momentum within the field of global health (Travis et al., 2004).

2.1 Millennium Development Goals

It is almost certain that the majority of developing countries will not meet many of the other goals. And some whole regions, especially sub-Saharan Africa, will miss them by a wide margin (Clemens, Kenny, & Moss, 2007). There is growing consensus that a primary bottleneck to achieving the MDGs in low-income countries is health systems that are too fragile and fragmented to deliver the volume and quality of services to those in need (Travis et al., 2004).

Table 1: The Eight Millennium Development Goals without the 21 Targets

| | |
|--|---|
| Goal 1: Eradicate extreme poverty and hunger | Goal 5: Improve maternal health |
| Goal 2: Achieve universal primary education | Goal 6: Combat HIV/AIDS, malaria, and other diseases |
| Goal 3: Promote gender equality and empower women | Goal 7: Ensure environmental sustainability |
| Goal 4: Reduce child mortality rates | Goal 8: Develop a global partnership for development |

It was always disappointing that telemedicine and e-health were not included in the specifics of the goals. That always seemed an oversight to the true believers in this community (Merrell & Doarn, 2011). The use of ICTs to promote and facilitate the delivery of health services has been recognized by a number of African countries that have put in place, as part of their ICT for Development (ICT4D) process, ICTs-in-Health (or e-health) policies and strategies to drive their efforts in this area (Dzidonu, 2010).

TWIVES is an application that could help to meet a number of these goals, and it could be scaled for a national roll-out in a developing country as a tool for providing access to healthcare in underserved areas. It is sustainable since users can be trained to offer the TWIVES services for a nominal fee and help others who could not access TWIVES services without assistance. This might be due to lack of Internet access or a lack of the necessary computer skills by potential users.

2.2 International Development Research Centre (IDRC) and Telemedicine

In May 1970, the International Development Research Centre (IDRC) was founded by an act of the Canadian parliament. One of the Centre's priorities was Information and Communication Technologies for Development (ICT4D) (Cormier, Porrett, & Curie-Adler, 2003). The Centre was interested in finding out how ICT could facilitate the provision of health care services to rural and remote areas of developing countries. In the evaluation and selection of suitable applications for funding, the Centre focused on effectiveness, adaptability and sustainability of solutions.

Canada's IDRC did not begin telemedicine projects in developing countries until the late 1990s, because of the generally poor telecommunications infrastructure in existence at that time (Elder & Clarke, 2009). It was not until

the Internet started to become available in developing countries that IDRC began to investigate the potential of telemedicine. According to Elder and Clarke, after numerous telemedicine projects, sufficient evidence has been generated from work carried out by IDRC partners and others to show that implementing telemedicine and e-health applications can have many benefits, including direct benefits to patients.

2.3 TWIVES as a Low Cost Telemedicine Tool

In developing countries of the world and especially in sub-Saharan Africa, there is a shortage of highly trained healthcare providers (Zachariah et al., 2009). There are many reasons why this is so, including brain drain and urban migration. The few available healthcare providers tend to concentrate in urban centers, leaving the remote communities underserved. To receive proper care, rural dwellers either commute to the cities or rely on operators of the local drug stores who act as emergency primary care agents as well as pharmacists. A telemedicine tool that is suitable in this environment should provide value, particularly when it is employed to strengthen and support a local team, rather than simply being used to import expertise from outside to supplement or supplant local efforts (Wootton, 2009).

TWIVES delivers a web-based real time video consult application for care delivery in rural areas. It includes a real-time video communication system which health workers and patients could use to access the services of specialists in distant locations. Most rural communities in developing countries could benefit tremendously from such solutions but they are not likely to have the budgets to set up expensive telemedicine centers. Simple and sustainable solutions as proposed in this work would help bring needed services to these communities.

TWIVES (see Figure 4) is an easy to use, low cost telemedicine tool that is patient-centered, integrated, increases access to care, and improves quality of care. Although it could be used in remote and rural regions of developed countries, it is most suitable for developing countries.



Figure 4: TWIVES as a Low Cost Telemedicine Tool

It is an easily-managed web-based video consult application for care delivery in rural areas, enabling community health workers and enrolled patients to access the services of healthcare providers at distant locations, who would play the role of eConsult Specialists.

The main challenge in developing countries is to improve health services and enable the poorest sections of society to obtain the health care they need (Mather & Ramaiah, 2002). The cost of developing and operating telemedicine solutions is usually too high for poor nations and would require external funding to keep related programs going after initial pilot implementations. If

telemedicine can bring quality health services to isolated and underserved populations at a reasonable price, the benefits will far outweigh the initial capital investment as well as the cost of operations (R. L. Bashshur, 1995). The international community could help this process by promoting fair trade, encouraging debt cancellation swapped for public health sector investment, and ensuring that vital drugs are not denied to poorer countries because of excessive costs and patent periods (Crowley, 2002).

TWIVES was developed to assist users to register, search for, and access available healthcare providers through the system. These providers could be located anywhere in the world but would only become visible and searchable within TWIVES based on their profile settings, through role-based access. Registered and authenticated patients could search for healthcare providers and access treatment through this system effectively, thus saving time, money and effort. (Please see Chapter 6 Discussions: Drupal User Authentication for explanation of user authentication).

CHAPTER 3

3 DESIGN OF TWIVES FOR HEALTHCARE

TWIVES was designed with a combination of two different technologies – one for content management and the other for video streaming. The content management was handled by Drupal while Videowhisper Video Chat script was used for video streaming (See Appendix - Development Technologies, Content and Testing).

There are scores of Content Management Frameworks available today. The most popular open-source CMFs are Drupal, Joomla!, Mambo, MODx CMS, Plone and XOOPS (to name a few) (HeadstandNedia.com & EnterpriseWCMS.com, 2011). The driving force in the development of TWIVES was the utilization of open-source applications. Drupal was chosen to take advantage of its enterprise level content management system and Videowhisper was used because of its performance at limited bandwidth settings.

3.1 Drupal for Content Management

Effective Web design is driven by the need to balance flexibility and simplicity. If a system is too simple, it can only be used for a single purpose - but if it is too flexible, it may be too difficult for new users to learn (Hunter, 2008b).

Drupal strives to reconcile these conflicting goals by providing its users with the tools they need to make their own content management solution, while still providing some prebuilt components to help them get started. Thus, it can be described both as a content management system (CMS) and a content management framework (CMF) - one system which strives to have the strengths of both, without their deficiencies (Esmerel, 2005). (Please see Chapter 6 Discussions: Drupal for more detail).

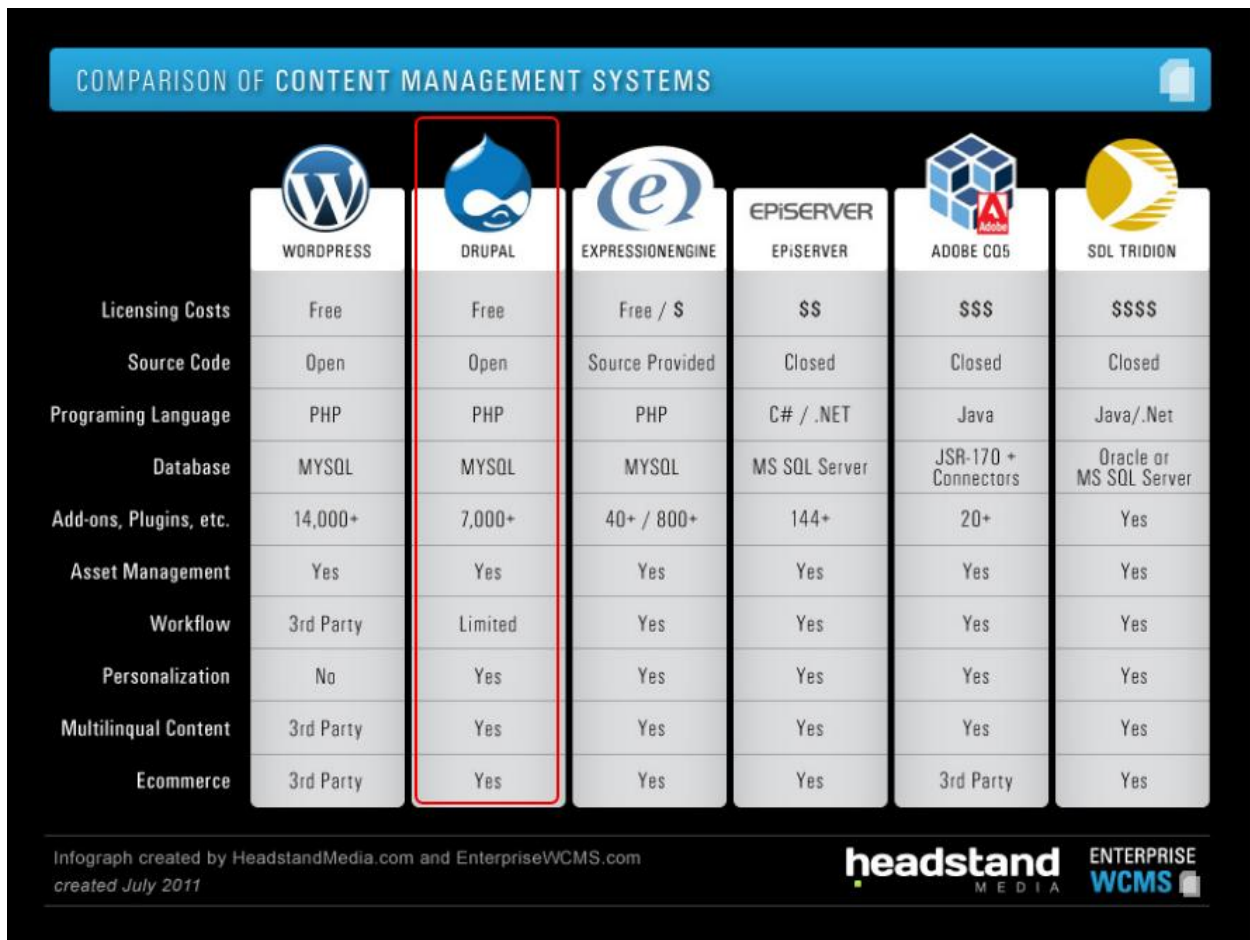


Figure 5: Comparison of Content Management Systems

Drupal Module

A Drupal module is piece of code used for extending the features and functionalities of Drupal. Drupal groups modules into core and contributed modules. The core modules come with a Drupal download and can be used without installation of additional software. The contributed modules, as the name implies, are developed by the user community. Creation of such modules requires a thorough grasp of PHP, Drupal, and Drupal's module Application Program Interface (API).

The development of TWIVES involved the use of more than thirty Modules. This is because certain modules extend the functionalities of other modules, which must be enabled in order for them to work.

Table 2: Non-Core Modules Used in TWIVES Development

| | | | | |
|--------------------|----------------|------------------|----------------|---------------|
| CCK | Features | Content Profile | Date/Time | LoginToboggan |
| Chaos Tool Suite | Feed Parser | Menu Permissions | Image | Image Cache |
| Social Networking | Mail | Access Private | DruTalk IM | Pathauto |
| Faceted Search | Feeds | Node Invite | Profile Search | Profile |
| Taxonomy Menu | Slideshow | Services Server | Invite | Services |
| User Relationships | User Interface | Video Whisper | Views | eCommerce |

Table 2 shows all the non-core modules that were used for the development of TWIVES. More information on these modules can be found at <http://drupal.org/project/Modules> (DRUPAL, 2012a).

User, Permission, and Role

In Drupal, all users are considered users even if they are not registered. Users who have no account are treated as anonymous while those with accounts are treated as authenticated users. Every user has a numeric user ID. Anonymous users are assigned a user ID of zero and authenticated users have a user name and an email address. There are modules for associating more information with users.

Users of the site are assigned permissions through roles. Drupal's permissions are very flexible and access in Drupal is totally controlled through roles. Users are able to access only areas that are permitted by their permission profiles (see Figure 6).

The current design allows system administrators to control access to any part of the website. This way TWIVES can accommodate and support the needs of different groups of users in different geographic locations. For instance, an

authenticated user is a user who has logged in. At a minimum, every user who has logged in is assigned the 'Authenticated' user role. The permissions of every role created for users are editable by the system administrators. If desired, the permissions of the authenticated user role can be limited until the user's authenticity has been verified by a registration authority. What logged in users can see or do on the site is determined by the permissions given to the Authenticated user role, unless users have additional roles assigned to them, such as Administrator. It is important to understand that permissions on the system are cumulative: users with multiple roles have all the permissions assigned to all of their roles. By default the Administrator role is always assigned all permissions available.

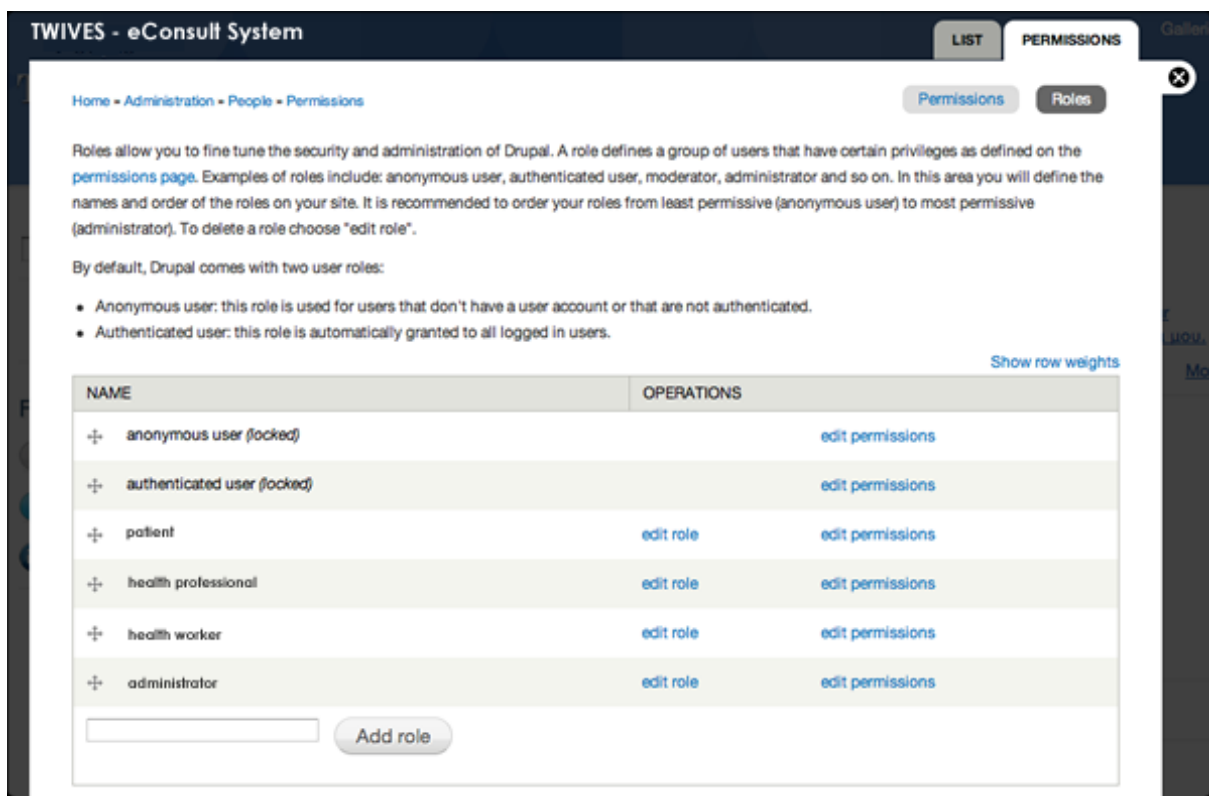


Figure 6: Role Based Access Permission Management View

Node

Drupal uses the generic concept of node for all types of content. Blogs, static pages, news items, and discussion topics in forums are all stored as nodes. Each node on a Drupal site has a content type as well as a node ID, title, creation date, author, body and other properties (see Figure 7).

| Name | Type | Description |
|-------------------------|------------------|--|
| 2 Way Video Chat room | v2wvc | A room that can be used for customized 2 way video chat. |
| Blog entry | blog | A <i>blog entry</i> is a single post to an online journal, or <i>blog</i> . |
| Book page | book | A <i>book page</i> is a page of content, organized into a collection of related entries collectively known as a <i>book</i> . A <i>book page</i> automatically displays links to adjacent pages, providing a simple navigation system for organizing and reviewing structured content. |
| Feed | aggregation_feed | Represents the feed the site aggregates from. Items are generated from feeds during cron runs. |
| Feed | feed | Subscribe to RSS or Atom feeds. Creates nodes of the content type "Feed item" from feed content. |
| Feed Item | aggregation_item | Items are usually auto-generated on cron runs, but this type exists in case you would like to manually add an item. |
| Feed item | feed_item | This content type is being used for automatically aggregated content from feeds. |
| Image | image | An image (with thumbnail). This is ideal for publishing photographs or screenshots. |
| Page | page | A <i>page</i> , similar in form to a <i>story</i> , is a simple method for creating and displaying information that rarely changes, such as an "About us" section of a website. By default, a <i>page</i> entry does not allow visitor comments and is not featured on the site's initial home page. |
| Profile | profile | A user profile built as content. |
| Story | story | A <i>story</i> , similar in form to a <i>page</i> , is ideal for creating and displaying content that informs or engages website visitors. Press releases, site announcements, and informal blog-like entries may all be created with a <i>story</i> entry. By default, a <i>story</i> entry is automatically featured on the site's initial home page, and provides the ability to post comments. |
| Video Consultation room | vconsult | A room that can be used for customized Video Consultation. |
| specialist | specialist | specialist |

Figure 7: Node Content Types used in TWIVES

Taxonomy

Drupal classifies content using a Taxonomy system. The taxonomy module allows users to categorize content using both tags and administrator defined terms.

| Name | Type |
|--------------------------|--|
| + Aggregation Feed Types | Feed |
| + Image Galleries | Image |
| + Specialist | Video Consultation room, 2 Way Video Chat room |

Figure 8: Taxonomy List for TWIVES

This is a core module for implementing taxonomy. Using taxonomy, developers can define their own vocabularies (groups of taxonomy terms) and add terms to each vocabulary. Figure 8 shows the Taxonomy list used for TWIVES.

Database Abstraction Layer

Drupal provides a slim database abstraction layer to provide developers with the ability to support multiple database servers easily. The intent of this layer is to preserve the syntax and power of SQL as much as possible, while letting Drupal control and provide the basic security checks for queries that need to be written differently for different servers (Hunter, 2008b).

Theme

The Drupal theme controls how sites are displayed. This includes the layout, the colors and the graphic look. A theme is made up of PHP files and CSS files. The former outlines the HTML output while the later defines the site's styles.

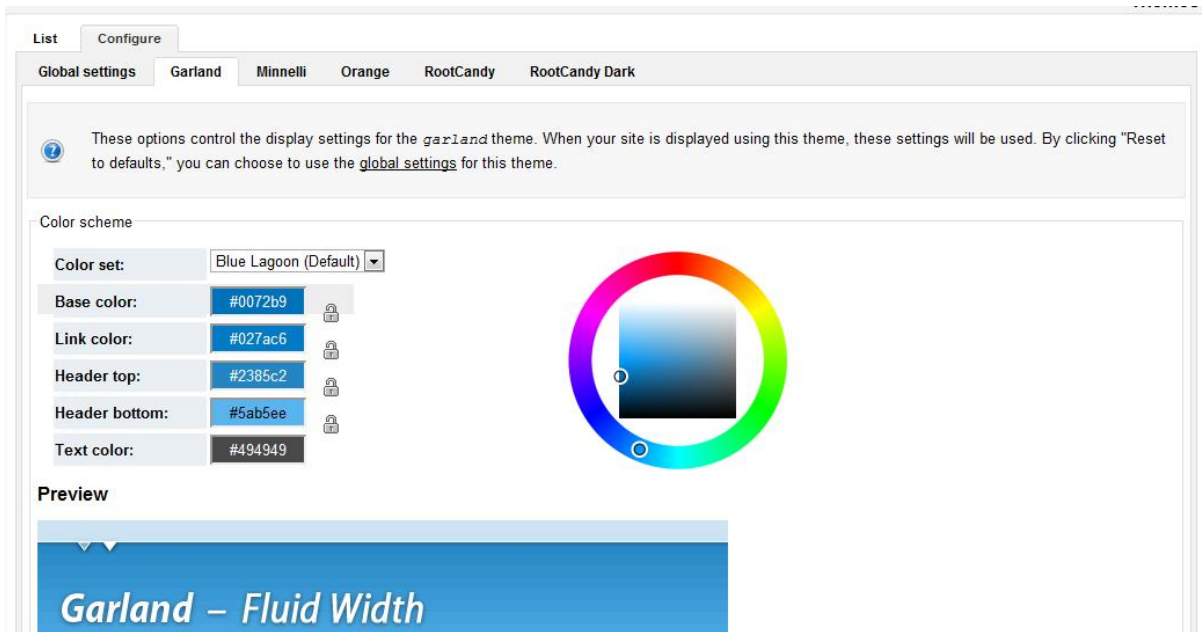


Figure 9: List of Themes Combined To Create TWIVES

The TWIVES theme was created by combining multiple themes available in Drupal (Figure 9). They are Garland Theme, Minnelli, Orange, RootCandy and RootCandy Dark. More information on different Drupal Themes is available at: <http://drupal.org/project/Themes>.

Regions and Blocks

A Drupal layout is controlled by template pages and is divided into regions. These usually include headers, footers, sidebars, and main content sections. More regions can be created by modifying the theme. Blocks are used to display information within regions and can be used to show menus, forum topics, and output data as well as dynamic and static bits of information.

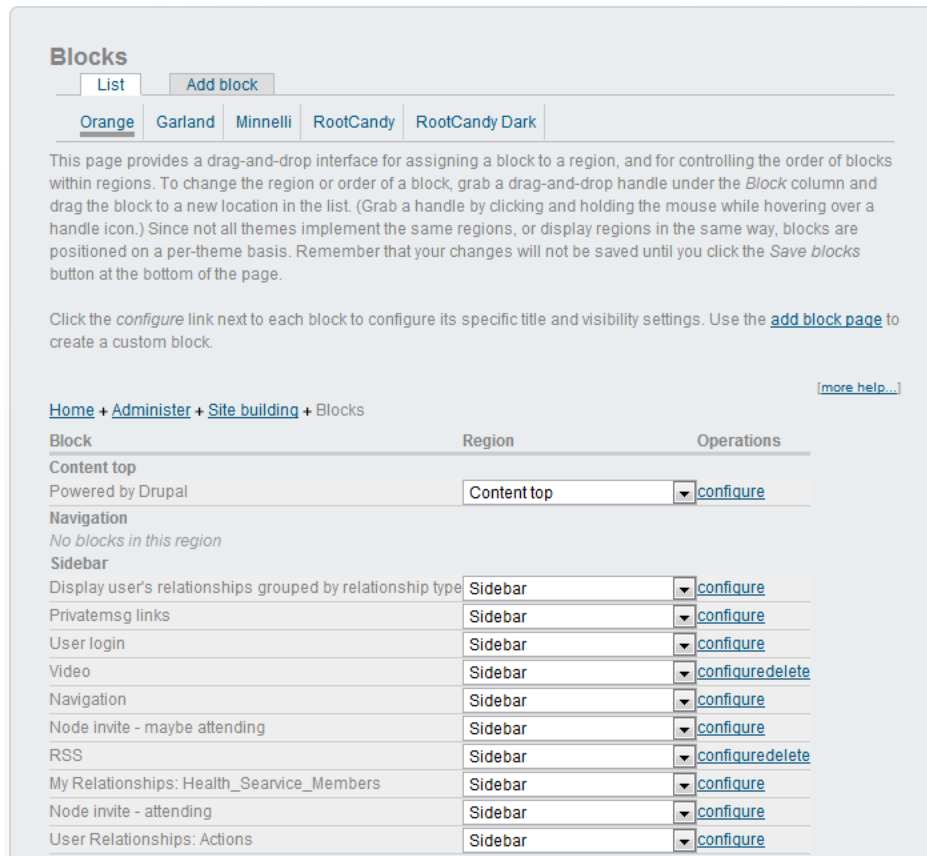


Figure 10: List of Blocks Used in TWIVES

A number of blocks were created for TWIVES. For every one that was eventually used, there are two others that were disabled. Figure 10 shows the screenshot of the TWIVES block list.

Menu

Drupal offers three categories of menus: primary links, secondary links, and navigation. Primary and secondary links are configured by site administrators, and displayed automatically in the page header of many themes. Navigation is the catch-all menu that contains administration menus, as well as links supplied by modules on the site. Custom menus can also be created and displayed by enabling their blocks. A menu item will only be shown to visitors who have the rights to view the page it links to; e.g., the admin menu item is

not shown to visitors who are not logged in (Esmerel, 2005). TWIVES utilized the primary menu for public navigation within the site as shown in Figure 11.

| Menu item | Enabled |
|--|-------------------------------------|
| + Home | <input checked="" type="checkbox"/> |
| + About Us | <input checked="" type="checkbox"/> |
| + Advanced Search | <input checked="" type="checkbox"/> |
| + E-Health FAQs (disabled) | <input type="checkbox"/> |
| + Health Articles | <input checked="" type="checkbox"/> |
| + Sign Up Login | <input checked="" type="checkbox"/> |

Figure 11: Primary Menu Items of TWIVES

Drupal System Flow

Information flow in Drupal is in five layers (see Figure 12). These layers are data, modules, blocks & menus, user permissions, and templates.

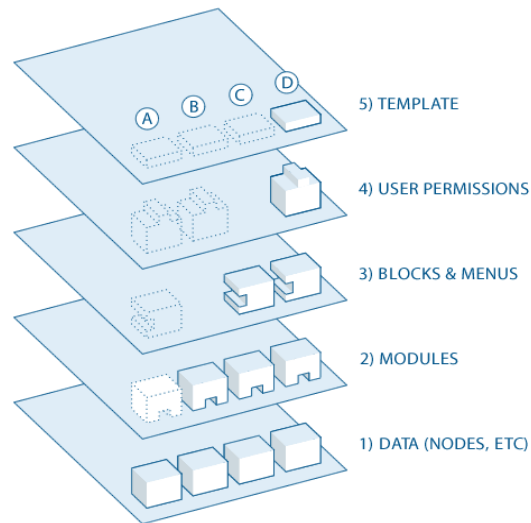


Figure 12: Drupal Information flow (Hunter, 2008a)

The directional flow from bottom to top controls how Drupal works (Hunter, 2008b). Therefore modifications made in the top layers always override those in lower layers.

3.2 Drupal and Security

Drupal security starts with the validation of input data. Therefore it makes extensive use of validation using APIs, an advantage of Drupal over most other sites not built on frameworks. Applications often protect sensitive information by hiding the URLs from unauthorized users, but Drupal uses an integrated access control system whereby every URL in the system must have configured access control.

Drupal also uses cryptographic functions to protect data and credentials. This is particularly useful in the handling of Personal Information (PI) and Personal Health Information (PHI), irrespective of where the data is stored. All passwords are stored using one-way hash, making it very difficult to decipher passwords, even with full access to the database. Drupal also supplies a randomly generated private key for each installation which modules can use to protect sensitive data like credit cards and patient information. As an example, for encrypting and decrypting sensitive information such as computer IPs, non-public email addresses and medical information, Drupal has a module called Client Side Encryption (CSE) which handles encryption with the web browser.

Administrators can configure Drupal (as with PHP) to privately log errors, intercepting them before they ever reach users. Drupal (unlike some PHP applications) never displays password information when experiencing database connection issues. Furthermore Drupal ships with an Apache web server configuration (.htaccess) file that prevents many forms of snooping. The purpose of .htaccess (hypertext access) file is to allow per-directory access

control. It can also override many other configuration settings including content type and character set and CGI handlers.

Other applications frequently fail to encrypt network traffic when it is necessary to protect sensitive communications. As a PHP-based system, Drupal can use Apache's widely-trusted SSL support. With the site protected by SSL, there are modules to control domain access and also directory-level access. As an example, administrators can install certain modules that are configured to ensure that particular URLs are available only through a secure connection. Login, ecommerce, and administration page URLs often have this sort of security configuration (Strauss, 2009).

3.3 TWIVES Drupal Database Design

Drupal uses databases for every type of information, with each dataset having its own database table. In Drupal, every type of content - users, roles, permissions, and various settings - have their own database tables and can also be easily encrypted with the right module (see also Drupal Data Encryption, Security and Privacy in Chapter 6).

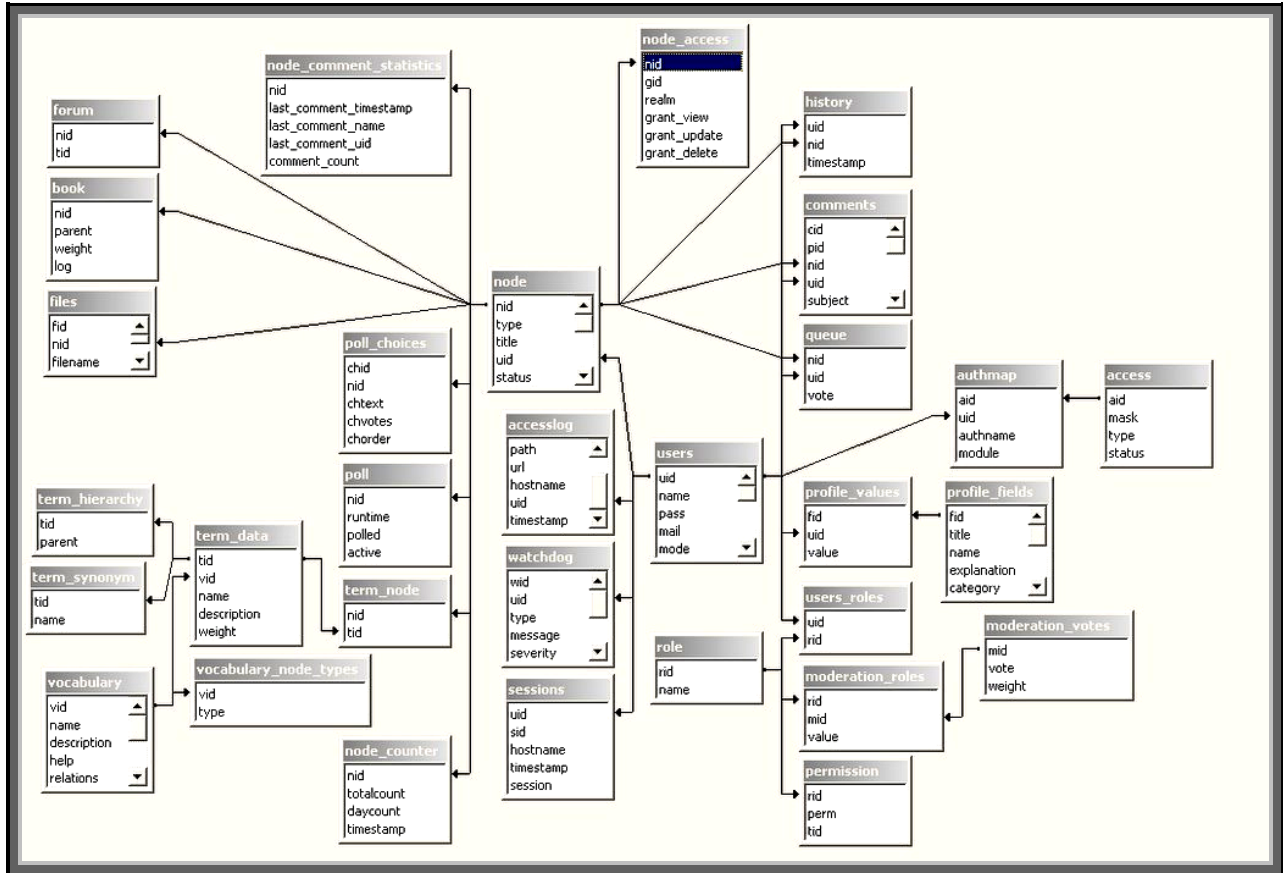


Figure 13: Drupal Core Tables

Figures 13 and 14 above shows the Drupal tables created for the TWIVES database. The tables for the core modules were automatically created by Drupal at installation. The tables are numbered and their respective fields are listed below them. Due to the modular nature of Drupal, fields can have the same names as long as they are not within the same module.

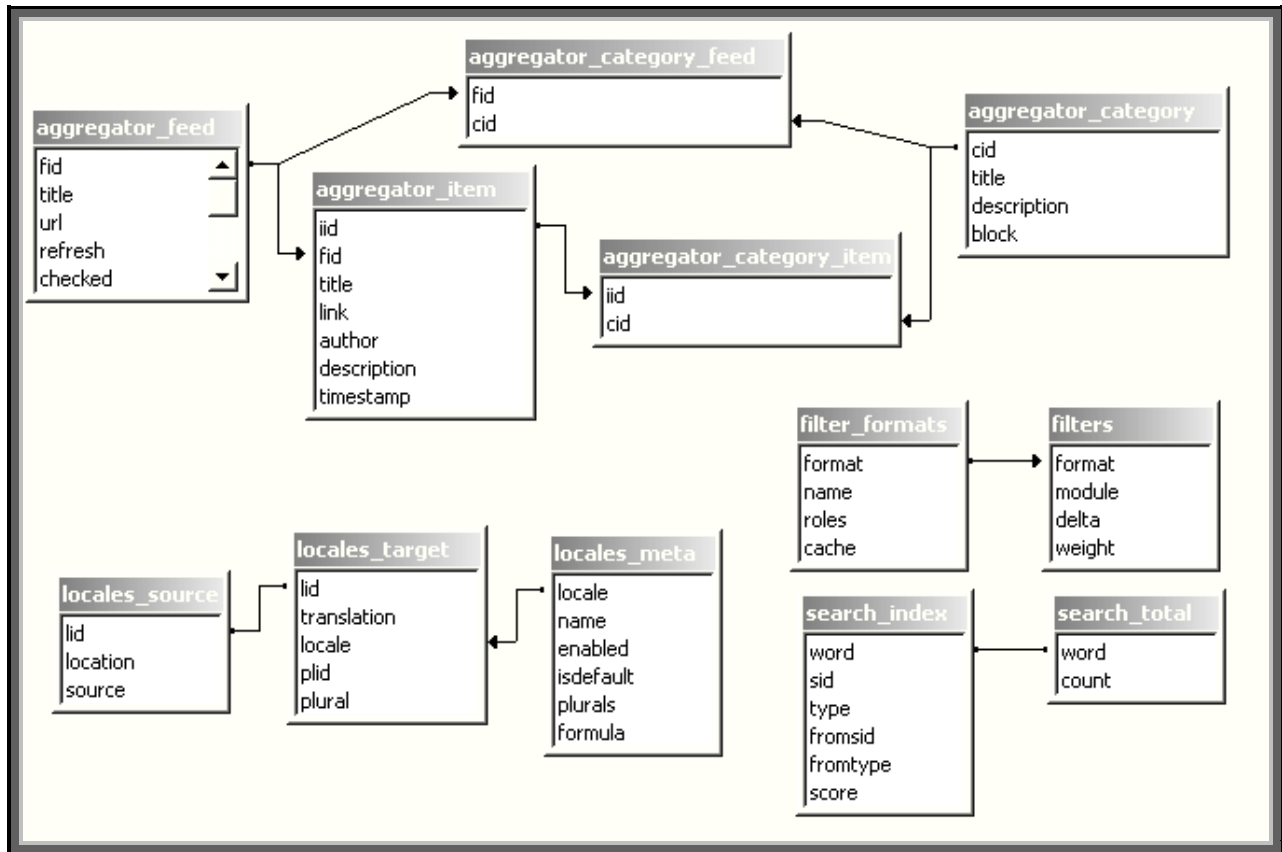


Figure 14: Drupal Non-Core Tables

3.4 Drupal Videowhisper Module & Application

For the development of TWIVES, Drupal 6 Videowhisper Module & Application solution was used (VideoWhisper, 2010).

Through special customization, TWIVES is able to stream live video in real time using Videowhisper script, which utilizes Real Time Messaging Protocol (RTMP) for streaming audio, video and data over the Internet. To accomplish this for TWIVES, Red5, an open and extensible platform widely used for Video Conferences, Multi-User Gaming and Enterprise Application Software development, was installed in a dedicated hosting space as shown in Figure 15 above (see also Appendix - Development Technologies, Content and Testing).

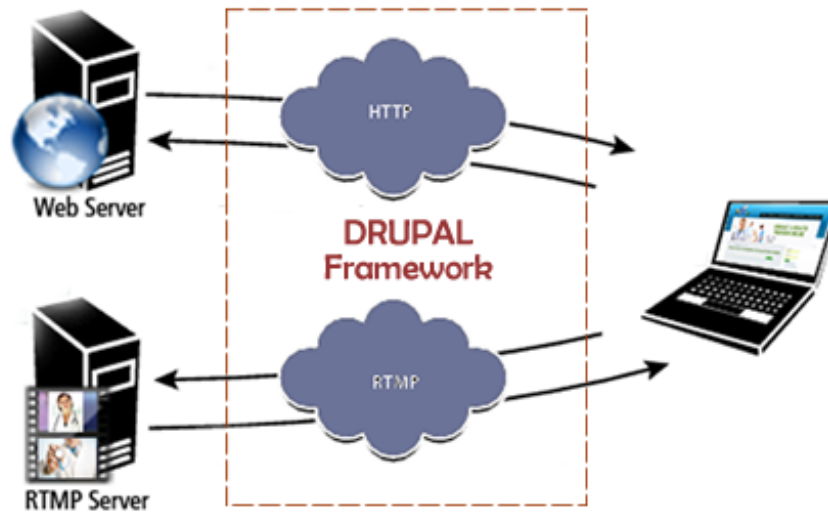


Figure 15: Web and RTMP Server Connections using Drupal

3.5 Design Use Case Diagram

Drupal runs on community version of MySQL and therefore can handle multiple simultaneous sessions by users. The figure below shows the use case diagram used in the design and development of the system. In the scenarios depicted by Figures 16 and 17, a user can be a registered user, an admin or a guest user, depending on the assigned roles.

Authenticated users can conduct searches for available healthcare providers, but guest users are prompted to sign up before they can do so. An authenticated user can select a provider from the list of healthcare providers and view the profile of the provider. If a provider matches the needs of the user (a patient for example) and exists in the system, this user-patient can set up an invitation which the system sends to the provider for acceptance. Both parties can then use the Message Center to confirm the time for the real-time video consult.

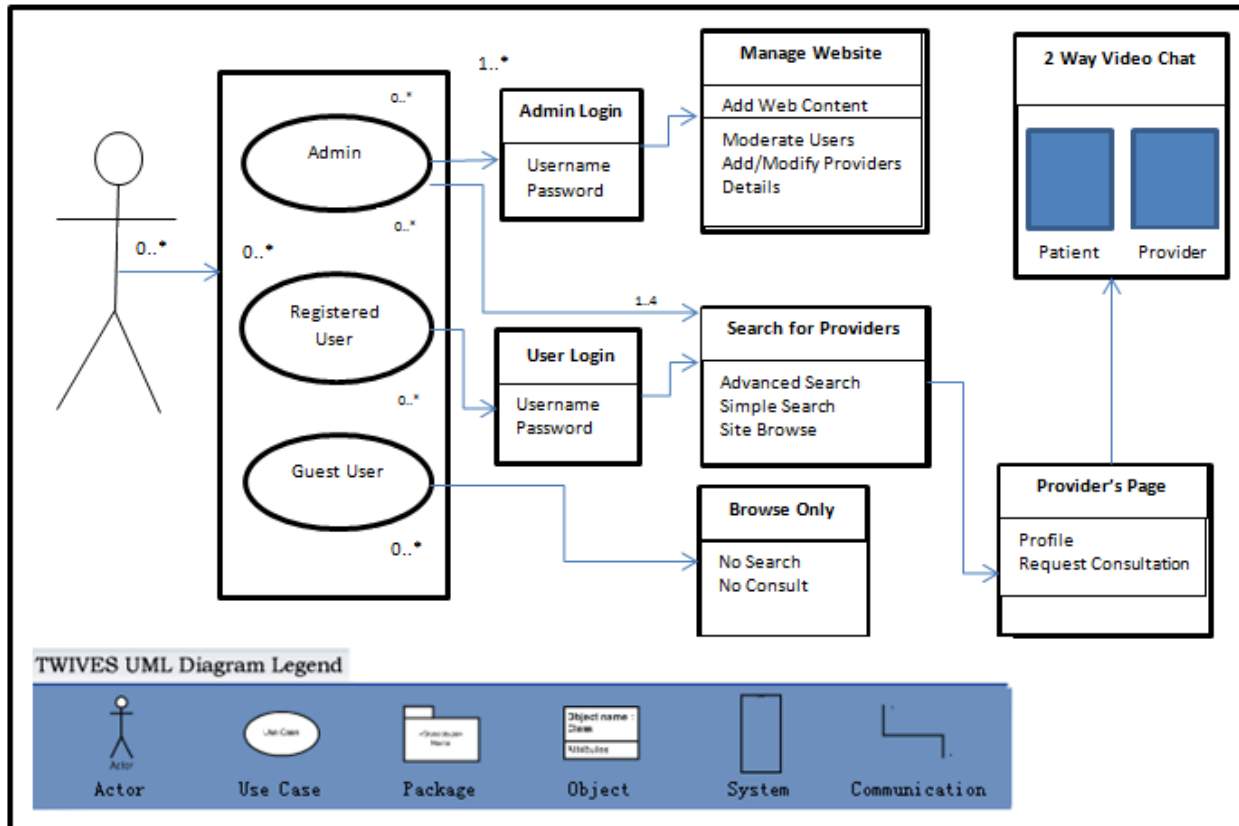


Figure 16: TWIVES Use Case Diagram

| User Types | Enrollment | Search | Invitation | eConsult |
|-----------------------|--|--|---|--|
| Patient | User Registers online by using a valid email address | User searches for Provider by Keyword | System handles RSVP Management and Messaging Service. | Patient and Provider log in at agreed time |
| Provider | Admin validates the user's registration (optional) | System displays all enrolled providers matching Keyword | Provider can accept or reject invitation; system informs all parties of decision by email | Patient and Provider have 15, 30, 45 or 60 minutes consult blocks |
| Support Worker | Admin Assigns permissions or can set system to assign a role to user | User selects/reviews the closest match and invites suitable Provider | Provider and Patient both agree on a time for consult through Messaging Service | During consult, Patient and Provider can chat through the system |
| | Newly registered User receives email confirmation | System sends RSVP email to provider | Provider and patient receive email confirmations | Consultation information is stored in secure server and also retrievable |

Figure 17: Use Case Diagram Explained

3.6 Connecting from Drupal to Videowhisper

User access is controlled by role permissions. Authorized users can create 2 way video consult rooms and send the access links to the providers they are interested in connecting with.



Figure 18: Video Consult Management Page

The Video Consult rooms are created as Drupal nodes and are therefore under the same rules as any node within Drupal. Links are also provided and can be shared by any method desired by the sender (e.g. email, instant message, etc.).

With Drupal integration, room settings, including quality and streaming time, permissions to use features (globally by role and locally by room) can be defined and used to control quality and duration of service.

3.7 Videowhisper Chat Room Creation

To set up a real-time video consult (see Figure 18), TWIVES uses an invitation management system, which is configured to automatically email consultation requests to registered and non-registered users. The system prompts a non-registered user to create an account prior to gaining access to the system.

Coupled with the Messaging Centre, this solution makes it easy to schedule a video consultation between users, in this case between a patient and healthcare provider. At the agreed on time, the user logs on, clicks on the video chat menu item and enters the video eConsult room, without any need to download any additional software (Figure 19). The entire transaction is browser based and works on almost any platform (Windows, Mac OS X, and Linux).

The screenshot shows the TWIVES - Test Video Consult interface. At the top, there are navigation tabs: View, Edit, Invite people, Outline, and Manage invites. Below the tabs is a breadcrumb trail: Home + TWIVES - Test Video Consult + TWIVES - Test Video Consult. The main content is a table with the following columns: Sent to, Sent by, Invite Sent, Status, Acted Upon, and Actions. The table contains seven rows of invitation data.

| Sent to | Sent by | Invite Sent | Status | Acted Upon | Actions |
|------------|---------|--------------------|---------|--------------------|---|
| [redacted] | admin | 04/17/2012 - 10:53 | Yes | 04/17/2012 - 11:40 | View Edit |
| [redacted] | admin | 04/17/2012 - 09:22 | Revoked | 04/17/2012 - 09:44 | Reinstate Edit |
| [redacted] | Marsha | 04/13/2012 - 00:01 | Revoked | 04/17/2012 - 10:57 | Reinstate Edit |
| [redacted] | admin | 04/18/2012 - 20:44 | No | 04/18/2012 - 21:29 | Revoke Resend View Edit |
| [redacted] | admin | 04/18/2012 - 21:28 | Yes | 04/18/2012 - 21:29 | View Edit |
| [redacted] | admin | 04/18/2012 - 21:34 | Yes | 04/18/2012 - 21:40 | View Edit |
| [redacted] | admin | 04/16/2012 - 00:37 | No | 04/18/2012 - 20:58 | Revoke Resend View Edit |

Figure 19: TWIVES Invitation Management System

Participants are initially connected to the room using Real Time Message Protocol (RTMP). In RTMP connection, end-users connect and communicate through the server, which although requires more bandwidth, is important for proper user authentication. However, when both participants are connected, TWIVES automatically tries to establish a peer to peer (P2P) connection using Real Time Message Flow Protocol (RTMFP). Communication using RTMFP enables end-users to connect directly, which reduces bandwidth needs (Please see Appendix A: APPENDIX A: DEVELOPMENT TECHNOLOGIES, CONTENT AND TESTING; Figure 48). Conversely, if P2P doesn't work due to client connections, TWIVES switches to TCP-based RTMP connection.

3.8 Videoconferencing Bandwidth Requirements

Voice-over-IP (VoIP) commonly refers to the communication protocols, technologies, methodologies, and transmission techniques involved in the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. VoIP has become popular in the wired Internet because of easy-to-use applications with high sound quality like Skype (Baset, 2004).

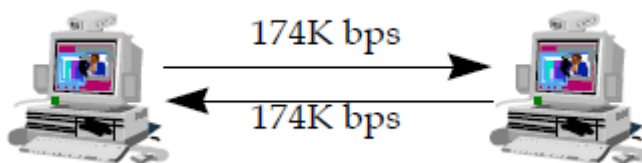


Figure 20: Simple Point to Point Videoconferencing Session

Bandwidth availability plays a very important role in the quality of VoIP and video communication alike. Each client in a videoconference sends audio and video information into the network and receives information from the network. A simple point-to-point videoconference is shown in Figure 20.

A simple VoIP connection, like LAN 3.0, uses approximately 174Kbps of bandwidth in each direction when using its 174K bandwidth option. The two directions are shown here as two different traffic streams. Each client sends audio and video data to the other client. Bandwidth utilization for this configuration is 174Kbps on a full duplex link (for example, a T1 or a full duplex Ethernet), and 348Kbps for a half-duplex link (Bartlett, 1997).

Table 4 shows the bandwidth requirements for a number of audio-visual communication clients that use H.323 protocol. The first two columns indicate one-way and bidirectional bandwidth respectively. One-way bandwidth is what is seen on each side of a full duplex link. The bidirectional bandwidth is what is seen on a shared LAN segment, such as a normal Ethernet (Boggs, Mogul, & Kent, 1995).

Table 3: Videoconferencing Client Bandwidth Requirements (Kbs)

| | One Way | Bi-directional | Audio Coding | Video Coding |
|-----------------------|----------------|-----------------------|----------------------------|-----------------------|
| Skype | 20 | 40 | NA | VP7 |
| Netmeeting 2.0 | 64 | 128 | G.723 3.4 KHz - 6.4Kbps | H.263 QCIF 176x144 |
| LAN 3.0 | 174 | 348 | G.722 7 kHz - 64Kbps | H.261 FCIF 352x288 |
| TWIVES (FLASH) | TBD | TBD | AAC | H.264 |

H.323 is an International Telecommunication Union (ITU) Voice over IP (VOIP) protocol for multimedia communication (voice, video, and data conferencing), as well as applications where interworking with the PSTN is vital. H.323 was designed from the outset with multimedia communications over IP networks in mind, making it the perfect solution for real-time multimedia communication over packet-based networks (Lange, 2011).

Since 2005 Skype has employed the proprietary Video Codec TrueMotion VP7 provided by On2 in order to manage one-to-one videoconferencing. The Codec supports real-time video encoding and decoding using a "data rate control"

which adjusts frame quality, video resolution and number of frame per seconds to adapt to bandwidth variations (De Cicco, Mascolo, & Palmisano, 2011). Using VP7, On2 claims to provide video transport starting from bit rates as low as 20 kbps; no information is provided on their maximum bit rate (On2-Technologies, 2005). Due to its closed source and proprietary design, Skype protocols and algorithms are unknown. Strong encryption mechanisms have been adopted by Skype, making it very difficult to even glimpse its presence in a traffic aggregate (Bonfiglio, Mellia, Meo, Rossi, & Tofanelli, 2007).

Videowhisper applications at default settings require 50kb per second each in order to stream quality audio and video. For a two way duplex operation, this requires 400 kbps (50kbps x 2 forward channels x 2 backward channels x 2 users). Multiplied by 3600 seconds in an hour and adding communications required for extra features adds up to about 0.2 GB per user per video per hour. This is the main reason why TWIVES is hosted on a dedicated server and interactions between users are limited to one-on-one only.

CHAPTER 4

4 TWIVES DEPLOYMENT

TWIVES was developed with the Drupal Framework to take advantage of the modular nature of Drupal. Drupal modules are like plugins and allow easy addition of functionalities and expansion of the features of a site. This adds a level of flexibility, allowing the addition of more features and functionalities as the need arises, by simply creating and enabling the proper module.

4.1 TWIVES – The Pages

TWIVES – Home Page

A screenshot of the landing page of TWIVES is shown in Figure 21; it highlights the page structure.



Figure 21: The Landing Page of the TWIVES Application

The look and feel of the entire page is controlled by a template file (~/page.tpl.php), which divides the page into regions: header, sidebar, top-body, lower-body and footer regions. Content can be placed in any region.

The template file can be customized to suit the cultural sensitivities of different groups using the system. There are ways to configure the file to display culturally suitable images and illustrations, depending on the location of the users.

The main menu resides at the top right corner and a logo on the top left corner of the header region. The menu is controlled by a module and therefore can be modified quite easily. Below the menu is the slideshow which again can be edited to add information that could be useful to users. To further promote ease of use, the search functionality is presented boldly. By design, users have to be registered in the system to be able to connect with healthcare providers.

TWIVES - Search Page

TWIVES search is located at the center of the main page, as shown in Figure 22. The purpose of the search is to enable users to quickly find a healthcare provider to help them.

The search functionality makes it easy to find information within the system, especially when users are accessing the system through a proxy or a helper, like a community health worker who uses one general account to help multiple users. Only registered and authenticated users are allowed to use the search functionality. This encourages user registration and proper support. For searches that are more in-depth, the Advanced Search functionality described later in this chapter is used.



Figure 22: TWIVES Application Search Page

TWIVES - Registration Page

Every user has to be registered with the site. Non-registered visitors can only see the areas of the site that the site administrator has made public. The registration process is made simple by design, so that in times of emergency, the process would not constitute a bottleneck.

Users are only required to provide a valid email address, and to choose a username and a password (Figure 23). In order to maintain account integrity and eliminate the issue of multiple accounts, the system checks the user-table in the database before an account is created to see if the supplied email as well as the username has been registered before.

A registrant is notified and prompted to supply a new username or reminded to log into an existing account with previously provided credentials. The administrator can also create an account for a user and the registration

information is then sent to the user's email address with a confirmation link that activates the account when accessed.



Figure 23: TWIVES Registration Page

Registered users are added to the authenticated-user role by default. Based on their area of interest, user permission and access levels are assigned and can be changed as needed (Figure 24). For example, it is very easy to create a role for all users logging in from a particular geographic region, which gives them information that is tailored to their area without being affected by the experience of users from other geographic regions.

| Permission | health_professional |
|---|-------------------------------------|
| administer taxonomy | <input type="checkbox"/> |
| upload module | |
| upload files | <input checked="" type="checkbox"/> |
| view uploaded files | <input checked="" type="checkbox"/> |
| user module | |
| access user profiles | <input checked="" type="checkbox"/> |
| administer permissions | <input type="checkbox"/> |
| administer users | <input type="checkbox"/> |
| change own username | <input type="checkbox"/> |
| user_relationship_node_access module | |
| grant delete permission to related users | <input checked="" type="checkbox"/> |
| grant update permission to related users | <input checked="" type="checkbox"/> |
| grant view permission to related users | <input checked="" type="checkbox"/> |
| user_relationships_api module | |
| can have relationships | <input checked="" type="checkbox"/> |
| user_relationships_ui module | |
| administer user relationships | <input type="checkbox"/> |
| maintain own relationships | <input checked="" type="checkbox"/> |
| view user relationships | <input checked="" type="checkbox"/> |
| v2wvc module | |
| access 2wayvideochat room | <input checked="" type="checkbox"/> |
| administer 2wayvideochat | <input type="checkbox"/> |
| create 2wayvideochat room | <input checked="" type="checkbox"/> |
| delete 2wayvideochat room | <input checked="" type="checkbox"/> |

Figure 24: Partial View of the Permission Matrix for the Health Provider Role

TWIVES - User Login

Every user in the system - patients, healthcare providers, system administrators – has to be registered prior to using the system. This registration process issues users unique usernames and passwords. As explained earlier, access to different sections of the site is role-based and each role has a permission matrix that controls access to all areas of the system.



Figure 25: TWIVES Login Page

Every user is assigned a role and the profile of that role defines the level of access and privileges available to the user. Each role can contain any number of permissions. A user can be in any number of roles and therefore receives the sum of the cumulative permissions belonging to these roles - users with multiple roles have all the permissions assigned to all of their roles. By default, the Administrator role is always assigned all permissions available.

To login, users simply supply their usernames and passwords (Figure 25). If they have forgotten their credentials, the site offers them a way of retrieving them.

TWIVES - User Profile Page

The profile page is a dashboard for users that shows what they have access to within the site.



Figure 26: TWIVES User Profile Page

It can also be extended to capture demographic information from users when required. The profile page becomes a great tool for system administrators when they require the input of users. The profile page could be used for targeted marketing, education, and interactions with the user like programing

personalized reminders and alerts for both patients and providers or for disseminating public health information useful to their geographic region.

As shown in the screenshot in Figure 26, users can also send and receive private messages to the healthcare providers they are dealing with. Another advantage with the Drupal-based system is that it is possible to add more features and functionalities to the profile page by means of an Advanced Profile module. These profiles would be useful for gathering information from users and could be enabled in TWIVES as the need arises.

TWIVES - eConsult Page

The screenshot of the TWIVES eConsult page appears in Figure 27.



Figure 27: TWIVES Video Consult View

The eConsult itself is recorded and stored in a database. At the top right is the exit button for ending a video session. Video eConsult sessions' information is

stored in cookies. For security's sake, the cookie does not contain personal information but acts as a key to retrieve the information stored on the server's side. When a user accesses the site, Drupal will check whether a specific session ID has been sent with the request. If this is the case, the prior saved environment is recreated. Once a session is ended all session objects are destroyed and users are directed to the landing page. The consult page has an embedded-code that makes it impossible for a user to go back to the video session page using the back button. This safeguard was added to protect the interests of users connecting with the video eConsult through proxies; once the session is ended in their presence, proxies cannot access their eConsult session.

The eConsult page runs on the Videowhisper Video chat module, which was developed with Adobe Flash. There are settings for controlling the audio, video and the side of the window that the patient wants to be on. This becomes important when a patient is sitting in front of the eConsult window with a third party like a nurse. By changing the display from left to right, a patient might feel more comfortable and communicate better with the healthcare provider at the other end. The settings made at one end of the eConsult are localized and do not affect those made at the other end.

TWIVES - Health Articles Page

The TWIVES Health Articles page is populated using Really Simple Syndication (RSS) feeds. Aggregators reduce the time and effort needed to regularly check websites for updates, creating a unique information space or personal newspaper. Once it has been subscribed to a feed, an aggregator is able to check for new content at user-determined intervals and to retrieve any updates (Wikipedia, 2012). The sample shown in Figure 28 utilizes a JAMA Current Issues RSS Feed.

The decision to use RSS feeds to populate this page was driven by the need to make available to a range of users, medical information for educational purposes from trusted sources. The feed can also be changed to reflect the needs of a particular group of users.



Figure 28: TWIVES EHealth Articles Page Populated With Feeds Aggregation

Additionally, the page can be configured to display feeds from multiple vendors and can also display non-RSS feed content.

TWIVES - Advanced Search Page

The TWIVES advanced search page is designed to help users search for hard-to-find information using keywords (Figure 29). The search algorithm used here is customizable and it could be configured to search the entire site, including archived data. It is also possible to exclude sensitive information especially those related to eConsult Videos, conversations and test data.

By the use of the role based access control process in place within the system, the search algorithm is easily modified to accommodate any changes in the needs of the users. There are advanced options possible with this search module.

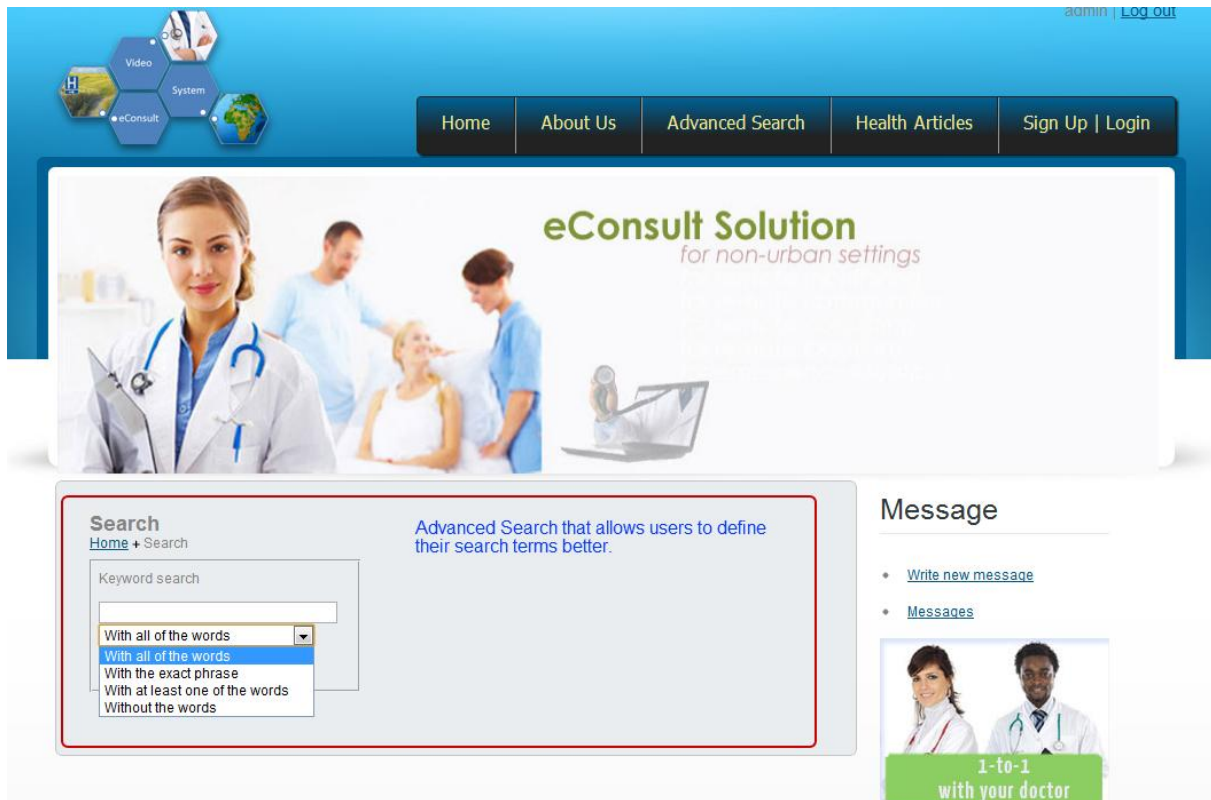


Figure 29: TWIVES Advanced Search Page

For the management of this functionality, advanced users with the right permissions (in this case with admin privileges) can change the default search box label, add default text to the search box, add advanced search criteria, change the default submit button text, use an image instead of the submit button and add a filter to the results page.

TWIVES – About Us Page

The About Us page briefly explains what the site is all about (Figure 30). The content presently in place is minimal by design but more can be added to suit the needs of users.



Figure 30: TWIVES About Us Page

Knowing that this is one of the first three pages that visitors go to when they visit a website (Nuesion, 2012); the page has been structured to allow for easy content development and editing. It is also possible to have different pages included that are specialized for access by different user groups in different geographic regions.

TWIVES - Contact Page

Figure 31 shows the Contact Us page, which allows user to send messages to the site administrators or webmasters. It has a very user-friend look and feel, automatically inserting the email address of the user into the right field.



Figure 31: TWIVES Site-wide Contact Page

The contact form can be modified to have categories of issues that a user can select from. It is also possible to assign specific admin users to specific issue

categories. For example, there could be an admin user assigned to eHealth Articles issues, another to handle Video eConsult session issues and user registration, etc. The contact module is very flexible and scalable.

Also to ensure that only validated users access the Contact page, extra security is provided with a CAPTCHA code which adds another layer of authentication for users. CAPTCHA is a program that can generate and grade tests that humans can pass but current computer programs cannot. They are usually used to prevent spamming, protect website registration, control online polls, prevent directory attacks, and protect a site from search engine bots. Generally, CAPTCHAs are used wherever there are web forms to be completed.

TWIVES - Message Center

The TWIVES message center is shown in Figure 32 below. By default, messages can only be sent to other registered users in the system.

There is an inbuilt code that searches a temporary names database and displays the names that closely match the letters typed in. The admin can also restrict the access of users, controlling who they can contact. For example, permissions can be set so that users can only contact the healthcare workers who have granted them the right to contact them.

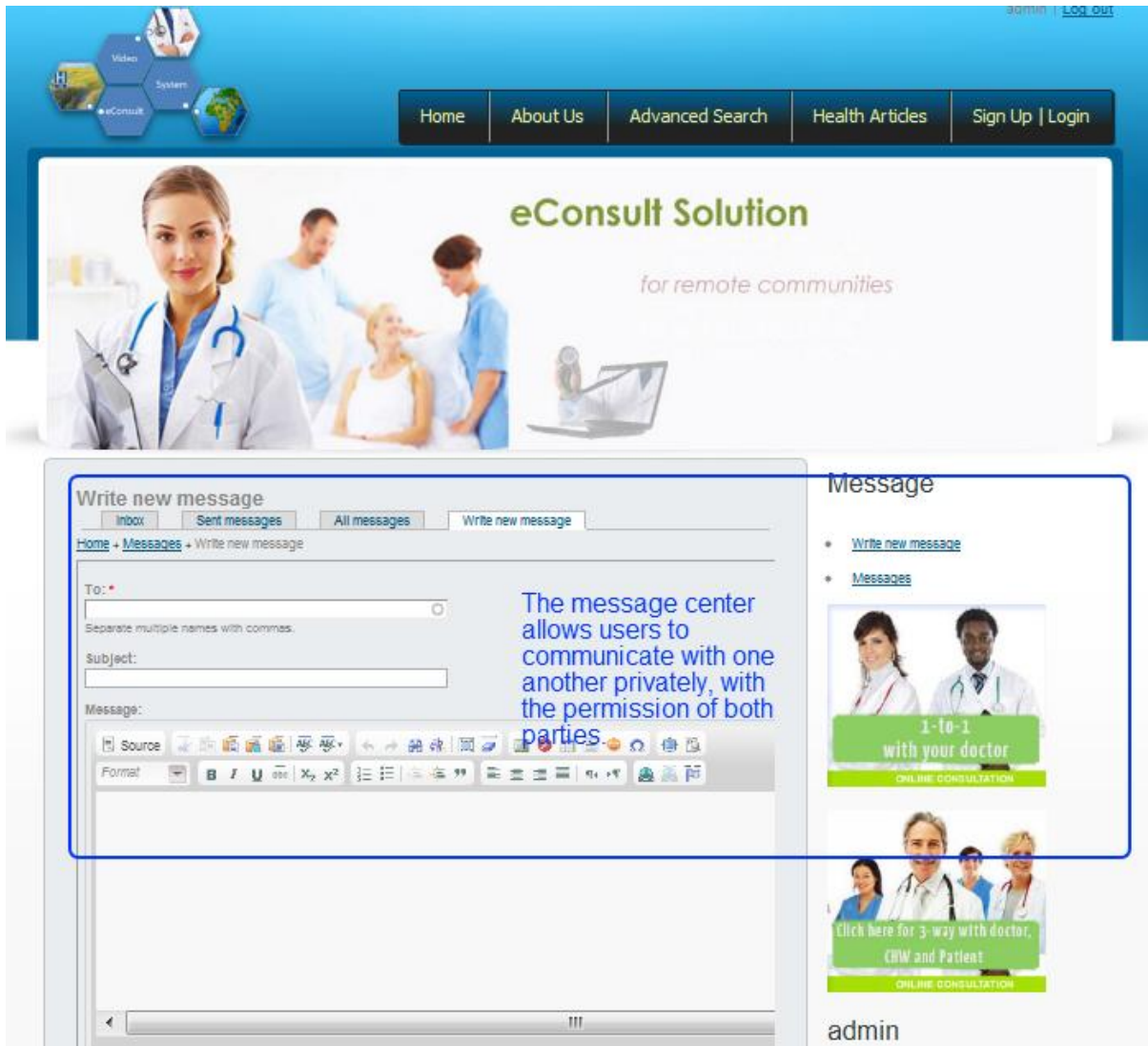


Figure 32: TWIVES Private Message Center Page

TWIVES - Invitation Page

TWIVES works by registering healthcare providers within the system. In order to make the enrollment process easy, the invitation module was created.

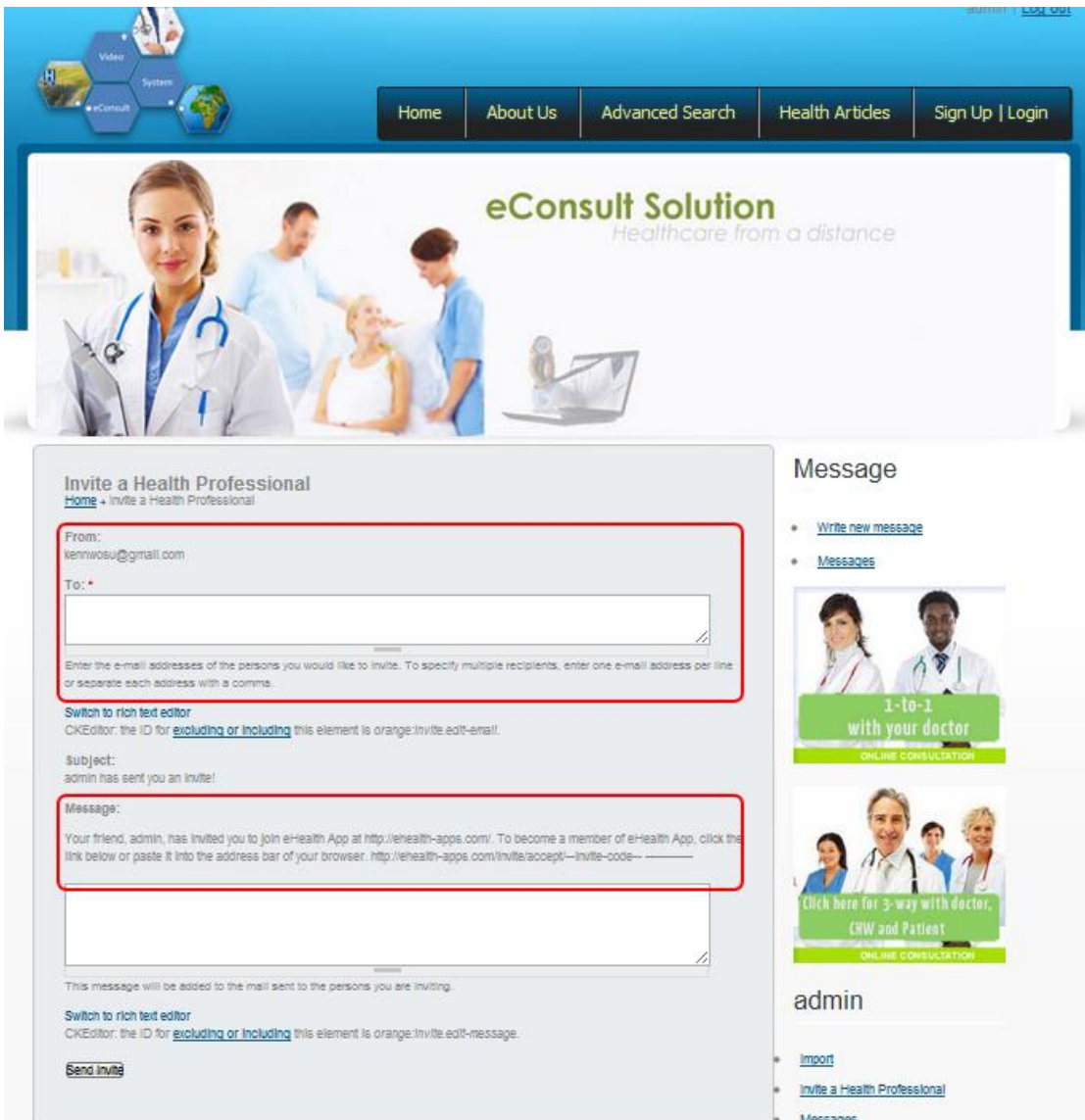


Figure 33: TWIVES eHealth Articles Page Populated with Feeds Aggregation

It offers users the ability to communicate privately with other users. In the case of TWIVES, this feature enables private emails between patient and healthcare providers on their list.

To set up a video consult, an admin sends an invitation to the provider which is delivered via email (Figure 33).

When the provider opens an incoming mail message, there is a link embedded which leads the provider to the website's registration page.

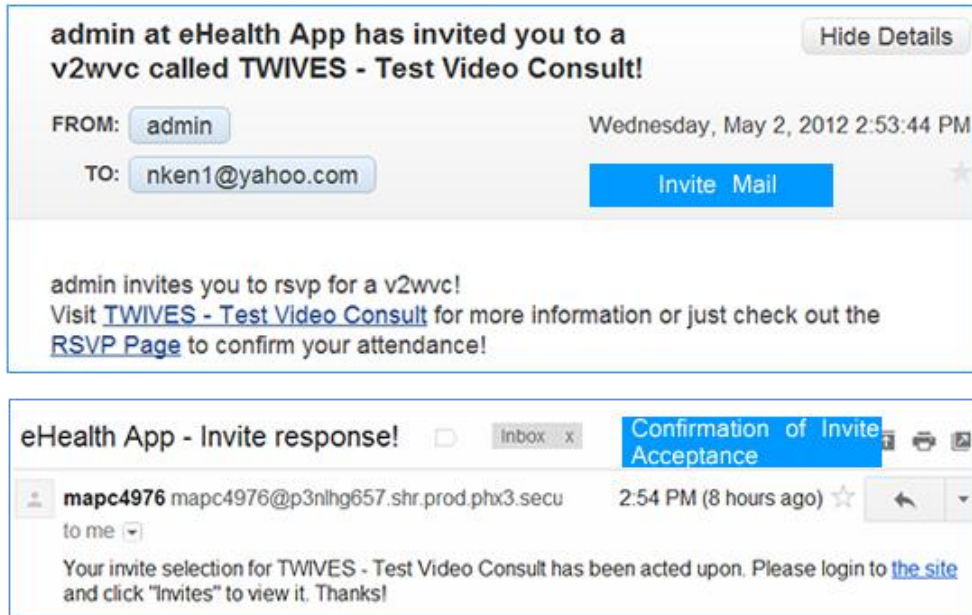


Figure 34: Samples of Confirmation Emails for an Invitation and Response

The confirmation emails are shown in Figure 34 above. The contents of the confirmation emails are customizable.

The image shows a web form titled 'TWIVES - Test Video Consult!'. Below the title, it says 'Use this form to confirm (or deny) attendance.' The main question is 'Will you accept this invite?'. There are three radio button options: 'Yes', 'No', and 'Maybe'. Below the options, it says 'You are RSVPing as admin. If this is not you, please click here.' At the bottom of the form, there is a 'Reply' button.

Figure 35: RSVP Confirmation Page

For the invited user, clicking on the RSVP link opens the RSVP page where they can choose to either accept the invitation or reject it as shown in Figure 35 above.

CHAPTER 5

5 INSTALLATION, CONFIGURATION AND TESTING

TWIVES is made up two components – a regular web server for the Content Management System (Drupal) and a Flash server for video streaming. This chapter describes the installation and testing of TWIVES. The testing covered components of System Integration, Performance, Functional and Security testing. User-acceptance testing was not conducted as this was a POC system.

5.1 Installation and Configuration

To install and run Drupal the web host must meet certain minimum requirements. Most web hosts meet these requirements (Kennedy, 2003). A minimum base installation of Drupal requires at least 15MB of disk space. TWIVES takes 10GB of disk space. For a web server, Drupal works in Apache 1.3 or Apache 2.x hosted on UNIX/Linux, OS X or Windows. TWIVES is hosted in a LINUX environment running Apache 2.x. On a database server, Drupal 6 supports MySQL 4.1 or higher. TWIVES runs on MySQL 5.0. For the PHP Version, TWIVES was developed in PHP 5.2.x which meets this requirement.

The Videowhisper video component runs a dedicated Virtual Private Server (VPS). Before installing Videowhisper, Red5 open source Flash RTMP server was deployed and the server hardware configuration set to allow for medium level traffic.

5.2 System Integration and Performance Testing

Different types of testing were conducted at different stages of the development of TWIVES. Unit testing was conducted at the development level as new functionalities were added.

Load Analysis with Pingdom Tools

The pages of TWIVES were tested individually with Pingdom. This was done by entering the full URL of the tested page into the textbox provided on the website <http://tools.pingdom.com/fpt/>. First to be tested was the landing (home) page of TWIVES and the results obtained are shown in the series of images below (Figures 36 – 39).

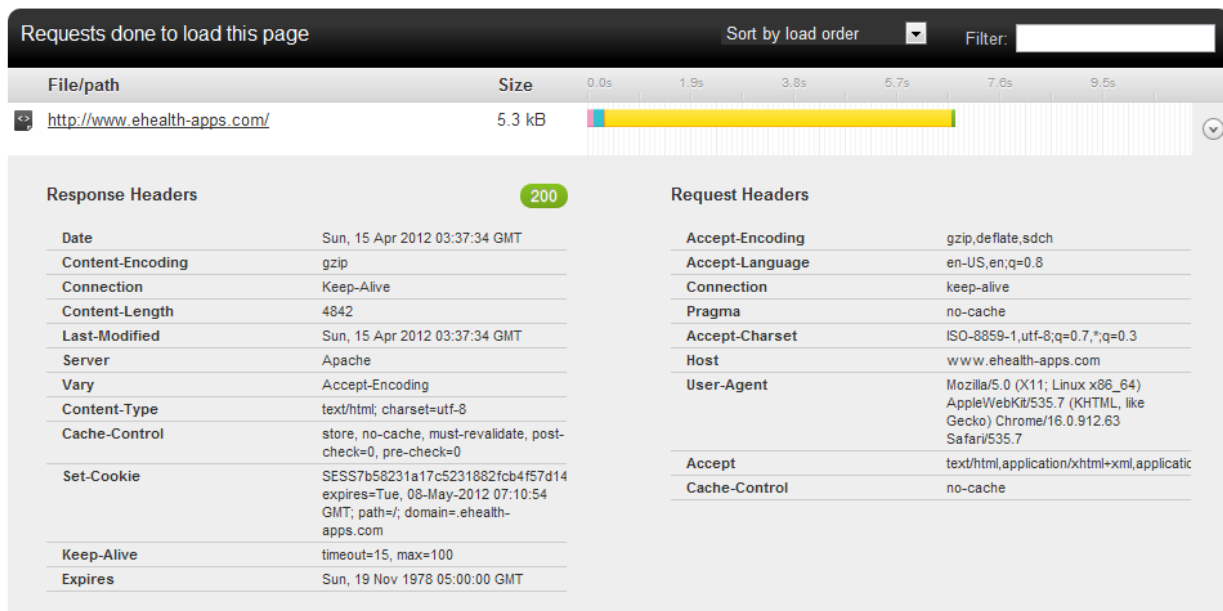


Figure 36: Landing Page Full-Page Analysis

Figure 33 above shows the result of testing the home page: the size of the HTML codes on the page is 5.3kB, which is optimal and makes the page easy to load for users with low bandwidth internet connections. The result shows that the cookie on the browser is set to expire in three weeks. Cookies are used to store session states on the client side which leads to reduced server memory footprint and the potential for lower response latency.

Figure 34 shows the result of the page speed performance test conducted on the landing page of TWIVES. Internet networks transport information by the use of data packets and most networks limit the size of data packets to 1500

bytes. Therefore it is a good design practice to ensure that HTTP requests can fit into a single packet by making the request less than 1500 bytes. Where this number is exceeded, a minimize request size call is made by the network.

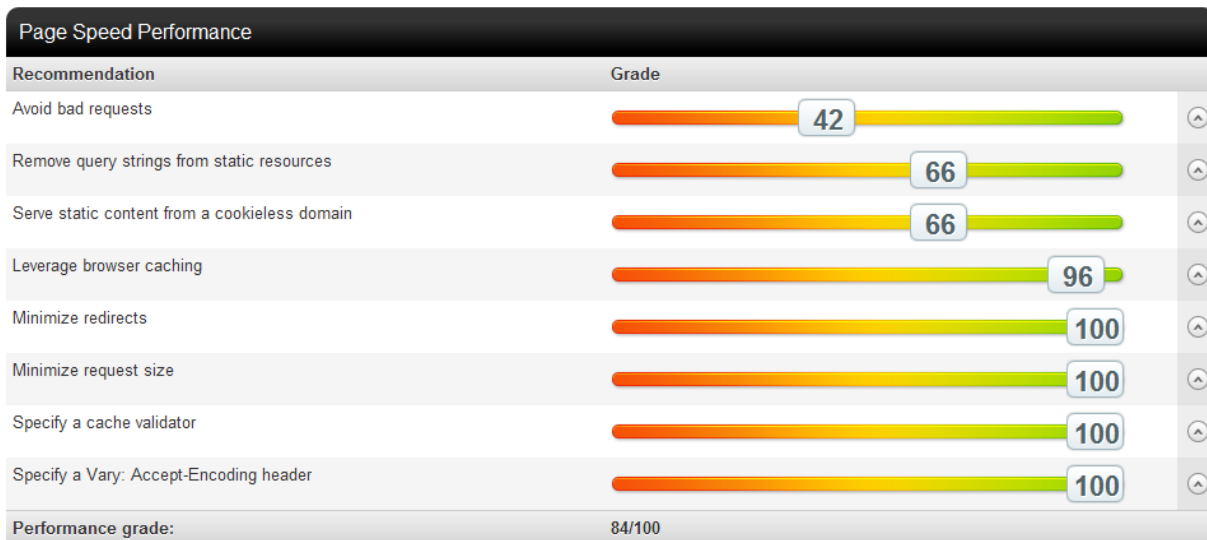


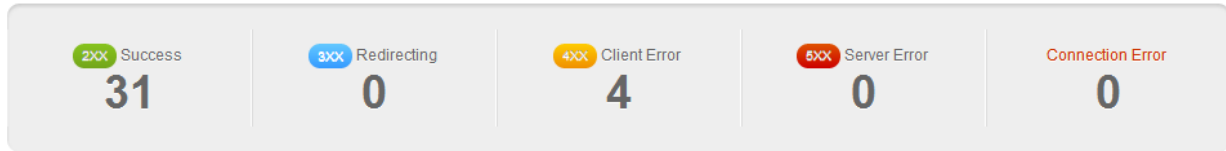
Figure 37: Page Speed Performance

From the result shown, the landing page of TWIVES performed excellently on the following: minimize request size, minimize redirects as well as leveraging of browser caching which resulted in a total score of 84%.

The other areas with low scores are as a result of general scripts that not all pages need every time. Drupal allows for the loading of all script files at the same time, instead of making individual calls by different pages. The meanings of the recommendations on the Page Speed Performance result and others are provided in a table in Appendix C: Google Page Speed Scores Table.

Figure 35 shows the result of load time analysis and the server response codes. For all the calls made in that particular test, thirty one were successful on first call and went through right away, none were redirected and there were neither server errors nor connection errors.

Server Response Code



Load Time Analysis

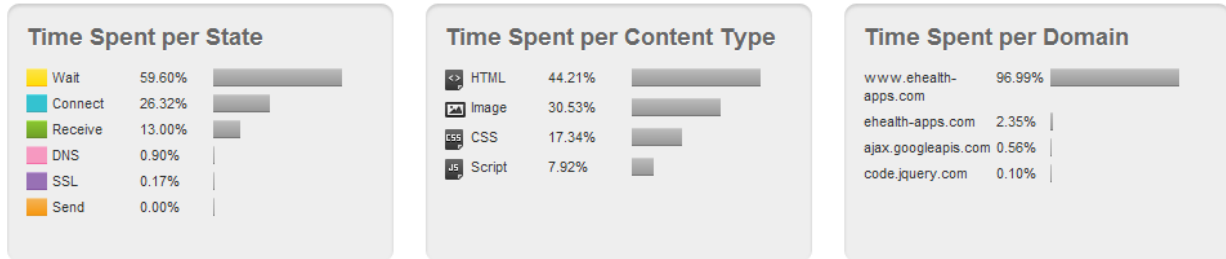
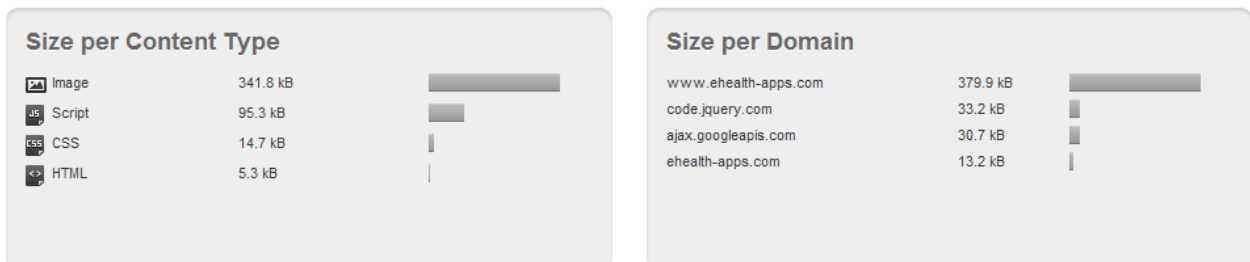


Figure 38: Server Load Time Analysis

However, there were four client errors which are attributable to the scripts that are loaded by Drupal as a batch operation; which the page being tested does not need and therefore were counted as errors.

Size Analysis



Request Analysis

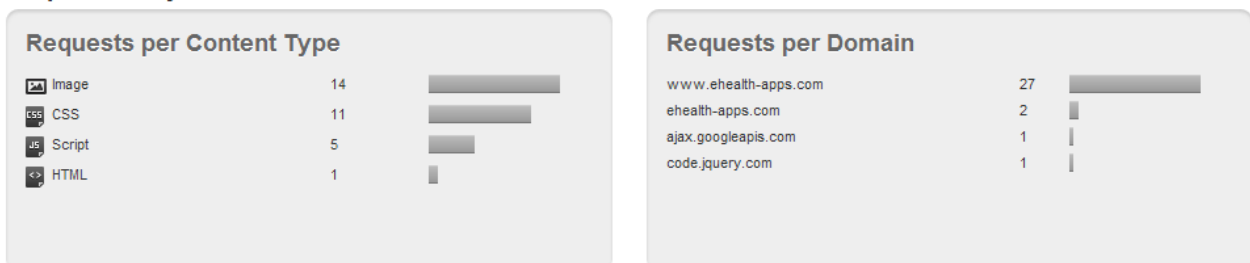


Figure 39: Size and Request Analysis

Figure 38 shows that for the load time analysis, the page was in a “wait” state for 59.60% of the test time interval. Pages do wait between calls for the server to respond to the request made. The wait time is a function of a lot of factors including host-server response time, quality of internet connection and the processor speed of the internet access computer itself.

On time spent per content type, the most time was spent on HTML at 44.21% (as expected), 30.53% on image content type and 7.92% on scripts. That the time spent on image content type is less than HTML content type is a clear indication of the design quality of the site. This is particularly important for low bandwidth internet connections typically available in remote and rural areas.

Web Browser Testing

The web browsers chosen to test TWIVES were Google Chrome (Version 18.0.1025.162), Mozilla Firefox (Version 10.0.2), Microsoft Internet Explorer (Version 9.0.8122.16421IC) and Apple Safari (5.0.5 (7533.21.1)).

Web browser testing was conducted only to see how the browsers rendered the look and feel of the site. There were negligible differences in the ways the different browsers interpreted the CSS files as shown in Figure 40 below.

The main visible difference was in the menu section of the site. As seen on the top right corner, the background of the menu module was rendered differently by all four browsers. Every other part appeared to display in the same way.



Figure 40: Testing TWIVES with Four Different Browsers

Narrow Band Network Emulation using SLOPPY

Sloppy (Dallaway & Brackeen, 2011) was used for testing the CMS component of TWIVES.



Testing with Sloppy Software and Online Stop Watch

Figure 41: Testing the Landing Page with Sloppy Software

An online stopwatch from <http://www.online-stopwatch.com/download-stopwatch/> was employed to measure the time taken to open the page.

Testing comprised of three steps – entering the address of the page to be tested, selecting the connection speed to simulate from a dropdown list and submitting by clicking on the `Go` button which opens and views the page on a new window (Figure 41).

The results of the test with Sloppy Software, which are discussed in Chapter 7, are as shown in Table 5 below. The highest page load time was obtained at 56kbps internet connection, which was expected. However, after 45 seconds, an RTMP connection was established and remained stable until the expiration of the 15 minute limit configured into the system for such slow connections.

The high page load time can be attributed to the “handshake” information exchange that occurs prior to the setup of the link between the host server and the client. The RTMP connection became stable at narrowband and lower broadband speeds. Narrowband speed is the recommended connection for the proper utilization of TWIVES, with a page load time of 5 seconds and stable media server RTMP connection.

Table 4: Page Load Times at Different Internet Connection Speeds

| Connection Type | Speed (kbps) | Load Time | Load Time Remark | Media Connection |
|------------------------|---------------------|------------------|-------------------------|-------------------------|
| Modem 56k | 56 | 45 seconds | Slow | Slow RTMP connection |
| Narrowband | 128 | 5 seconds | Acceptable Minimum | RTMP connection |
| Lower Broadband | 256 | 4 seconds | Acceptable | Stable RTMP connection |
| Broadband | 512 | 3 seconds | Acceptable | RTMFP connection |
| Upper Broadband | 768 | 2 seconds | Acceptable | RTMFP Connection |
| High-Speed | 1500 | 1 second | Acceptable | RTMFP Connection |
| High-Speed | 3000 | 1 second | Acceptable | RTMFP Connection |

The red color coding on the result set implies that although there is a connection at 56kbps, the system took too long to establish a usable connection. This is not an issue however as the use of such an internet connection has been on the decline in the last 5 years and does not affect the usefulness of TWIVES in remote and rural areas where GSM has made broadband wireless access possible.

The telephone circuits required for dial up access are practically non-existent in the rural areas. Even in Canada with a sophisticated Public Switched Telephone Network (PSTN) infrastructure, dial up internet use is on the decline too. A surveys by the Media Technology Monitor suggested about three per cent of the population was using dial-up Internet in 2011 (Oliveira, 2012).

Slow Internet Connection Simulation with Charles

Charles (Randow, 2012) uses sessions to record browser interactions with servers which are displayed in Session windows.

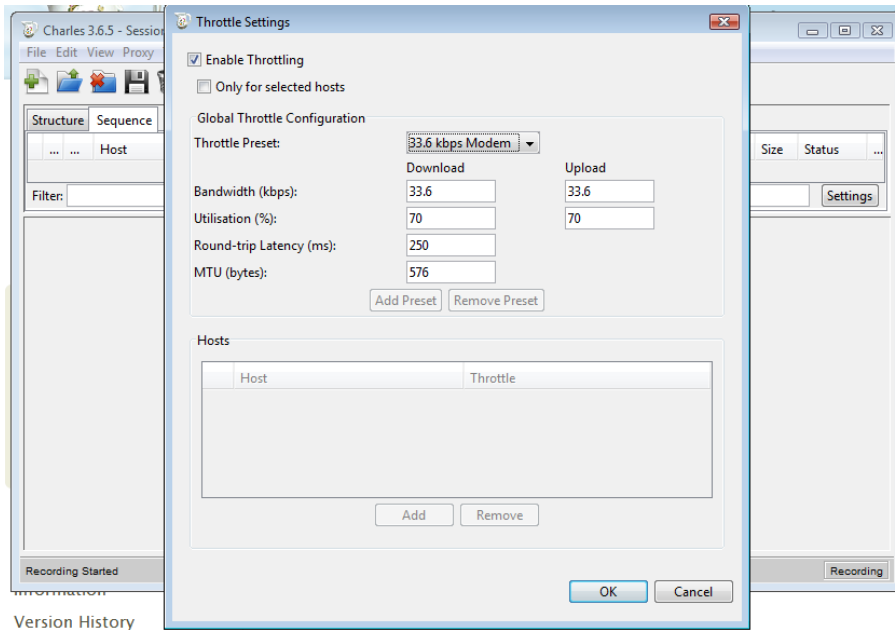


Figure 42: Charles Throttling Settings

Once Charles is running, it continuously gathers information on any browser activity on the host computer. The recorded information can be exported, saved, or displayed as a chart. Charles also offers a menu item for activating Throttling, which produces bandwidth limiting using the settings selected (Figure 39).

For TWIVES, testing was commenced by conducting a bandwidth speed test on the available Internet connection. Figure 43 shows the screenshot of the result of the internet connection speed test. As shown, the download speed at the time of testing was 8.38 Mbps and the upload speed was 0.84 Mbps.

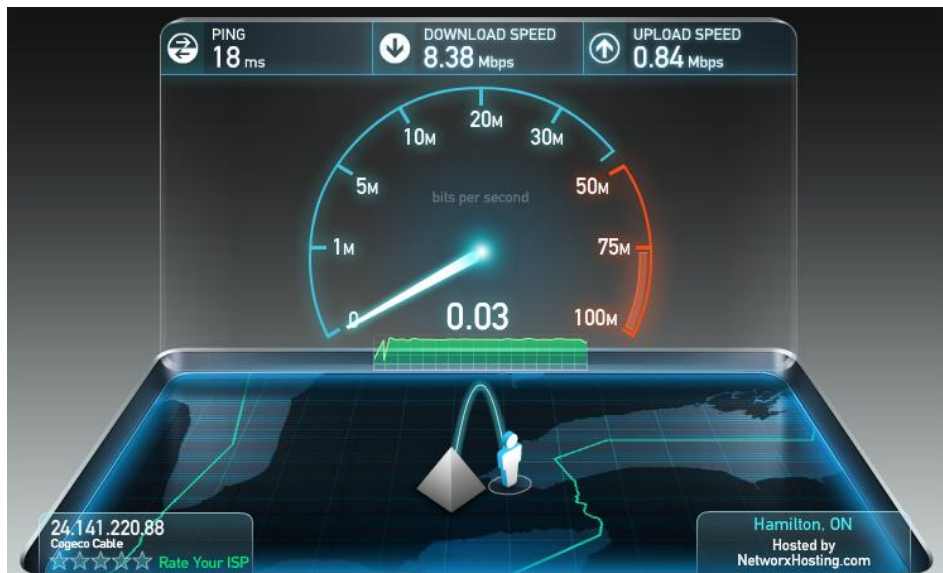


Figure 43: Bandwidth Test Result from Speedtest.net

After completing the speed test, Charles was restarted, in order to clear the session cache for the testing of TWIVES.

| Overview | Request | Response | Summary | Chart | Notes |
|----------------------|-------------------------------|----------|---------|-------|-------|
| Name | | Value | | | |
| Content-Type | text/html | | | | |
| Client Address | /127.0.0.1 | | | | |
| Remote Address | ehealth-apps.com/184.168.43.1 | | | | |
| Timing | | | | | |
| Request Start Time | 19/04/12 1:26:14 AM | | | | |
| Request End Time | 19/04/12 1:26:14 AM | | | | |
| Response Start Time | 19/04/12 1:26:15 AM | | | | |
| Response End Time | 19/04/12 1:26:15 AM | | | | |
| Duration | 168 ms | | | | |
| Request Duration | 16 ms | | | | |
| Response Duration | 1 ms | | | | |
| Latency | 151 ms | | | | |
| Speed | 48.06 KB/s | | | | |
| Response Speed | 281.25 KB/s | | | | |
| Size | | | | | |
| Request Header Size | 788 bytes | | | | |
| Response Header Size | 186 bytes | | | | |
| Request Size | 7.02 KB (7191 bytes) | | | | |
| Response Size | 102 bytes | | | | |
| Total Size | 8.07 KB (8267 bytes) | | | | |
| Request Compression | - | | | | |
| Response Compression | -18.6% (gzip) | | | | |

| Overview | Request | Response | Summary | Chart | Notes |
|----------------------|-------------------------------|----------|---------|-------|-------|
| Name | | Value | | | |
| Content-Type | text/html | | | | |
| Client Address | /127.0.0.1 | | | | |
| Remote Address | ehealth-apps.com/184.168.43.1 | | | | |
| Timing | | | | | |
| Request Start Time | 19/04/12 1:32:54 AM | | | | |
| Request End Time | 19/04/12 1:32:58 AM | | | | |
| Response Start Time | 19/04/12 1:32:58 AM | | | | |
| Response End Time | 19/04/12 1:32:58 AM | | | | |
| Duration | 4.10 sec | | | | |
| Request Duration | 3.66 sec | | | | |
| Response Duration | 40 ms | | | | |
| Latency | 395 ms | | | | |
| Speed | 1.94 KB/s | | | | |
| Response Speed | 6.52 KB/s | | | | |
| Size | | | | | |
| Request Header Size | 788 bytes | | | | |
| Response Header Size | 165 bytes | | | | |
| Request Size | 6.92 KB (7087 bytes) | | | | |
| Response Size | 102 bytes | | | | |
| Total Size | 7.95 KB (8142 bytes) | | | | |
| Request Compression | - | | | | |
| Response Compression | -18.6% (gzip) | | | | |

Figure 44: TWIVES Sessions at High Speed (Left) and at Low Speed (Right)

The actual test was quite repetitive and involved modifying the throttling settings within Charles for the connection speeds of interest and capturing the session information for the same URL and action from TWIVES (Figure 44).

Table 5: Test Results at Various Charles-Simulated Low Speed Connections

| Link: http://ehealth-apps.com/2wvc/vc_snapshots.php?name=admin&room=McMaster+eHealth+Testing+Room | | | | | | | |
|---|---------------|---------------------|---------|----------|---------|--------------|----------|
| Connection | IP Address | Duration | Request | Response | Latency | Request | Response |
| Speed (kbps) | | Time (milliseconds) | | | | Speed (kbps) | |
| 768 | /184.168.43.1 | 168 | 16 | 1 | 151 | 48.06 | 281.25 |
| 512 | /184.168.43.1 | 1250 | 864 | 1 | 387 | 7.17 | 281.25 |
| 256 | /184.168.43.1 | 582 | 511 | 6 | 65 | 13.30 | 43.46 |
| 128 | /184.168.43.1 | 666 | 544 | 6 | 116 | 12.48 | 46.88 |
| 64 | /184.168.43.1 | 1150 | 1110 | 13 | 30 | 6.90 | 20.86 |
| 36.4 | /184.168.43.1 | 634 | 415 | 26 | 193 | 1.64 | 9.09 |
| 28.8 | /184.168.43.1 | 4100 | 3660 | 40 | 395 | 1.94 | 6.52 |

For TWIVES, the most important test was to determine how it performed with low speed connections. The remote IP address and URL of the actual Video Consult page used for this test are shown in the table below (Table 6).

The decision to test the Video Consult page was determined by the fact that it is the core of TWIVES. It was imperative to ascertain whether the Video Consult page would load and operate properly at low connection speeds.

From the results of these tests, as shown in Tables 5 and 6, TWIVES performed excellently at very low speeds and most importantly video consult connections were successfully established at the speeds shown. It is therefore possible to use TWIVES in developing countries where the bandwidth is low and Internet connections are slow.

5.3 Functional Testing

This section covers the testing of the main features of this POC, namely the user registration, administrator registration and privileges, search functionality, real-time video consult and logging out of the system.

User Registration

The user registration section was tested for the basic functionality of registering a user with an email and password as well as adding this information into the system database, with optimal results. The system handled the entire process without any errors.

Admin Section Testing

The administrator has the permission to administer the site including other users of the system. This functionality was tested extensively and successfully.

Search for Healthcare Provider

This feature was tested first by logging off the system. On log off, the search feature becomes inactive and a user is prompted to sign up or log in before conducting a search. This feature successfully worked as designed.

Once a user signed up, the search feature became active. Searches were successfully conducted. Registered healthcare providers within the system who matched the search criteria were displayed. The profiles of the providers were also successfully viewed. Emailing an invitation to a healthcare provider was successful too.

Video eConsult Testing

The Video eConsult feature was successfully conducted, with two users logging in from two separate computers at different locations with appreciable high speed Internet connection. The audio was clear and crisp and the video quality was optimal. This limited testing was for communication purposes only and did not involve the use of actual subjects like health care providers and patients, which is beyond the scope of this work.

Logout from Video Consult Testing

At the completion of the Video Consult, both users logged out successfully. Using the back button to reconnect to the session just ended was not possible; instead, users were re-directed to the main page of the site and prompted to log in.

CHAPTER 6

6 DISCUSSION

TWIVES was developed as a Proof of Concept (POC) of an idea. POC systems are typically developed quickly, without a lot of testing (Pentakalos, 2008), and should in no way be considered the final deliverable. POC systems are used to illustrate the look and feel of the interface, demonstrate the functionalities that are being proposed, and use the feedback generated to either propose better features or enhance existing ones.

Development of a POC system provides many benefits, including a better understanding of requirements, assessing the capabilities and limitations of new technologies, an ability to assess design decisions and visualize early on the look-and-feel of the solution as well as reducing the overall risk of project failure (Pentakalos, 2008).

Discussing Technologies

This section will focus on the observations made on the technologies used in the development and testing of TWIVES with the intention of sharing the lessons learned. TWIVES was intended to be totally open-source; my decision to use PHP scripting, Drupal Framework and a free version of Videowhisper script, which though had limitations, was enough to deliver the services required for the proper functioning of TWIVES.

All design work and development was handled by me, with some help for custom Drupal module development and the configuration of the Dedicated Virtual Server, which hosts the video component.

There is an abundance of video conferencing software in the market today. However, these products are not well-suited for healthcare use due to privacy requirements: though the services are free, they tend to store the transaction information which they oftentimes sell to advertisers to recoup their investment in the delivery of such free services. This is not acceptable in healthcare.

Furthermore, the available commercial video conferencing tools depend on the availability of high speed internet access which is not always available in remote regions of the world where TWIVES is targeting. TWIVES works well at narrowband and dial-up connection speeds.

Drupal

The core of Drupal is well suited to the development of a system like TWIVES. However, there have been arguments that Drupal does have performance issues which are not specific to Drupal, but commonly the case with systems designed for maximum flexibility. The performance issues are not due to bad database design – but rather purely due to the number of functions that Drupal has to execute for all possibilities and functionalities. A good example is the MySQL auto-incrementing feature that is not used by Drupal; instead an additional query is made to the sequences table on every individual insert.

This problem is not unique to Drupal; all the big Content Management Systems available experience similar problems (Dixon, 2007). According to Dixon, Drupal is built to run with either Postgres or MySQL open source databases - and consequently is optimized for neither. The use of contributed modules with Drupal can cause subtle problems, because the design of each module is different and of different quality. For example, some modules make repeated queries when they should be using static variables.

Drupal Data Encryption, Security and Privacy

Drupal framework offers modules for total data encryption like SecurePages and Encryption Module which supports the MCrypt. MCrypt is a replacement for the old method crypt package (crypt ()) and crypt command (crypt (1)), with extensions. It allows developers to use a wide range of encryption functions, without making drastic changes to their code. It allows users to encrypt files or data streams without having to be cryptographers (Smith, 2003).

SecurePages: This module ensures that users are running on secure pages at all times when accessing the system. It requires that the web server has SSL enabled and the Drupal installation has been configured to support SSL access.

Encryption: This module supports the use of Mcrypt AES 256 Method if Mcrypt is enabled in the system. By default, this module uses a key that is stored in the database. The main use of this module is to store encrypted data in the database.

Drupal stores the MD5 hash of a user's password in the database and so it is not feasible to find a plaintext for a given hash. MD5 is a cryptographic hash function developed by Ronald Rivest in 1991, which produces a 128-bit hash value (Rivest, 1991).

There is a difference between hashed passwords and encrypted ones. The fundamental difference between hashing and encryption is that with encryption it would be possible to recover the original password. But for hashed passwords, by design, it is not possible to recover the original passwords.

The MD5 mode works by generating an 8 character random salt which is prepended to the password and hashing the resulting string with MD5. This

process is then repeated for several thousand iterations with the previous hash taking the place of the random salt in the first application of MD5.

```
1. $final = '$P$'  
2. $final .= encode64_int($rounds) (from constructor, minimum is 5 on PHP 5+, 3 other)  
3. $final .= genSalt() (Salt is 6 bytes... 8 bytes in "encode64" format).  
4. $hash = md5($salt . $password)  
5. For 2 $rounds times, do $hash = md5($hash . $password)  
6. $final = encode64($hash)
```

So the final hash essentially is this:

```
$P$9IQRaTwmfFeRo7ud9Fh4E2PdI0S3r.L0
```

Actual Hash

\$P\$ 9 IQRaTwmf

Salt

Rounds (not decimal representation, 9 is actually 11)

Hash Header

Figure 45: How Hashes in Portable Mode Are Generated

The whole final hash value is encoded into 16 base64 characters and prepended by an identifying string, the standard phpass MD5 mode uses \$P\$ (Drupal's modified version uses \$\$\$ to indicate SHA-512) and a single base64 character to indicate the number of MD5 iterations used.

Salting is done by generating a small, random bit sequence and adding it to the password before it is hashed. The salt is then stored as plaintext along with the password hash.

Drupal User Authentication

According to Nathaniel Catchpole, all registered users need to authenticate by supplying local username and password which are hashed with Message Digest 5 (MD5) and stored in the database. When a user enters a password it is also hashed with MD5 and compared with what is in the database. If the hashes match, the username and password are correct. Once a user authenticated session is started, and until that session is over, the user will not have to re-authenticate. To keep track of the individual sessions, Drupal relies on PHP's session support (Catchpole, 2005).

Videowhisper

Videowhisper is built with Adobe Flash and the main issue here revolves around the Adobe Flash player not being supported by popular Mobile Operating Systems available today (WINOKUR, 2011). Even Flash 10.3, which was specifically built for Android 2.2 and above, has below average performance. According to Steve Jobs, Flash was created during the PC era – for PCs and mice (Abell, 2010). Flash is a successful business for Adobe, and we can understand why they want to push it beyond PCs. But the mobile era is about low power devices, touch interfaces and open web standards – all areas where Flash falls short (Jobs, 2010).

Videowhisper requires a minimum Internet connection speed of 50kbps for a video stream. Translated into a typical two-way video consult, this means 400kbps for streams with default quality; though 512kbps is recommended. At minimum, a stable 1Mbps symmetric connection is required to participate in a two way video consult session, to cover upload stream and download stream. On Asymmetric Digital Subscriber Line (ADSL) where upload is much lower than download, users will need a 6Mbps connection that has 512kbps upload if they want a good quality broadcast. Skype Video call, for example, requires a

minimum of 40 kbps available bandwidth to start and it is able to fill a bandwidth of up to 450 kbps (De Cicco et al., 2011).

This is not a readily available bandwidth for the rural communities that TWIVES was specifically designed for. These rural dwellers are often not connected to high-speed networks but rather connected through GSM networks. Even in areas such as Northern Ontario, the connections there are largely 2G and higher bandwidths are more predominant in urban areas. However, as 4G and LTE networks, the gold standard for wireless technology, are rolled out this bandwidth constraint will cease to be a major concern. Bandwidth-intensive activities like watching videos, running business applications and downloading large files will be faster and better. Currently 4G and LTE networks provide access to peak speeds up to 75 Mbps (expected average speeds of 12-25 Mbps). As 4G and LTE networks and devices evolve, even greater speeds approaching 150 Mbps will be achieved (Bell, 2012).

Video Conference Capacity Needs

TWIVES is a video conferencing application and therefore could be very bandwidth-resource intensive due to the video files generated in the course of a session. That is why Drupal was used for the handling non-core media features like file sharing and this makes the system more affordable to run, in terms of media storage space management. Using Drupal's framework and content management system ensured that users do not have to download or install any additional software prior to the use of TWIVES.

A cursory search of the internet shows that Drupal framework has been used for enterprise level websites. Drupal is used by some of the biggest sites on the web, like The Economist, Examiner.com, British Medical Journal and The White House (Buytaert, 2012b). There are a number of Drupal sites that

currently handle over 10 million page views per month, 2 million page views in a single day, 9000 concurrent logged in users and 30,000 registrations in a single day. While those numbers might not represent the top tier of high-traffic sites, clearly this is adequate for the TWIVES (Fuller, 2008).

Testing with Sloppy

Sloppy is very simple network speed emulation software. Sloppy does a poor job of analyzing web pages – it does not have a way of capturing the actual metrics that should come with such analysis. One has to devise other means of gathering the network utilization and web page performance metrics. Furthermore, Sloppy cannot test Flash video streams on its own because if a Flash player initiates a connection after the page has been loaded, Sloppy does not capture it, as it focuses on the initial page load only - refreshing the window afterward within Sloppy's proxy server does not work. Normally by controlling the connection, one could test such a stream locally by pointing Sloppy to the Streaming Media Server and send the SWF (Shock Wave Flash files) to Sloppy. However, Sloppy's GUI prepends "http://" to everything and this does not work with a Flash Video Streaming area.

6.1 Future Enhancements

One of the main reasons for developing a POC system is to evaluate requirements while identifying potential enhanced features and functionalities. Testing the POC has revealed many exciting features that could be added to TWIVES. TWIVES is able to capture virtual visit notes using the chat feature on the session window. However, more work would be required to format the data being captured for possible insertion into a patient's health record. On follow-ups and scheduling of next visits, it may be a better idea to handle the schedules right away while in the video session and use the RSVP functionality after the session to finalize the schedules. TWIVES also has the ability to

record and store all consultation sessions in a virtual dedicated server and could be accessed by users with the proper authority. Some of the additional functionalities that could be included in the next production/version of this system are:

- a) **Prescription Management** – This would be an essential module, especially in the distribution of donated medications to indigent patients in rural areas. This module would also bring transparency to the system as reporting tools could be added to help manage the prescription and drug distribution information. Suppose a physician wants to prescribe a medication, then providing online prescriptions that would be funneled through the pharmacy closest to the patient would be a valuable function, especially since pharmacies play such a dominant role for patients who have no access to qualified medical practitioners in developing countries. Quite often it is the local pharmacy that currently assists a patient with healthcare problems, and that pharmacy would then receive and fill the prescriptions for the patient.
- b) **Short Message Service (SMS) Notification for Video Consult sessions and invitations** – TWIVES currently uses email notification for setting up and managing video consult sessions. Adding the ability to get SMS notifications would improve response time to requests.
- c) **Export of eConsult Data** – Presently, TWIVES does not have export functionality for the encounter records. Currently the encounter records can be retrieved for the health care provider who may want to confirm something he/she thought was seen during the consult. In addition, if needed, the health care provider could be given a direct access to the files. With export functionality built in, these encounter records could be inserted into a patient’s medical records, and possibly made available to the patient through a personal health record portal (PHR), for example.

- d) **Integration with Electronic Medical Records** – As with any other health care application, there is a need to create ways for integrating data and results from eConsults with patient records in Electronic Medical Records systems, for obvious reasons that cannot be over-emphasized.

Although not within scope of this study, it is worth mentioning that more work could be done in the area of product marketing, the development of capitation models for use of real time video consult and last but not least, product sustainability. The way we design, and consequently use, software-intensive systems has a significant impact on sustainability (Mahaux, Heymans, & Saval, 2011).

Drupal Page Optimization

There are a number of ways that the Drupal section of the solution could be optimized. This is necessary for this particular system, because of the limited bandwidth typically available in the rural areas in which TWIVES is likely to be used extensively. Moreover, optimizing the web pages will lead to improved user experience.

Network Utilization

As stated earlier, Drupal creates a database table for every piece of data. Drupal also uses a lot of cookies and the average cookie size for all requests on TWIVES' tested pages was 62bytes. The first step in optimizing the application's Drupal end is to minimize the cookie size – 62bytes may not seem like a lot, but with limited bandwidth, this becomes a concern quite quickly.

Production Server Power for TWIVES

TWIVES can handle multiple consult sessions simultaneously in a production environment. This ability to handle stable multiple simultaneous sessions

depends on the hardware configuration - a function of the expected number of users, website settings and targets. TWIVES uses a media server that runs RTMP. The most important consideration in RTMP operation is server connectivity. Servers with 100Mbps or 1000Mbps ports in well-connected data centers (that have gigabyte connections with several providers) are adequate. A dedicated 100Mbps connection can host, in theory, a maximum of 200 streams at 512kbps each. In a typical 2 way video consultation, where each user is viewing and transmitting also, only 2 streams per user will be required.

The number of users depends on communication logic. To host hundreds or thousands of streams less than 512kbps simultaneously, servers with 1000Mbps connection and 4-8 GB of Random Access Memory (RAM) are required. It's important to have the server in a reputable data center with many connections so all your users can connect to the server at good speed, from their different networks and providers.

Although it is a POC, TWIVES is hosted in a Virtual Dedicated Server which runs on Linux CentOS 64-Bit Operating System (OS), Intel® Core™ i3 - 2 cores Central Processing Unit (CPU), 2 GB RAM, 2 x 160 Gigabytes (GB) hard drives for storage and a bandwidth of 5 Terabytes (TB) per month. If needed, this can be upgraded to a top-of-the-line performance, storage and bandwidth option: Linux CentOS 64-Bit OS, Intel Core i7 - 4 cores CPU, 16 GB of RAM, 2 x 2 TB hard drives for storage and a bandwidth of 20 TB per month.

Web Page Performance

In web development, the order of styles and scripts play a significant role on how the page performs. To ensure CSS files are downloaded in parallel, external CSS are always included before external JavaScript. Looking at the head section of the following external CSS files, grid.css, nivo-slider.css,

nav.css and style.css were included after an external JavaScript file. One inline script block was also found in the head section between an external CSS file and another resource. To allow parallel downloading, moving the inline script before the external CSS file, or after the next resource is recommended.

While testing the index page, it became apparent that Drupal loads a lot of unused CSS rules which could be eliminated or reduced to improve performance. Figure 46 shows the result of a test conducted on the index/default page.

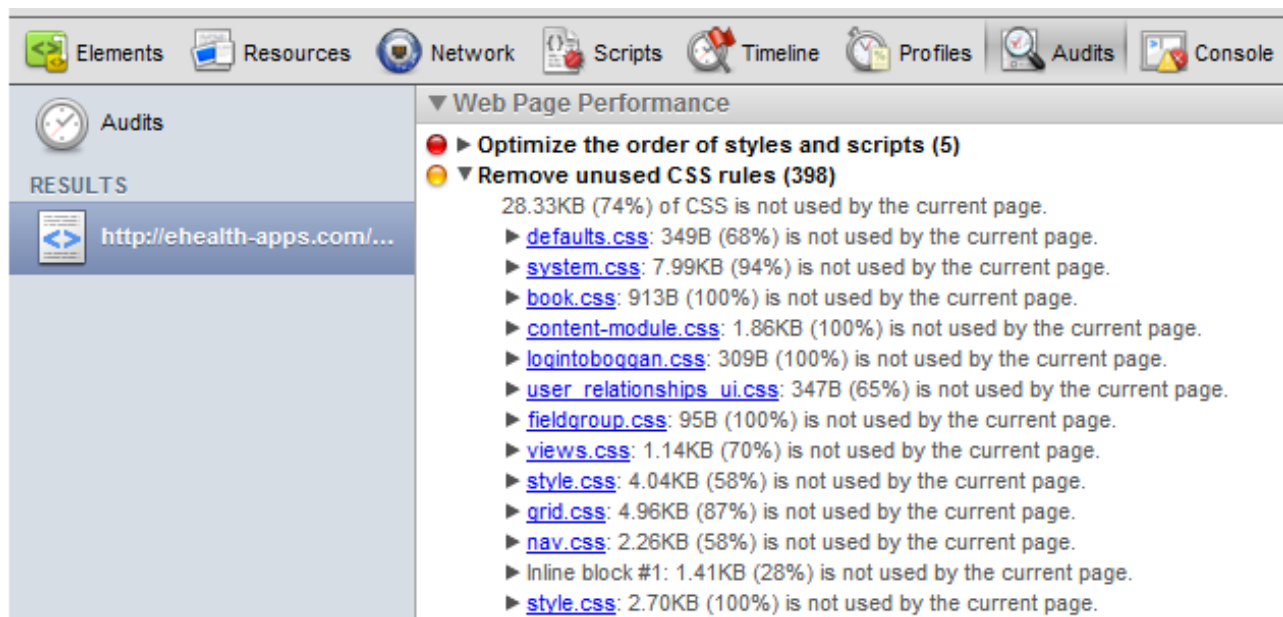


Figure 46: Web Page Performance Audit Using Google Chrome 18.0.1025.162 m

6.2 Security Testing for Web Attacks

Security is not an event, but a process that requires the cooperation and responsibility of everyone. Drupal is better than some open source packages purely because it has addressed some serious vulnerability in the past, and therefore the (Drupal) core team is aware of some of the most common attack vectors (Day-Reynolds, 2008).

Websites have to be built to withstand popular web attacks. The most common types of web attacked, as compiled by web security experts, which TWIVES should be tested for are introduced below.

Cross-Site Request Forgery (CSRF)

A CSRF attack forces a logged-on victim's browser to send a pre-authenticated request to a vulnerable web application, which then forces the victim's browser to perform a hostile action to the benefit of the attacker. CSRF can be as powerful as the web application that it attacks (Jayamsakthi Shanmugam & M. Ponnaivaikko, 2008).

If a site allows users to load any content from external servers, the site can be used to originate attacks. A solution to this is configurable either way in Drupal. Drupal filters out scripting variations of this attack, leaving only simpler (GET-type) ones. The simpler CSRF attacks fail when attacking Drupal because the Form API isolates state changing operations behind POST requests (Strauss, 2009). The Form API also requires loading forms prior to submission, making CSRF attacks much harder.

Insecure Direct Object Reference

A direct object reference occurs when a developer exposes a reference to an internal implementation object, such as a file, directory, database record, or key, such as a URL or form parameter. Attackers can then manipulate those references to access other objects without authorization. Drupal's menu and Form APIs encourage validating and sanitizing data submitted from users. When object references are passed through the Form API, Drupal core protects the values from tampering by site users. Drupal and PHP provide file and

session APIs that allow convenient and secure object reference passing (David, 2009).

Malicious File Execution

Execution code vulnerable to remote file inclusion (RFI) allows attackers to include hostile code and data, resulting in devastating attacks, such as total server compromise. Malicious file execution attacks affect PHP, XML and any framework which accepts filenames or files from users (Park, Lee, Lee, Kim, & Won, 2009). PHP has a configurable base directory for inclusions. Using this option limits possible attacks to only the Drupal directories. Drupal modules generally offer no entry point except through Drupal's secure URL/menu handler. So, while users may be able to load arbitrary PHP files, the "attacks" will have no effect (David, 2009).

Injection Flaws

Injection flaws, particularly SQL injection, are common in web applications. Injection occurs when user-supplied data is sent to an interpreter as part of a command or query. The attacker's hostile data tricks the interpreter into executing unintended commands or changing the data (Park et al., 2009). Drupal provides a database API with built-in SQL injection attack prevention. Properly used, it is not possible to inject arbitrary SQL. Drupal provides a set of functions to process URLs and SQL arguments, making security an easy choice for developers (David, 2009).

Cross-Site Scripting (XSS)

XSS flaws occur whenever an application takes user supplied data and sends it to a web browser without first validating or encoding that content (Jayamsakthi Shanmugam & M Ponnaivaikko, 2008). XSS allows attackers to execute script in the victim's browser which can hijack user sessions, deface web sites and

introduce worms. Drupal has a system of input filters that remove potential XSS exploits from user input. The Form API verifies that a user has loaded a form before submitting it. This verification makes effective XSS against Drupal sites considerably more difficult (Bakiyanathan, 2012).

CHAPTER 7

7 LIMITATIONS AND CONCLUSION

My research exposed me to a plethora of telemedicine applications that have been built and tested in the past. Many were discontinued after the initial pilots while a few were scaled, deployed and are currently in use. In addition to lack of funding, one of the major factors affecting the life cycle of such developments is the lack of sustainability considerations in the design. The way we design, and consequently use, software-intensive systems has a significant impact on sustainability (Mahaux et al., 2011). TWIVES was created with that in mind.

7.1 Limitations

The tests conducted on TWIVES were in simulated environments. The decision to use simulations was informed by the sheer cost of visiting these remote settings for testing. Also, using simulations eliminated the need for direct involvement of patients and providers which would have required Research Ethics Board approval.

Furthermore, in order to control scope, not all the features that are possible within TWIVES were implemented. Further work needs to be done to develop robust recommendations for the use of TWIVES for continuity of care in rural and remote settings and especially in developing countries.

TWIVES needs to be tested for WC3 standards especially in the areas of privacy, internationalization and web accessibility which are very important to ensure secure and equitable access to health care.

7.2 Conclusion

TWIVES was a proof of concept intended to examine the suitability and feasibility of developing a low cost video consult system that could be applied in rural communities with limited access to healthcare facilities, health providers and Internet resources. This need for a simple system devoid of bells and whistles led to the development of a web application that these populations can utilize for improved healthcare, irrespective of location, culture, religion and status.

The TWIVES POC accomplishes those goals, offering a sleek user interface, a solution appropriate for restricted bandwidth, and a simplified process for registration and consultation management. Areas of improvement, including new features and functionalities as well as ways to optimize the production version of the system have been researched and evaluated.

TWIVES in Canada

For developed countries like Canada, though TWIVES could be used by clinicians in some of the remote areas, it would even be more valuable when deployed as part of a system redundancy strategy or used as a last resort in times of emergency (like a snow storm that we experience in Northern Ontario), when for one reason or another patient cannot leave their location.

TWIVES could also be a follow-up tool for physicians who had already seen their patients face to face. In some cases, for patients with an apparent minor problem, it could also serve well for the first point of contact. The provider could then initiate a face to face visit if he or she and the patient agreed the problems were more serious.

According to Fariba Rawhani, the Vice President of Development and Delivery at eHealth Ontario, tools like TWIVES have also been used to provide services to patients with mental health issues. This is particularly important in view of the stigma associated with mental health. People who would normally not seek help tend to be more comfortable using this approach. This also has allowed for better monitoring of crisis and providing real-time services. The patient does not have to wait to see a health care provider; they can directly connect with a provider during a crisis episode.

TWIVES could be also be used in Employee Assistance Programs (EAP) as a video counseling option available to the employees and counselors. EAP counselors could use TWIVES for secure, private, confidential and real-time video counseling sessions without the need for special training, expensive hardware or high speed internet connections. This would also allow a larger variety of time zones to be available to the employees as well as the counselors.

For example, a counselor could be in British Columbia and the employee in Ontario and TWIVES would make it possible for these users to access the services in early morning or evening hours, when most convenient for them and it would not incur additional costs in the form of overtime. In all, using TWIVES would also ensure that the records of sessions are properly managed and stored at secure data centers chosen by the providers.

Additionally, TWIVES could be deployed in a secure provincial server maintained by the government of Ontario. This would make TWIVES available to all citizens of Ontario and their healthcare providers and ensures that the healthcare information generated is safe and secured – access could be controlled through the Provider Registry being deployed by the government.

A respectable percentage of health care providers and patients alike are conversant with the Internet and therefore they do not need to learn new skills before they can use TWIVES since it is browser based. TWIVES employs the same internet processes and computer technologies they already use and are comfortable with.

Most importantly, TWIVES performed well in simulated low-bandwidth settings. As shown in Table 5, at 28.2kbps, it took TWIVES 4100 milliseconds in total to load the application when the request was placed on the IP address. The request itself took 3660 milliseconds and TWIVES responded in 40 milliseconds after that. Latency was at 395 milliseconds and the actual initialization of the Video Interface occurred at a relatively slow rate (1.94KB/s) and the response speed between the two way conference links was 6.52 milliseconds. The positive result though is that once connection was made, the link remained stable enough for the duration of the transaction.

At Narrowband speeds (128kbps <speed>256kbps), TWIVES performed better: load time improved to 582 milliseconds, response to request was 6 milliseconds, latency dropped to 65 milliseconds and video response for two way conference jumped to 43.46 kbps.

At the threshold of broadband however, the load time was 1250 millisecond. This was as a result of the system switching from RTMP to RTMFP at 512 kbps. As explained in the Appendix section - Development Technologies, Content and Testing, RTMP is 2-way TCP-based protocol for streaming audio, video and data over the Internet, between a player and a server while RTMFP is a UDP-based communication protocol that enables direct end user to end user peer-to-peer communication.

At high speed connection, TWIVES improved considerably - total load time was 168 milliseconds, response time became 1millisecond, system request speed increased to 48 kbps and the two-way conference response speed jumped to 281.25 kbps. Overall, TWIVES performed as expected and could be used in low bandwidth resource settings obtainable in remote regions and developing countries.

Future Research

TWIVES was proof of concept and therefore the testing was quite limited. Full feasibility testing (actually using subjects) is beyond the scope of this thesis and would be the next step to be undertaken in future research.

APPENDIX

APPENDIX A: DEVELOPMENT TECHNOLOGIES, CONTENT AND TESTING

TWIVES is made up of two core components – a Content Management System and a Media Streaming System.

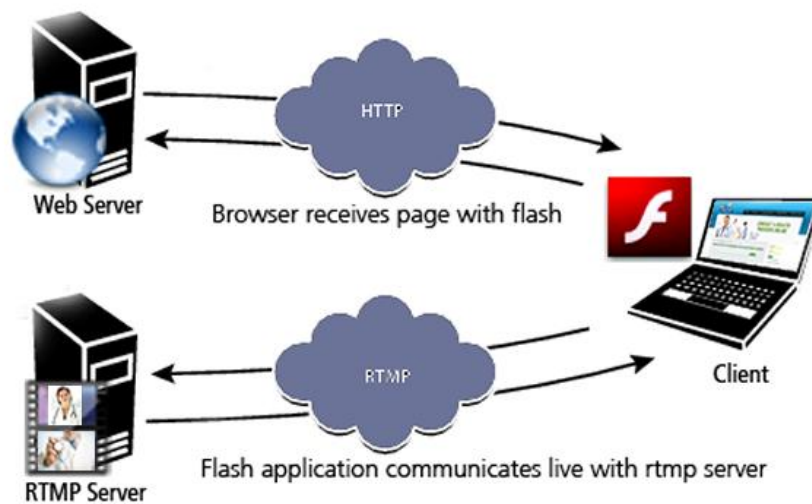


Figure 47: Core Components of TWIVES

These components are hosted on two different servers – an RTMP Server hosts the Red5 Video Streaming component and a Web Server hosts the Drupal Content Management System (CMS). Other technologies utilized in the development include the PHP scripting language, jQuery, JavaScript, CSS and HTML, described in more detail below.

Drupal – Open Source Content Management System

Drupal is open source software maintained and developed by a community of 630,000+ users and developers that allows developers to easily organize,

manage and publish content, with an endless variety of customization. It's distributed under the terms of the GNU General Public License (or "GPL"), which means anyone is free to download it and share it with others (Buytaert, 2012a). It is used as a back-end system for at least 1.5% of all websites worldwide, ranging from personal blogs to corporate, political, and government sites including the major US site whitehouse.gov (Fu, Sun, & Xu, 2010). Drupal's core contains basic features that are common to most of the available content management systems and covers user account registration, permission management, RSS-feeds, menu management, page theming and customization, as well as system administration. The installation of a Drupal core alone can be used as a simple website, blog or forum with the ability to support user-generated content, one of the main features of content management systems.

Drupal is modular by design and works with add-ons or plug-ins called modules. The strength of Drupal comes from these thousands of community-contributed modules. These can be used to alter and extend Drupal's core capabilities and add new features or customize Drupal's behavior and appearance. Because of this plug-in extensibility and modular design, Drupal is sometimes described as a content management framework. Drupal is also described as a web application framework, as it meets the generally accepted feature requirements for such frameworks (Drupal, 2012b). Although Drupal runs on all platforms that support PHP and web servers, most developers use a combination of LAMP capabilities (Linux, Apache, MySQL and PHP). The current version of Drupal, known as Drupal 7, requires PHP 5.2 or higher, while Drupal 6 requires PHP 4.4.0+.

Hypertext Preprocessor (PHP)

The name PHP is a recursive acronym for Hypertext Preprocessor. It is used to write server side codes for accessing the website databases. PHP is an HTML-

embedded scripting language and much of its syntax is borrowed from C, Java and Perl, with a couple of unique PHP-specific features thrown in. The goal of the language is to allow web developers to write dynamically generated pages quickly (PHP-Manual, 2012). PHP is currently used on more than 19 million websites, surpassing Microsoft's ASP.NET technology in popularity. Programmers love its flexibility and speed; designers love its accessibility and convenience. (Tatroe, 2005).

Before the advent of scripting languages like PHP, server side scripting was dominated by other languages such as Perl scripting, Shell scripts and the C language, using the common gateway interface (CGI). However with PHP, the scripts are executed directly by the web server, thereby reducing processing time due to reduced calls to external interpreters. Since Drupal was used in the development of TWIVES, it follows that the scripting language is PHP, for the two core components of the application – the video and content management systems.

MySQL

PHP and MySQL work together, the relationship being described aptly by LAMP. The MySQL database management system was originally developed to handle large databases faster than existing solutions and has been successfully used in highly demanding production environments for several years. Though under constant development, MySQL today offers a rich and useful set of functions. The connectivity, speed, and security make MySQL highly suited as an Internet accessible database. MySQL is an Open Source relational database management system.

A relational database stores data in separate tables rather than putting all the data in one big complex storage space. This adds speed and flexibility. The tables are linked by defined relations making it possible to combine data from

several tables on request. The SQL part of MySQL stands for "Structured Query Language" - the most common standardized language used to access databases (MySQL, 2001).

Hypertext Markup Language (HTML)

HTML is the acronym for Hypertext Markup Language and is the universal language of web browsers for describing web pages. HTML is not a programming language; instead it is a markup language and uses markup tags to describe web pages. These tags are interpreted by the web browser, enabling them to define how to display the color of the text, size, font, tables, etc. HTML is simple, yet powerful enough to create web pages. For TWIVES, Adobe Dreamweaver was used for coding and editing HTML as well as scripting PHP.

Cascaded Style Sheets (CSS)

CSS stands for Cascading Style Sheets and is used to define the styles of HTML pages. With CSS, editing style information is simple, as changes made for a style sheet are reflected in all the segments of the web page using that CSS file. Styles define the look and feel of web pages and were incorporated in HTML after version HTML 4.0.

JavaScript, Ajax and JQuery

Just as PHP is used for server side scripting; JavaScript is mainly used for client side scripting. Client side scripting means that the codes run on the web browser in the client computer. The use of client side scripting often saves time since it does not exert any load on the server. JavaScript works on all major web browsers, including Google Chrome, Apple Safari, Internet Explorer and Mozilla Firefox. It is a lightweight language and embeds directly in an HTML page while adding interactivity to web pages.

Ajax is an acronym for Asynchronous JavaScript and XML. Ajax is not a technology; it is a group of interrelated web development techniques used on the client-side to create asynchronous web applications (Garrett, 2005). With Ajax, web applications can send data to, and retrieve data from, a server in the background without interfering with the display and behavior of the existing page.

JQuery is free, open source software and its syntax is designed to make it easier to navigate a document, create animations, handle events, and develop Ajax applications. JQuery also provides capabilities for developers to create plug-ins on top of the JavaScript library. This enables developers to create abstractions for low-level interaction and animation, advanced effects, and high-level, theme-able widgets. The modular approach to the jQuery library allows the creation of powerful dynamic web pages and web applications. The jQuery toolkit supports client interfaces (Resig, 2012).

Web Server

A web server program is software that runs on the web site host server. Its main purpose is serving web pages; which mean it waits for requests from web browsers (also known as clients) and responds by sending the required data back. This client-server interaction is the hallmark of how the web works. Web servers - the computer or the program - have a vital role on the Internet. The server machine hosts (stores) the web site on its hard disk while the server program helps deliver the web pages and their associated files to client-browsers (webdevelopersnotes, 2010).

There are a number of host servers available today. The most basic criterion used for differentiating one web server from another is the operating system it uses. Based on this difference, the web server may be known as a Windows

server or UNIX server. Most Windows servers are licensed while most UNIX servers are not. The most popular web servers are Internet Information Service (IIS), Apache, and Apache Tomcat. TWIVES was developed with open source technologies in order to eliminate licensing issues, so Apache HTTP Server, an open source server, was used.

Media Server

Red5 is an Open Source Flash Server written in Java that delivers a powerful video streaming and multi-user solution to the Adobe Flash Player, along with other exciting client technologies. Red5 includes support for the latest multi-user APIs (Application Provider Interfaces) and also provides a powerful RTMFP and RTMP Servlet implementation enabling TWIVES video application to run on the server side, accepting and serving connections.

Real Time Media Flow Protocol (RTMFP)

Real Time Media Flow Protocol (RTMFP) is a new UDP-based communication protocol from Adobe that enables direct end user to end user peer-to-peer communication between multiple Adobe Flash Players and applications built using the Adobe AIR (Adobe Integrated Runtime) framework for the delivery of rich, live, real-time communication. AIR is a cross platform runtime environment for building Rich Internet Applications (RIA).

Real Time Media Protocol (RTMP)

RTMP is a proprietary 2-way TCP-based protocol developed by Adobe Systems for streaming audio, video and data over the Internet, between a Flash player and a server.

Difference between RTMFP and RTMP

The principal difference between the two protocols RTMFP and RTMP is how they communicate over the network (see Figure 6). RTMFP is based on the User Datagram Protocol (UDP), whereas RTMP is based on the Transmission Control Protocol (TCP). UDP-based protocols have significant advantages over TCP-based protocols in the efficient delivery of live streaming media, decreased latency, increased voice/audio quality, and greater connection reliability.

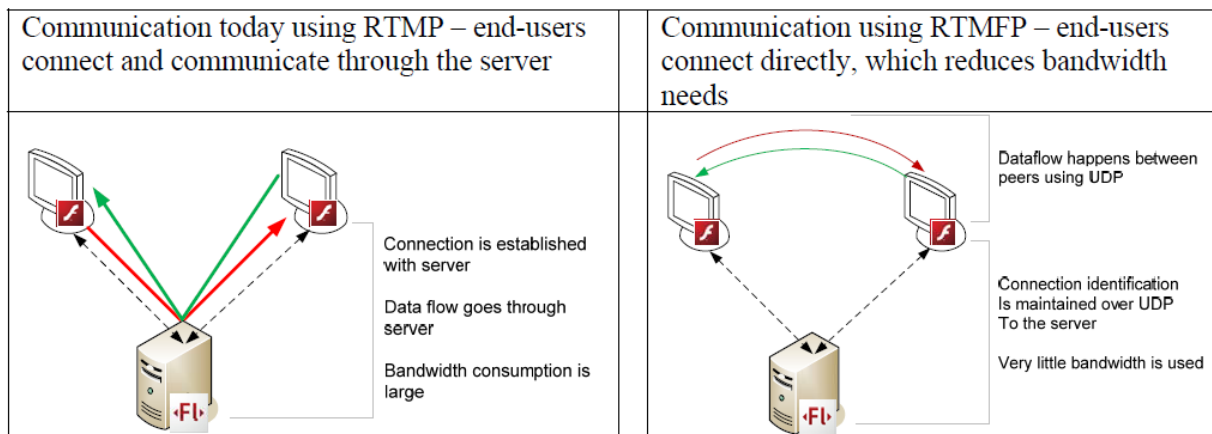


Figure 48: Difference between RTMP and RTMFP Source: (Interlake, 2010)

Unlike RTMP, RTMFP also supports sending data directly from one Adobe Flash Player to another, without going through a server. A server-side connection will always be required to establish the initial connection between the end-users and can be used to provide server-side data execution or gateways into other systems. The user of a Flash Media Server will also be required to authorize network address lookup and NAT (Network Address Translation) traversal services for the clients, to prevent Flash Player from being used in an unmanaged way.

RTMFP - Security and End User Privacy

RTMFP network traffic is always encrypted with a 128-bit cipher. For a client to play a stream that is published via RTMFP, the client will need to know the name of the stream as well as the Peer ID of the publisher. The ID will be a 256-bit value associated with the publisher's identity. In addition, the publisher must accept a peer request before connection can be made.

Content - Really Simple Syndication (RSS)

The origins of RSS began with the publication of the first RSS protocol (Resource description framework Site Summary) in 1999 (Cann, 2006). Within two years, several revisions of this protocol had been published and the methodology had become known as "Really Simple Syndication". The development of this technology coincided with the start of web logging or "blogging" (McAndrew, 2006)

To date, the most common way to access RSS feeds has been with an aggregator, a program which allow readers to subscribe to feeds, check for new content at user-determined intervals, and retrieve and display their content (Wikipedia, 2012).

Testing Tools

Pingdom Web Page Load Time Test

The Pingdom "Full Page Test" tool is a free, easy-to-use tool to help webmasters and web developers everywhere optimize the performance of their websites. It analyzes the load speed of websites and shows how to make them faster.

All related tests are done with real web browsers, so the results match the end-user experience exactly. This was accomplished in this work by using instances of Google's Chrome web browser to load websites, record performance data, and test them on Pingdom Servers (Pingdom, 2012).

Charles Web Debugging Proxy Application

The intent behind TWIVES is the development of a system that could be used in remote areas with limited Internet bandwidth. It therefore makes sense to test TWIVES in low speed environments. There are two normal ways to test the application: 1) physically test it in rural areas with low speed dial-up connections, or 2) use simulation software to create such networks in a controlled setting. Charles (Randow, 2012) was found to offer a solution from the second category, which is the simulation of low speed networks.

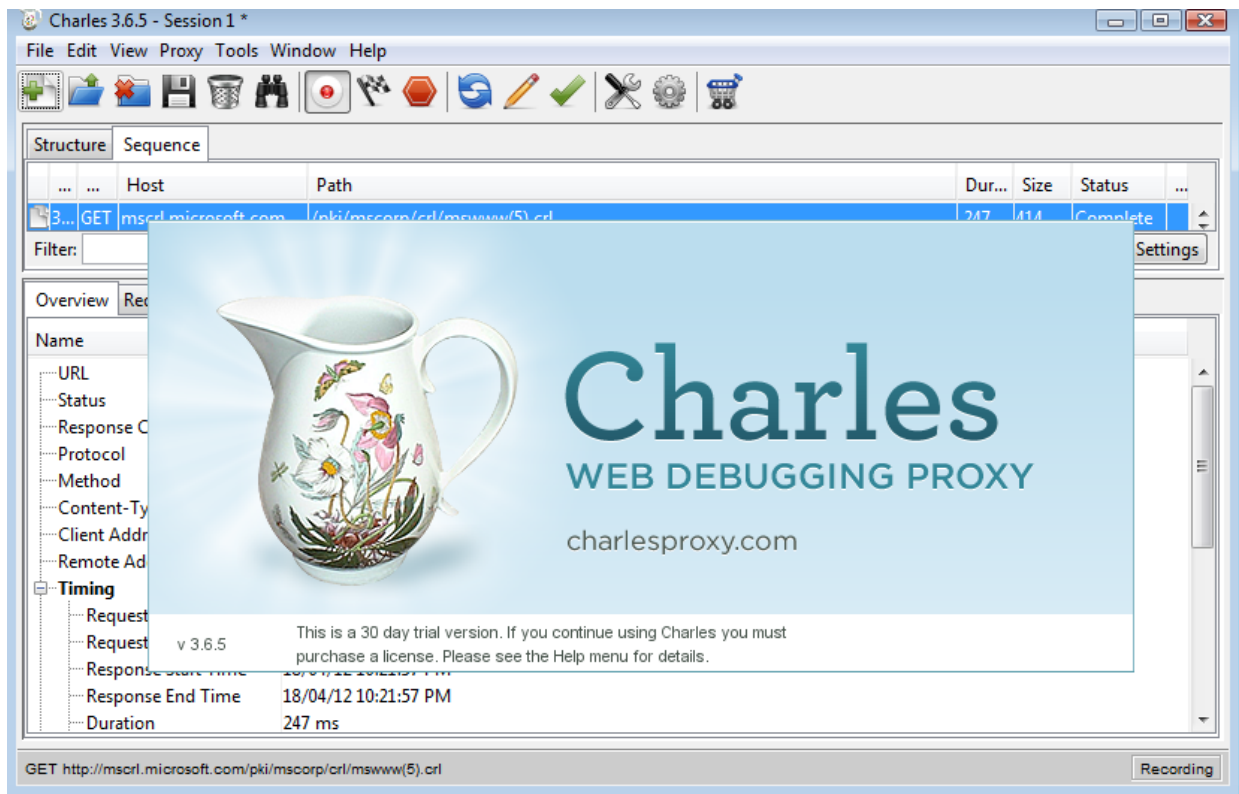


Figure 49: Charles Web Debugging Proxy

Charles (see Figure 7) is an HTTP Proxy and HTTP Monitor that is designed to gather web metrics on the host computer. By the use of a web-browser plugin,

Charles records and displays all the Internet web traffic from the web browser. This is very useful in web development as it allows the developer to gather information on transactions between the browser and the server. This saves time as it brings visibility to the interactions that occur between the client and the server, and is extremely useful in debugging, making diagnosis and error corrections relatively easy.

Additionally, Charles simulates slower Internet connections by limiting bandwidth (throttling). This is useful for testing the performance of a web application in low speed connection environments. For the development of TWIVES, it was important to test the application at Internet connection speeds typically available in rural communities in developing countries.

Charles allows TWIVES to be tested at connection speeds as low as 28.8 kbps. It can also be used to adjust the latency of an Internet connection to any arbitrary number. Latency here measures the delay between making a request and the request being received at the other end, as experienced on slower connections (Randow, 2012).

Charles also utilizes port forwarding to debug XMLSocket connections in Macromedia Flash. This is achieved by configuring any TCP/IP or UDP data stream to be forwarded from Charles to a remote host. This found application in the testing of the video streaming component of TWIVES.

Sloppy Software

Sloppy (Dallaway & Brackeen, 2011), a slow proxy, is a Java Web Start application that can be used to emulate slow Internet connections. Sloppy works by deliberately slowing the transfer of data between a client and a server.

It is useful for testing the performance of a web page or application on slower Internet connections, which are likely to occur in developing countries. Solutions like Sloppy make it possible to test web pages during development as it creates a dial-up experience, without having to use or install a modem.

Sloppy (see Figure 8) does not work as a real HTTP proxy; therefore browsers cannot be configured to use it. Also Sloppy does not check the HTML stream that comes to the browser.

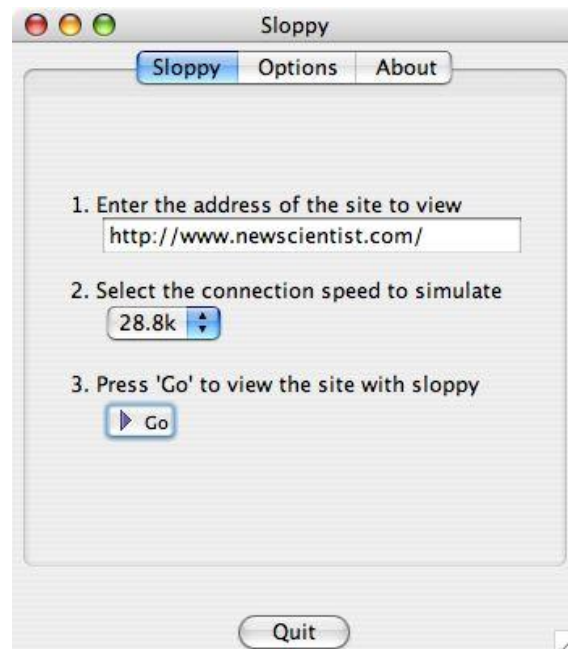
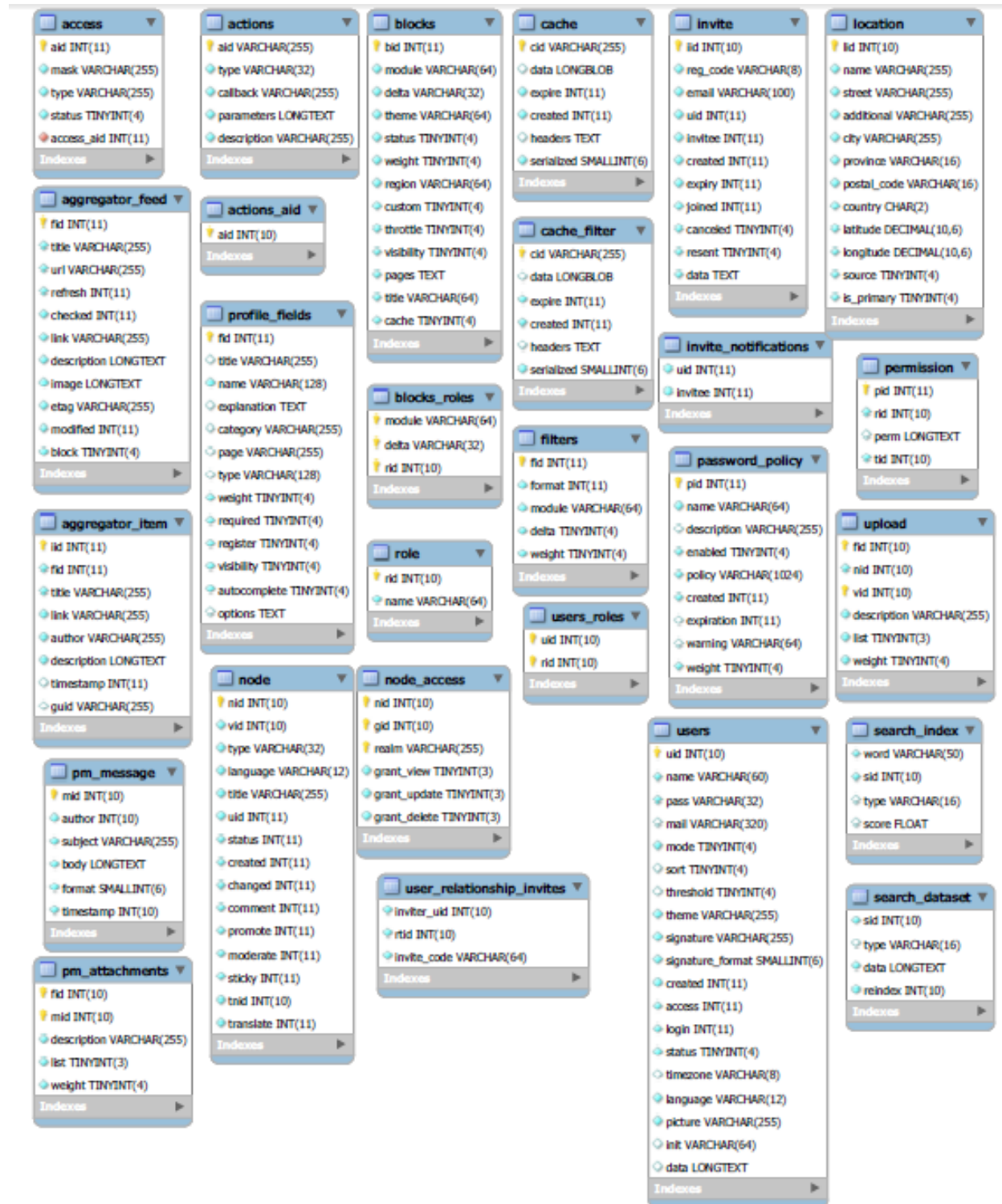


Figure 50: Sloppy Slow Proxy Emulator

If the returned HTML contains absolute links, following them would be browsing without Sloppy. For each page test, Sloppy has to be reinitialized, as using the browser's refresh function would not work. When Sloppy is active, the address is usually seen as "http:localhost:7563", where 7563 is the port number being used by Sloppy on the host computer (Dallaway & Brackeen, 2011).

APPENDIX B: TWIVES FULL ENTITY RELATIONSHIP DIAGRAM



APPENDIX C: GOOGLE PAGE SPEED SCORE TABLE

Table 6: Google Page Speed Score Table

| Google PageSpeed Score | |
|---|---|
| https://developers.google.com/speed/pagespeed/insights?url=www.ehealth-apps.com&mobile=false | |
| Avoid CSS @import | Using CSS @import in an external stylesheet can add additional delays during the loading of a web page. |
| Avoid bad requests | Removing "broken links", or requests that result in 404/410 errors, avoids wasteful requests. |
| Remove query strings from static resources | Enabling public caching in the HTTP headers for static resources allows the browser to download resources from a nearby proxy server rather than from a remote origin server. |
| Serve resources from a consistent URL | It's important to serve a resource from a unique URL, to eliminate duplicate download bytes and additional RTTs. |
| Leverage browser caching | Setting an expiry date or a maximum age in the HTTP headers for static resources instructs the browser to load previously downloaded resources from local disk rather than over the network. |
| Minimise redirects | Minimizing HTTP redirects from one URL to another cuts out additional RTTs and wait time for users. |
| Minimise request size | Keeping cookies and request headers as small as possible ensures that an HTTP request can fit into a single packet. |
| Specify a cache validator | By specifying a cache validator - a Last-Modified or ETag header - you ensure that the validity of cached resources can efficiently be determined. |
| Specify a Vary: Accept-Encoding header | Instructs proxy servers to cache two versions of the resource: one compressed, and one uncompressed. This helps avoid issues with public proxies that do not detect the presence of a Content-Encoding header properly. |

APPENDIX D: MONITORING TOOLS

There are a number of tools available for the proper monitoring of Drupal websites (Andrews, 2008).

ps

Ps displays information about all processes that are currently running on the server. The command line utility supports a large number of optional flags that control which processes are displayed, and what information is displayed about each process. Information that can be displayed includes CPU usage, memory usage, how much CPU time the process has used, and much more. Common invocations of ps include `ps -ef` and `ps aux`. Learn more about ps by typing `man ps` on most Unix servers.

Top

<http://www.unixtop.org/>

Top provides an automatically updating view of the processes running on a server. It offers a quick summary of a server's health, showing CPU utilization, as well as memory and swap usage. Processes can be sorted in many ways, such as listing the processes that are consuming the most CPU, or the processes that are using the most memory.

vmstat

Vmstat offers a useful report on several areas of system health, including the number of processes waiting to run, memory usage, swap activity, CPU utilization, and Disk IO. A common invocation of vmstat is `vmstat 1 10`. Learn more about vmstat by typing `man vmstat` on most Unix servers.

Sar

<http://pagesperso-orange.fr/sebastien.godard/>

Sar is part of the Sysstat collection of Unix performance monitoring tools. Sar can be configured to collect regular comprehensive snapshots of a system's health without putting any noticeable load on the system. It is a very good idea to enable Sar on any server that you are managing, as the historical information this utility collects can prove invaluable when tuning a server, or when performing damage control on a failed server.

Cacti

<http://www.cacti.net/>

Cacti is a PHP front-end for RRDTool, displaying useful graphs based on historical data collected from your servers. By default it tracks useful system information such as CPU and memory utilization; however it can also be integrated with programs such as MySQL, Apache, and memcache, displaying useful historical graphs of their performance.

Yslow

<http://developer.yahoo.com/yslow/>

YSlow is a FireFox add-on that enhances Firebug to analyze how quickly your web pages load, highlighting areas that can be improved. This tool is discussed in depth in chapter 13.

AWStats

<http://awstats.sourceforge.net/>

AWStats is a log analyzer that can be used to create graphical reports from web server and proxy log files. When scaling a Drupal website, you can achieve better performance by disabling Drupal's core statistics module, and instead using AWStats to generate regular reports from Apache's own access logs.

devel module

<http://drupal.org/project/devel>

The devel module is one of a suite of development oriented Drupal modules. Among its many useful features, it can display a list of all queries used to build each page served by a Drupal powered website, highlighting slow queries and queries that are run multiple times.

Mysqlreport

<http://hackmysql.com/mysqlreport>

Mysqlreport is a perl script that generates reports based on numerous internal "status variables" maintained by MySQL. With this script, you can quickly interpret what these variables mean, helping you to tune your server for better performance.

Mysqlsla

<http://hackmysql.com/mysqlsla>

Mysqlsla, the MySQL Statement Log Analyzer, is a perl script that helps you analyze MySQL logs.

Mytop

<http://jeremy.zawodny.com/mysql/mytop/>

Mytop is a useful tool for monitoring a MySQL database from the command line. It offers a summary of database threads in a format similar to how top lists running server processes.

Innotop

<http://innotop.sourceforge.net/>

Innotop was originally written to monitor MySQL's InnoDB storage engine, but it has long since evolved into a very powerful tool for monitoring all aspects of MySQL. Inspired by mytop, it takes MySQL monitoring to a new level.

APPENDIX E: LIST OF ABBREVIATIONS

| | |
|------------|--|
| 3GPP | 3rd Generation Partnership Project |
| 4G | Fourth Generation of cell phone mobile communications standards |
| AAC | Advanced Audio Coding |
| ABI | Acquired Brain Injury |
| ADSL | Asymmetric Digital Subscriber Line |
| AIR | Adobe Integrated Runtime |
| Ajax | Asynchronous JavaScript and XML |
| API | Application Programming Interface |
| ASP | Active Server Pages |
| Byte | A Byte is made up of 8 bits |
| CAPTCHA | Completely Automated Public Turing test to tell Computers and Humans Apart |
| CCK | Content Construction Kit |
| CGI | Common Gateway Interface |
| CMF | Content Management Framework |
| CMS | Content Management System |
| CPU | Central Processing Unit |
| CSE | Client Side Encryption |
| CSS | Cascading Style Sheets |
| DB | Database |
| DruTalk IM | Drupal Talk Instant Messaging |
| ECG | Electrocardiography |
| FEC | Forward Error Correction |
| GB | Giga Bytes |
| GET | The Get method – get(). See also Post method |
| GNU | GNU's Not Unix! - (recursive acronym) |
| GPRS | General Packet Radio Service |

| | |
|----------|---|
| GSM | Global System for Mobile Communications, originally Groupe Spécial Mobile |
| GUI | Graphic User Interface |
| HSDPA | High-Speed Downlink Packet Access |
| HTACCESS | Hypertext Access – (aka <i>.htaccess</i>) |
| HTML | Hyper Text Markup Language |
| HTTP | Hyper Text Transfer Protocol |
| ICT | Information and Communication Technologies |
| ICT4D | Information and Communication Technologies for Development |
| ID | Identification Number |
| IDRC | International Development Research Centre |
| IIS | Internet Information Services |
| iOS | iPhone Operating System |
| IP | Internet Protocol |
| ITU | International Telecommunication Union |
| JAMA | Journal of the American Medical Association |
| kb | kilo bits |
| KB | Kilo Bytes (a byte is 8bits) |
| kbps | kilobits per second |
| KBps | Kilo Bytes per second |
| LAMP | Linux Apache MySQL PHP |
| LAN | Local Area Network |
| LTE | Long Term Evolution |
| Mac OS | Macintosh Operating System |
| Mac OS X | Mac OS Version 10.6 - Snow Leopard |
| mb | mega bits |
| MB | Mega Bytes |
| mbps | Megabits per second |
| MBps | Mega Bytes per second |
| MD5 | Message Digest – Series 5 |

| | |
|----------|--|
| MDG | Millennium Development Goals |
| MySQL | My Structured Query Language Server |
| NASA | National Aeronautics and Space Administration |
| NAT | Network Address Translation |
| ODSP | Ontario Disability Support Program |
| On2 | On2 Technologies (AMEX: ONT), formerly known as The Duck Corporation |
| OS | Operating System |
| OW | Ontario Works |
| P2P | Peer to Peer |
| Pathauto | Drupal Pathauto Module |
| PC | Personal Computer |
| PDA | Personal Digital Assistant |
| PHI | Personal Health Information |
| PHP | Hypertext Preprocessor - (recursive acronym) |
| PHPASS | Password Hashing in PHP |
| PHR | Personal Health Record |
| PI | Personal Information |
| POC | Proof of Concept |
| POST | The Post Method – post() |
| PSTN | Public Switched Telephone Network |
| RAM | Random Access Memory |
| R&D | Research and Development |
| Red5 | Red5 Media Server |
| RIA | Rich Internet Application |
| RSVP | Répondez, S'il Vous Plaît |
| RTMFP | Real-Time Media Flow Protocol |
| RTMP | Real Time Messaging Protocol |
| RTT | Round Trip Time |
| SMS | Short Message Service |

| | |
|--------|--|
| SQL | Structured Query Language |
| SSL | Secure Sockets Layer |
| SWF | Shockwave Flash Movie – Adobe file extension |
| TB | Terabyte |
| TCP | Transmission Control Protocol |
| TWIVES | Two Way Interactive Video eConsult System |
| UDP | User Datagram Protocol |
| UMTS | Universal Mobile Telecommunications System |
| UN | United Nations |
| URL | Uniform Resource Locator |
| VOIP | Voice Over Internet Protocol |
| VP7 | Video Processor 7 |
| WANem | Wide Area Network Emulation |
| WHO | World Health Organization |
| WLAN | Wireless Local Area Network |
| XML | Extensible Markup Language |

APPENDIX F: WIKIPEDIA DEFINITION OF ABBREVIATIONS

3GPP

The 3rd Generation Partnership Project (3GPP) is collaboration between groups of telecommunications associations, known as the Organizational Partners. The initial scope of 3GPP was to make a globally applicable third-generation (3G) mobile phone system specification based on evolved Global System for Mobile Communications (GSM) specifications within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU).

4G

In telecommunications, 4G is the fourth generation of cell phone mobile communications standards. It is a successor of the third generation (3G) standards. A 4G system provides mobile ultra-broadband Internet access, to laptops with USB wireless modems, to smartphones, and to other mobile devices. Conceivable applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing and 3D television.

AAC

Advanced Audio Coding (AAC) is a standardized, ``lossy`` compression and encoding scheme for digital audio. Designed to be the successor of the MP3 format, AAC generally achieves better sound quality than MP3 at similar bit rates.

ABI

An acquired brain injury (ABI) is brain damage caused by events after birth, rather than being a part of a genetic or congenital disorder. ABI can result in

cognitive, physical, emotional, or behavioral impairments that lead to permanent or temporary changes in functioning. These impairments result from either traumatic brain injury or traumatic injury derived from either an internal or external source. ABI does not include damage to the brain resulting from neurodegenerative disorders.

ADSL

Asymmetric Digital Subscriber Line (ADSL) is a type of digital subscriber line technology, a data communications technology that enables faster data transmission over copper telephone lines than a conventional voice band modem can provide. It does this by utilizing frequencies that are not used by a voice telephone call.

AIR

Adobe Integrated Runtime, also known as Adobe AIR, is a cross-platform runtime environment developed by Adobe Systems for building Rich Internet Applications (RIA) using Adobe Flash, Apache Flex (formerly Adobe Flex), HTML, and Ajax, that can be run as desktop applications or on mobile devices.

Ajax

Ajax (also AJAX; an acronym for Asynchronous JavaScript and XML) is a group of interrelated web development techniques used on the client-side to create asynchronous web applications. With Ajax, web applications can send data to and retrieve data from a server asynchronously (in the background) without interfering with the display and behavior of the existing page.

API

An application programming interface (API) is a specification intended to be used as an interface by software components to communicate with each other. An API may include specifications for routines, data structures, object classes,

and variables. An API specification can take many forms, including an International Standard such as POSIX or vendor documentation such as the Microsoft Windows API, or the libraries of a programming language, e.g. Standard Template Library in C++ or Java API.

ASP

Active Server Pages (ASP), also known as Classic ASP or ASP Classic, was Microsoft's first server-side script engine for dynamically generated web pages. Initially released as an add-on to Internet Information Services (IIS) via the Windows NT 4.0 Option Pack (ca. 1998), it was subsequently included as a free component of Windows Server (since the initial release of Windows 2000 Server). ASP.NET has superseded ASP.

Byte

The byte is a unit of digital information in computing and telecommunications that most commonly consists of eight bits. Historically, a byte was the number of bits used to encode a single character of text in a computer and for this reason it is the basic addressable element in many computer architectures. The size of the byte has historically been hardware dependent and no definitive standards existed that mandated the size.

CAPTCHA

A CAPTCHA is a type of challenge-response test used in computing as an attempt to ensure that the response is generated by a person. The process usually involves a computer asking a user to complete a simple test which the computer is able to grade. These tests are designed to be easy for a computer to generate, but difficult for a computer to solve, so that if a correct solution is received, it can be presumed to have been entered by a human.

CCK

This is a module for the Drupal Content Management System (CMS) that enables users to create and customize fields with a browser. Most content in a Drupal site will come from instances of Content Types. The Content Construction Kit allows developers to add custom fields to any of the content types using a web interface.

CGI

The Common Gateway Interface (CGI) is a standard method for web server software to delegate the generation of web content to executable files. Such files are known as CGI scripts; they are programs, often stand-alone applications, usually written in a scripting language.

CMF

A content management framework (CMF) is a system that facilitates the use of reusable components or customized software for managing web content. It shares aspects of a web application framework and a content management system (CMS).

CMS

A content management system (CMS) is a computer system that allows publishing, editing, and modifying content as well as site maintenance from a central page. It provides a collection of procedures used to manage workflow in a collaborative environment. These procedures can be manual or computer-based.

CPU

The central processing unit (CPU, occasionally central processor unit) is the hardware within a computer system which carries out the instructions of a computer program by performing the basic arithmetical, logical, and

input/output operations of the system. The CPU plays a role somewhat analogous to the brain in the computer.

CSE

Client-side encryption is the cryptographic technique of encrypting data before it is transmitted to a server in a computer network. Usually, encryption is performed with a key that is not known to the server. Consequently, the service provider is unable to decrypt the hosted data. In order to access the data, it must always be decrypted by the client. Client-side encryption allows for the creation of zero-knowledge applications whose providers cannot access the data its users have stored, thus offering a high level of privacy.

CSS

Cascading Style Sheets (CSS) is a style sheet language used for describing the presentation semantics (the look and formatting) of a document written in a markup language. It's most common application is to style web pages written in HTML and XHTML, but the language can also be applied to any kind of XML document, including plain XML, SVG and XUL.

DB

A database is an organized collection of data, today typically in digital form. The term database is correctly applied to the data and their supporting data structures, and not to the database management system (DBMS). The database data collection with DBMS is called a database system.

DruTalk IM

DruTalk (also druTalk) is a Video IM (Video Instant Messaging) module. It works together with the User Relationships module and the Services module.

With DruTalk, Drupal users can chat (text chat or video chat) with their friends on the same site.

EKG

Electrocardiography (ECG or EKG from the German Elektrokardiogramm) is a transthoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the outer surface of the skin and recorded by a device external to the body.

FEC

In telecommunication, information theory, and coding theory, forward error correction (FEC) or channel coding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. The central idea is the sender encodes their message in a redundant way by using an error-correcting code (ECC).

GB

The gigabyte is a multiple of the unit byte for digital information storage. The prefix giga means 10^9 in the International System of Units (SI), therefore 1 gigabyte is 1000000000bytes. The unit symbol for the gigabyte is GB or Gbyte, but not Gb (lower case b) which is typically used for the gigabit.

Gb

The gigabit is a multiple of the unit bit for digital information or computer storage. The prefix giga (symbol G) is defined in the International System of Units (SI) as a multiplier of 10^9

GET

The GET method retrieves whatever information (in the form of an entity) is identified by the Request-URI. If the Request-URI refers to a data-producing

process, it is the produced data which shall be returned as the entity in the response and not the source text of the process, unless that text happens to be the output of the process.

GNU

GNU is a Unix-like computer operating system developed by the GNU Project, ultimately aiming to be a "complete Unix-compatible software system" composed wholly of free software. Development of GNU was initiated by Richard Stallman in 1983 and was the original focus of the Free Software Foundation (FSF).

GPRS

General packet radio service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication system's global system for mobile communications (GSM). GPRS was originally standardized by European Telecommunications Standards Institute (ETSI) in response to the earlier CDPD and i-mode packet-switched cellular technologies. It is now maintained by the 3rd Generation Partnership Project (3GPP).

GSM

GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe technologies for second generation (2G) digital cellular networks. Developed as a replacement for first generation (1G) analog cellular networks, the GSM standard originally described a digital, circuit switched network optimized for full duplex voice telephony.

GUI

In computing, a graphical user interface (GUI, commonly pronounced gooey) is a type of user interface that allows users to interact with electronic devices

using images rather than text commands. GUIs can be used in computers, hand-held devices such as MP3 players, portable media players or gaming devices, household appliances and office equipment.

HSDPA

High-Speed Downlink Packet Access (HSDPA) is 3G (third generation) mobile telephony communications protocol in the High-Speed Packet Access (HSPA) family, also dubbed, which allows networks based on Universal Mobile Telecommunications System (UMTS) to have higher data transfer speeds and capacity. Current HSDPA deployments support down-link speeds of up to 42 Mbit/s.

HTACCESS

A .htaccess (hypertext access) file is a directory-level configuration file supported by several web servers, that allows for decentralized management of web server configuration. The original purpose of .htaccess - reflected in its name - was to allow per-directory access control, by for example requiring a password to access the content. Nowadays however, the .htaccess files can override many other configuration settings including content type and character set, CGI handlers, etc.

HTML

Hypertext Markup Language (HTML) is the main markup language for displaying web pages and other information that can be displayed in a web browser. HTML is written in the form of HTML elements consisting of tags enclosed in angle brackets (like <html>), within the web page content.

HTTP

The Hypertext Transfer Protocol (HTTP) is an application protocol for distributed, collaborative, hypermedia information systems. HTTP is the

foundation of data communication for the World Wide Web. Hypertext is a multi-linear set of objects, building a network by using logical links (the so-called hyperlinks) between the nodes (e.g. text or words). HTTP is the protocol to exchange or transfer hypertext.

ICT

Information and Communications Technology or Information and Communication Technology (ICT), is often used as an extended synonym for information technology (IT), but is a more specific term that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information.

ICT4D

Information And Communication Technologies for Development (ICT4D) is a general term referring to the application of Information and Communication Technologies (ICTs) within the fields of socioeconomic development, international development and human rights. The basic hypothesis behind the approach is that more and better information and communication furthers the development of a society (be this to improve income, education, health, security, or any other aspect of human development).

ID

In computer science, identifiers (IDs) are lexical tokens that name entities. The concept is analogous to that of a "name." Identifiers are used extensively in virtually all information processing systems. Naming entities makes it possible to refer to them, which is essential for any kind of symbolic processing.

IDRC

The International Development Research Centre (IDRC) (French: Centre de recherche pour le développement international—CRDI) is a Canadian Crown Corporation created by the Parliament of Canada that supports research in developing countries to promote growth and development. The aim of IDRC is to create innovative, lasting local solutions that build "healthier, more equitable, and more prosperous societies.

IIS

Internet Information Services (IIS) – formerly called Internet Information Server – is a web server application and set of feature extension modules created by Microsoft for use with Microsoft Windows. IIS 7.5 supports HTTP, HTTPS, FTP, FTPS, SMTP and NNTP. It is an integral part of the Windows Server family of products, as well as certain editions of Windows XP, Windows Vista and Windows 7. IIS is not turned on by default when Windows is installed.

iOS

iOS (previously iPhone OS) is a mobile operating system developed and distributed by Apple Inc. Originally released in 2007 for the iPhone and iPod Touch, it has been extended to support other Apple devices such as the iPad and Apple TV. Unlike Microsoft's Windows CE (Windows Phone) and Google's Android, Apple does not license iOS for installation on non-Apple hardware.

IP

The Internet Protocol (IP) is the principal communications protocol used for relaying datagrams (also known as network packets) across an internetwork using the Internet Protocol Suite. Responsible for routing packets across network boundaries, it is the primary protocol that establishes the Internet.

ITU

The International Telecommunication Union (Union internationale des télécommunications, in French), previously the International Telegraph Union, is the specialized agency of the United Nations which is responsible for information and communication technologies. ITU coordinates the shared global use of the radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve telecommunication infrastructure in the developing world and establishes worldwide standards.

JAMA

The Journal of the American Medical Association (JAMA) is a weekly, peer-reviewed, medical journal, published by the American Medical Association.

kb

The kilobit is a multiple of the unit bit for digital information or computer storage. The prefix kilo (symbol k) is defined in the International System of Units (SI) as a multiplier of 10 to power 3 (1 thousand)

KB

The kilobyte (symbol: kB) is a multiple of the unit byte for digital information. Although the prefix kilo- means 1000, the term kilobyte and symbol kB or KB have historically been used to refer to either 1024 (2 to power 10) bytes or 1000 (10 to power 3) bytes, dependent upon context, in the fields of computer science and information technology.

kbps

In telecommunications, bit rate or data transfer rate is the average number of bits, characters, or blocks per unit time passing between equipment in a data transmission system. This is typically measured in multiples of the unit bit per second or byte per second.

A kilobyte per second is a unit of data transfer rate equal to:
1,000 bits per second

KBps

A kilobyte per second is a unit of data transfer rate equal to:
8,000 bits per second or 1,000 bytes per second or 8 kilobits per second.

LAMP

LAMP is an acronym for a solution stack of free, open source software, referring to the first letters of Linux (operating system), Apache HTTP Server, MySQL (database software) and originally Perl (but now sometimes PHP or Python), principal components to build a viable general purpose web server.

LAN

A local area network (LAN) is a computer network that interconnects computers in a limited area such as a home, school, computer laboratory, or office building using network media. The defining characteristics of LANs, in contrast to wide area networks (WANs), include their usually higher data-transfer rates, smaller geographic area, and lack of a need for leased telecommunication lines.

LTE

LTE (an initials of Long Term Evolution), marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using new modulation techniques.

Mac OS

Mac OS is a series of graphical user interface-based operating systems developed by Apple Inc. (formerly Apple Computer, Inc.) for their Macintosh line

of computer systems. Mac OS is credited with popularizing the graphical user interface.

Mac OS X

OS X formerly Mac OS X, is a series of Unix-based graphical interface operating systems developed, marketed, and sold by Apple Inc. OS X is designed to run exclusively on Macintosh computers, having been pre-loaded on all Macs since 2002. OS X, whose X is the Roman numeral for 10 and is a prominent part of its brand identity, is built on technologies developed at NeXT between the second half of the 1980s and Apple's purchase of the company in late 1996.

mb

The megabit is a multiple of the unit bit for digital information or computer storage. The prefix mega (symbol M) is defined in the International System of Units (SI) as a multiplier of 10 to power 6 (1 million)

MB

The megabyte (abbreviated as Mbyte or MB) is a multiple of the unit byte for digital information storage or transmission with three different values depending on context: 1048576 bytes (2 to power 20) generally for computer memory; and one million bytes (10 to power 6, generally for computer storage.

mbps

A megabit per second is a unit of data transfer rate equal to:

1,000,000 bits per second or 1,000 kilobits per second or

125,000 bytes per second or 125 kilobytes per second.

MBps

A megabyte per second (MB/s or MBps) is a unit of data transfer rate equal to:

8,000,000 bits per second, or 1,000,000 bytes per second, or

1,000 kilobytes per second, or 8 megabits per second.

MD5

The MD5 Message-Digest Algorithm is a widely used cryptographic hash function that produces a 128-bit (16-byte) hash value. Specified in RFC 1321, MD5 has been employed in a wide variety of security applications, and is also commonly used to check data integrity. An MD5 hash is typically expressed as a hexadecimal number, 32 digits long.

MDG

The Millennium Development Goals (MDGs) are eight international development goals that all 193 United Nations member states and at least 23 international organizations have agreed to achieve by the year 2015. The goals are:

1. Eradicating extreme poverty and hunger,
2. Achieving universal primary education,
3. Promoting gender equality and empowering women
4. Reducing child mortality rates,
5. Improving maternal health,
6. Combating HIV/AIDS, malaria, and other diseases,
7. Ensuring environmental sustainability, and
8. Developing a global partnership for development.

MySQL

MySQL (officially, but also called "My Sequel") is the world's most used open source relational database management system (RDBMS) that runs as a server providing multi-user access to a number of databases.

NASA

The National Aeronautics and Space Administration (NASA) is the agency of the United States government that is responsible for the nation's civilian space program and for aeronautics and aerospace research.

NAT

In computer networking, network address translation (NAT) is the process of modifying IP address information in IP packet headers while in transit across a traffic routing device. The simplest type of NAT provides a one-to-one translation of IP addresses.

ODSP

The Ontario Disability Support Program (ODSP) is means-tested income support paid to "persons with a disability" as defined in the ODSP legislation. It is paid monthly, with the main component consisting of a fixed amount for basic needs, and a variable - though capped - amount for shelter.

On2

On2 Technologies (NYSE Amex: ONT), formerly known as The Duck Corporation, was a small publicly traded company (on the American Stock Exchange), headquartered in Clifton Park, New York, that designed video codec technology. It created a series of video codecs called TrueMotion (including TrueMotion S, TrueMotion 2, TrueMotion RT 2.0,[2] TrueMotion VP3, 4, 5, 6, 7 and 8).

OS

An operating system (OS) is a set of software that manages computer hardware resources and provides common services for computer programs. The operating system is a vital component of the system software in a computer system. Application programs require an operating system to function.

OW

Ontario Works is a program that provides income and employment assistance for people who are in financial need by developing an Action Plan in certain agencies. In other agencies participants are referred to other resources. This Plan identifies and addresses an individual's barriers to employment. It is a benefit for persons 18 years and older and by exception for peoples 16 to 18 and also single parents regardless of age. In order to qualify for Ontario Works, an applicant must be a resident of the province of Ontario, in immediate need of financial help, not have excessive assets and be a willing participant in employment assistance programs and activities.

P2P

A peer-to-peer (abbreviated to P2P) computer network is one in which each computer in the network can act as a client or server for the other computers in the network, allowing shared access to files and peripherals without the need for a central server. P2P networks can be set up in the home, a business or over the Internet. Each network type requires all computers in the network to use the same or a compatible program to connect to each other and access files and other resources found on the other computer. P2P networks can be used for sharing content such as audio, video, data or anything in digital format.

Pathauto

The Pathauto module automatically generates URL/path aliases for various kinds of content (nodes, taxonomy terms, users) without requiring the user to manually specify the path alias. This allows you to have URL aliases like /category/my-node-title instead of /node/123. The aliases are based upon a "pattern" system that uses tokens which the administrator can change.

PC

A personal computer (PC) is any general-purpose computer whose size, capabilities, and original sale price make it useful for individuals, and which is intended to be operated directly by an end-user with no intervening computer operator. This contrasted with the batch processing or time-sharing models which allows larger, more expensive minicomputer and mainframe systems to be used by many people, usually at the same time. Large data processing systems require full-time staff to operate efficiently.

PDA

A personal digital assistant (PDA), also known as a palmtop computer, or personal data assistant is a mobile device that functions as a personal information manager. PDAs are largely considered obsolete with the widespread adoption of smartphones.

PHI

PHI or Personal Health Information (or Protected Health Information) are the patients' personal and private information such as the patient's name, birth date, social security number, diagnosis, tests, treatments, the doctors or medical provider who provided services to the patient, the insurance company or the health card number, claim information, etc. The information must not be divulged unless it is required or if it's authorized by law and/or the patient for an important purpose.

PHP

PHP is a general-purpose server-side scripting language originally designed for Web development to produce dynamic Web pages. It is one of the first developed server-side scripting languages to be embedded into an HTML source document rather than calling an external file to process data. The code is

interpreted by a Web server with a PHP processor module which generates the resulting Web page.

PHPASS

This is a portable public domain password hashing framework for use in PHP applications. It is meant to work with PHP 3 and above, and it has actually been tested with at least PHP 3.0.18 through 5.4.x so far. (PHP 3 support is likely to be dropped in next revision.)

PHR

A personal health record, or PHR, is a health record where health data and information related to the care of a patient is maintained by the patient. This stands in contrast with the more widely used electronic medical record (EMR), which is operated by institutions (such as a hospital) and contains data entered by clinicians or billing data to support insurance claims. The intention of a PHR is to provide a complete and accurate summary of an individual's medical history which is accessible online. The health data on a PHR might include patient-reported outcome data, lab results, data from devices such as wireless electronic weighing scales or collected passively from a smartphone.

PI

Personal information is “information about an identifiable individual.” It includes among other things a person's name, address, telephone number, age, health, financial and educational information, and identifying numbers and symbols like a student number and employee number.

POST

In computing, POST is one of many request methods supported by the HTTP protocol used by the World Wide Web. The POST request method is used when

the client needs to send data to the server as part of the request, such as when uploading a file or submitting a completed form.

PSTN

The public switched telephone network (PSTN) is the network of the world's public circuit-switched telephone networks. It consists of telephone lines, fiber optic cables, microwave transmission links, cellular networks, communications satellites, and undersea telephone cables, all inter-connected by switching centers, thus allowing any telephone in the world to communicate with any other. Originally a network of fixed-line analog telephone systems, the PSTN is now almost entirely digital in its core and includes mobile as well as fixed telephones.

RAM

Random access memory (RAM) is a form of computer data storage. A random access device allows stored data to be accessed in any order in very nearly the same amount of time for any storage location or size of memory device. A device such as a magnetic tape requires increasing time to access data stored on parts of the tape that are far from the ends.

R&D

The term R&D or Research and Development refers to a specific group of activities within a business. The activities that are classified as R&D differ from company to company, but there are two primary models. In one model the primary function of an R&D group is to develop new products in the other model the primary function of an R&D group is to discover and create new knowledge about scientific and technological topics for the purpose of uncovering and enabling development of valuable new products, processes, and services.

Red5

Red5 is an Open Source Flash Server written in Java that supports the streaming Video (FLV, F4V, MP4, 3GP), streaming Audio (MP3, F4A, M4A, AAC), recording Client Streams (FLV and AVC+AAC in FLV container), Shared Objects, Live Stream Publishing, Remoting and Protocols (RTMP, RTMPT, RTMPS, and RTMPE).

RIA

A Rich Internet Application (RIA) is a Web application that has many of the characteristics of desktop application software, typically delivered by way of a site-specific browser, a browser plug-in, an independent sandbox, extensive use of JavaScript, or a virtual machine. Adobe Flash, JavaFX, and Microsoft Silverlight are currently the three most common platforms, with desktop browser penetration rates around 96%, 76%, and 66% respectively (as of August 2011).

RSVP

In the context of social invitations RSVP or Rsvp (or either of these with a period inserted after each letter) is a request for a response from the invited person. It is an initialism derived from the French phrase *répondez s'il vous plaît*, meaning "Please respond."

RTMFP

The Secure Real-Time Media Flow Protocol (RTMFP) is a proprietary protocol suite developed by Adobe Systems for encrypted, efficient multimedia delivery through both client-server and peer-to-peer models over the Internet.

RTMP

Real Time Messaging Protocol (RTMP) was initially a proprietary protocol developed by Macromedia for streaming audio, video and data over the

Internet, between a Flash player and a server. Macromedia is now owned by Adobe, which has released an modified version of the specification of the protocol for public use.

RTT

In telecommunications, the round-trip delay time (RTD) or round-trip time (RTT) is the length of time it takes for a signal to be sent plus the length of time it takes for an acknowledgment of that signal to be received. In the context of computer networks, the signal is generally a data packet, and the RTT is also known as the ping time. An internet user can determine the RTT by using the ping command.

SMS

Short Message Service (SMS) is a text messaging service component of phone, web, or mobile communication systems, using standardized communications protocols that allow the exchange of short text messages between fixed line or mobile phone devices.

SQL

SQL ("S-Q-L" sometimes referred to as Structured Query Language) is a special-purpose programming language designed for managing data in relational database management systems (RDBMS).

SSL

Transport Layer Security (TLS) and its predecessor, Secure Sockets Layer (SSL), are cryptographic protocols that provide communication security over the Internet.[1] TLS and SSL encrypt the segments of network connections at the Application Layer for the Transport Layer, using asymmetric cryptography for key exchange, symmetric encryption for privacy, and message authentication codes for message integrity.

SWF

SWF is an Adobe Flash file format used for multimedia, vector graphics and ActionScript.[3] Originating with FutureWave Software, then transferred to Macromedia, and then coming under the control of Adobe, SWF files can contain animations or applets of varying degrees of interactivity and function.

TB

The terabyte is a multiple of the unit byte for digital information. The prefix tera means 10 to power 12 in the International System of Units (SI), and therefore 1 terabyte is 1000000000000bytes, or 1 trillion (short scale) bytes, or 1000 gigabytes. 1 terabyte in binary prefixes is 0.9095 tebibytes, or 931.32 gibibytes. The unit symbol for the terabyte is TB or TByte, but not Tb (lower case b) which refers to terabit.

TCP

The Transmission Control Protocol (TCP) is one of the core protocols of the Internet Protocol Suite. TCP is one of the two original components of the suite, complementing the Internet Protocol (IP), and therefore the entire suite is commonly referred to as TCP/IP. TCP provides reliable, ordered delivery of a stream of octets from a program on one computer to another program on another computer. TCP is the protocol used by major Internet applications such as the World Wide Web, email, remote administration and file transfer. Other applications, which do not require reliable data stream service, may use the User Datagram Protocol (UDP), which provides a datagram service that emphasizes reduced latency over reliability.

TWIVES

This is an acronym for Two Way Interactive Video eConsult System (TWIVES), a telemedicine application for the continuity of care in rural communities, remote areas, and in developing countries. TWIVES can be a useful alternative when

mobility is limited, the patient is disabled, or commuting is not an option for the patient.

UDP

The User Datagram Protocol (UDP) is one of the core members of the Internet protocol suite, the set of network protocols used for the Internet. With UDP, computer applications can send messages, in this case referred to as datagrams, to other hosts on an Internet Protocol (IP) network without requiring prior communications to set up special transmission channels or data paths.

UMTS

Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular technology for networks based on the GSM standard. Developed by the 3GPP (3rd Generation Partnership Project), UMTS is a component of the International Telecommunications Union IMT-2000 standard set and compares with the CDMA2000 standard set for networks based on the competing cdmaOne technology. UMTS employs Wideband Code Division Multiple Access (W-CDMA) radio access technology to offer greater spectral efficiency and bandwidth to mobile network operators. UMTS specifies a complete network system, covering the radio access network (UMTS Terrestrial Radio Access Network, or UTRAN), the core network (Mobile Application Part, or MAP) and the authentication of users via SIM cards (Subscriber Identity Module).

UN

The United Nations (abbreviated UN in English, and ONU in French and Spanish), is an international organization whose stated aims are facilitating cooperation in international law, international security, economic development, social progress, human rights, and achievement of world peace. The UN was founded in 1945 after World War II to replace the League of Nations, to stop

wars between countries, and to provide a platform for dialogue. It contains multiple subsidiary organizations to carry out its missions.

URL

In computing, a uniform resource locator (URL) is a specific character string that constitutes a reference to an Internet resource. A URL is technically a type of uniform resource identifier (URI) but in many technical documents and verbal discussions URL is often used as a synonym for URI

VOIP

Voice over IP (VoIP, or Voice over Internet Protocol) commonly refers to the communication protocols, technologies, methodologies, and transmission techniques involved in the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. Other terms commonly associated with VoIP are IP telephony, Internet telephony, voice over broadband (VoBB), broadband telephony, IP communications, and broadband phone.

VP7

TrueMotion VP7 is a video codec developed by On2 Technologies as a successor to earlier efforts such as VP3, VP5 and TrueMotion VP6. It is a codec with both VFW and DirectShow support that On2 Technologies claims has better compression than leading competitive codecs such as MPEG-4 AVC (H.264) and VC-1.

WANem

WANem (Wan Area Network EMulation) is a piece of software running on Knoppix, a well-known Linux distribution based on Debian. It is launched through a LiveCD at computer startup or can also be launched from a VMware platform. As of the 1.2 version, WANem cannot be installed on a hard drive.

This should be possible in the next releases. The goal of WANem is to emulate specific link qualities for testing the behavior of an application.

WHO

The World Health Organization (WHO) is a specialized agency of the United Nations (UN) that is concerned with international public health. It was established on 7 April 1948, with headquarters in Geneva, Switzerland and is a member of the United Nations Development Group. Its predecessor, the Health Organization, was an agency of the League of Nations.

WLAN

A wireless local area network (WLAN) links two or more devices using some wireless distribution method (typically spread-spectrum or OFDM radio), and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network. Most modern WLANs are based on IEEE 802.11 standards, marketed under the Wi-Fi brand name.

XML

Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the XML 1.0 Specification produced by the W3C, and several other related specifications, all gratis open standards.

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