Life at the Edge of the Internet
Preserving the Digital Heritage of Indigenous Cultures

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Abstract
This paper presents our research and field work with the Waorani Indians in eastern Ecuador regarding how they can preserve their digital heritage and culture on the Internet. We focused on empowering the Waorani to use technology to approach the Internet on their terms: to tell their story, not have their story told, to be independent, not dependent. Using analogies to life in the jungle, we explored issues such as digital self-determination, proprietary file formats, control of material entrusted to cloud service providers, international data import/export, content ownership vs. licensing, and intellectual property. Archival systems are only as valuable as their input data. This data is at risk due to competing economic and legal forces that can adversely influence content, digitization, ownership, and permitted usage. To address this problem, we present an encryption framework that encourages medical tourism to indigenous villages by protecting archived medical data, privacy, and constitutional rights.

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1. Introduction
Preserving the memory of the world in the digital age requires more than good solutions to the technical challenges of the digital documentary lifecycle (data capture, indexing, archival, and retrieval). Any system of digitization and preservation is only as valuable as its input data (i.e., “garbage-in; garbage-out”). For this reason, one must also consider the competing economic and legal forces that drive digital content creation, acquisition, processing, ownership, distribution, and permitted usage. For example, the constitutions of the authors’ home countries – Ecuador and the United States of America – guarantee citizens some degree of
digital self determination.¹ Yet, in Florida, USA, it is common business practice for doctors to withhold medical data about patients from patients because they do not want to provide patients with evidence that could be used against a doctor in court (in the event that the patient sues the doctor for medical malpractice). This business practice, combined with proprietary data storage formats and disparate repositories of medical data, makes it difficult for patients to independently access a unified view of their own medical history. The evolution of medical information processing systems in the USA have been driven, in large measure, by the economic interests of and laws written for doctors, insurance companies, and lawyers. This challenge is an example of information hiding, one of the patterns of human interaction on the Internet, which is explored in this paper. Such patterns potentially present challenges to the digital preservation of the heritage of indigenous cultures. Private companies and even governments are not immune to the special interests and market forces that create these challenges. The work and leadership of UNESCO is needed to build consensus around solutions that protect the input to digitization and preservation systems.

This paper is based on our work with the Waorani Indians of Eastern Ecuador. Their quest for digital self-determination, including their desire to overcome the challenges to preserving their digital heritage, provides a proto-typical model for indigenous peoples elsewhere. There are still pockets of indigenous people throughout the world who are isolated, geographically, culturally, and economically from mainstream society. In general, indigenous people can take one of several paths when initially contacting the outside world, specifically via the Internet:

- **Indigenous communities remain in isolation** – They can chose to remain in isolation, avoiding contact with the outside world thereby protecting their cultures from external influences. In eastern Ecuador, the government has set aside land for the Tagaeri in a region of the Amazon in which all outside contact or travel is forbidden. The indigenous people living there, a clan of the Waorani, are left in total isolation and can continue their traditional ways of life undisturbed.² Similar groups in Peru and Brazil have had little if any contact with the outside world.³

- **Indigenous communities take their chances by themselves** – They explore newly discovered access to the Internet from towns on the edge of the Amazon and must rely on commercial vendors for preservation and digitization. This approach to preserving their cultural heritage consists of random successes and failures. There is potential for the Internet and all commercial interests that come with it to dilute indigenous cultures.

- **Indigenous communities receive guidance** – This is a hybrid approach in which a community receives guidance with digitization and preservation, generally from non-profit non-governmental organizations (NGOs) whose mission and values are aligned with the best interest of the indigenous community.⁴ This is our recommended approach and the basis of this paper. This is the best chance for indigenous people to maintain their digital self-determination as they preserve their culture, history, and legacy on the world wide web. This path requires the leadership of UNESCO and similar organizations.

¹ See the 4th amendment of the constitution of the USA. http://www.law.cornell.edu/constitution/fourth_amendment. [Note: All on-line references valid as of September 24, 2012.]
Humanity has a choice: for those cases where isolated societies interact with the industrialized world, we can either help them to successfully preserve their cultural heritage on the Internet or let them attempt to make it on their own, risking exploitation, cultural dilution, and loss of digital memory of the world. We see at least three aspects of providing guidance to indigenous communities:

1. **Legal frameworks that protect the ability for indigenous people to preserve their digital heritage** – Organizations like UNESCO publish recommendations that governments enact and enforce laws to better protect the digital content acquisition, processing, ownership, distribution, and permitted usage of digital content. This will, in turn, protect the input to digitization and preservation systems. In computer science nomenclature, this problem is known as “garbage in – garbage out.” Any system of digitization and preservation is only as good as its input data.

2. **Education for indigenous authors regarding the challenges to preserving digital heritage** – Educate indigenous communities so that they are aware of these challenges. This paper presents our experiences in Ecuador to build common understanding of these challenges as well as potential solutions. This education process is particularly difficult given that indigenous people living in isolation have no prior experience nor frame of reference with which to approach concepts of digitization and preservation in the digital age.

3. **Technical solutions that mitigate these challenges despite environments with competing commercial interests** – Technical solutions such as identity escrow achieve a balance between protecting the integrity of information entered into archival systems v. the commercial influences that bias it. It is important protect the digital rights of content originators: both the Waorani in Ecuador and the Musqueam native Americans in British Columbia have independently expressed the same concern, namely their intent to retain some degree of ownership and editorial control over indigenous content when published by third parties. Further, the commercial interests of content originators and the owners of archival systems are not always aligned (e.g., the archival of medical data by health insurance companies in the USA). This paper presents an example of a technical solution in this area.

This paper is organized as follows. First, we describe the experience of living on the edge of the Internet, particularly for the Waorani people in eastern Ecuador. The Waorani provide a model for indigenous people elsewhere in the world who are also living at the edge of the Internet and seek to preserve their digital heritage. Next we explore the import/export of information across the edge of the Internet in the context of constitutional rights and digital self-determination of indigenous communities. We then identify challenges, in the form of patterns, to preserving the digital heritage of indigenous cultures. We show how analogies between patterns in the digital world vs. life in the jungle can provide common understanding when educating indigenous communities on how to best approach the Internet, specifically to document their cultures in digital form. Finally, we present an example of a technical solution that mitigates some of the challenges that they will encounter. We use an example the medical challenges in the USA, which relate directly to challenges the Waorani communities will experience as they archive data captured in their medical clinics in the Amazon. The paper presents an example of how current business practices inadvertently infringe on citizen’s rights to digital self determination, at times even violating constitutional rights. We conclude with recommendations for future work that will help indigenous communities to digitize and preserve their cultural heritage on their own terms.
2. Life at the Edge of the Internet

The expansion of the Internet and its dominant role in our lives has become ubiquitous in almost all corners of the world. Figure 1 shows a map of the Internet that was generated by analyzing network traffic volumes. The lines represent data flowing between the switching nodes in cities. The brighter the line, the higher the volume of data. Stepping back, one can see that this image appears as a network of neurons in a brain. This is a good metaphor for our planet as it becomes wired into a collective consciousness assimilating all peoples and cultures – including isolated tribes in the Amazon.

As humanity’s collective consciousness reaches out to the last remaining isolated tribes, we must consider the degree to which our interactions across the edge of the Internet bias the cultures we seek to document and archive. For example within the past century, Christian missionaries have entered eastern Ecuador to spread the Word of God. This has had profound consequences on the local cultures, mostly positive. Internal warfare ceased as each longhouse group of Waorani was contacted by missionaries, beginning in

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5 http://www.opte.org/maps
On one hand, the tribes living there have stopped killing each other and now live in relative peace. On the other, some traditional ways such as the medicinal treatments of shamans or witch doctors have been suppressed. While much research has been done regarding the cause of these trends, there is no doubt that western influences have the potential to profoundly alter indigenous cultures.

One must visit the Amazon to truly appreciate its vastness and the isolation of its jungle settlements. Many of the roads in eastern Ecuador lead only to the oil fields and logging camps along the edge of the jungle. The only way into or out of isolated indigenous villages is via boat, small aircraft, or on foot. To reach Tzapino, the Waorani village that was studied for this paper, one must fly north east from Puyo, a small city on the edge of the jungle. During the flight, the volcanoes of the mighty Andes rise to the west while the endless expanse of jungle stretches 3,000 kilometers to the east. Upon reaching Tzapino, a skilled pilot must land a heavily loaded airplane onto a 500 meter grass airstrip next to one of the countless small rivers that feed the Amazon. The airfield is deep in the jungle surrounded by trees and traditional Waorani houses made of bamboo and palm leaves. There is no electricity in Tzapino, no Internet, and no running water. It is a day’s walk to the nearest dirt road. Communication with the outside world is batched, not real-time. Figure 2 shows a Cessna 206, which is typical of the aircraft used by missionaries and NGOs to fly supplies into the jungle, export handicrafts to markets, and occasionally to evacuate people for emergency medical care (e.g., snake bite).

The Waorani territories in Ecuador cover 790,000 hectares in the provinces of Pastaza, Napo, and Orellana (which includes the Yasusi biosphere). The 2,200 indigenous Waorani who live in these territories are represented by N.A.W.E., the Nacionalidad Waorani del Ecuador. N.A.W.E. represents

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Figure 2. Mission aircraft used to reach indigenous communities.

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7 www.nacionalidadwaorani.org
their collective bargaining via meetings the government and private companies such as oil drilling and timber companies. The challenges N.A.W.E. and the Waorani communities face are foreign to many in the industrialized nations, and yet the preservation of the digital heritage of these cultures begins with basic necessities such as access to clean drinking water and emergency medical support.

The Waorani now live on both sides of the Edge of the Internet: they retain their jungle communities while also maintaining a presence in frontier towns and cities such as Puyo, Ecuador, population 25,000. Since joining the modern world, the Waorani no longer depend entirely on the natural work of the forest to survive, and they are no longer nomadic. Instead, the young Waorani who live in neighboring towns are concerned with finding jobs, participating in government projects, and of course western culture, particularly as it appears to them on the Internet. This is a concern to the older generations of Waorani who seek to preserve traditional ways and who still view the land as their mother giver of food. To strike a balance, they are seeking technologies that can improve their management model for governance to help their people avoid poverty. They also want to protect their culture, stories, photos, and intellectual property, which is often published by third parties without their permission.

N.A.W.E. has established goals for the Waorani people in four areas: education, healthcare, territory, and community development (undertaken in partnership with the government and NGOs). Our work focuses on the information archival aspects of these goals, particularly education, healthcare, and the multi-jurisdictional legal framework for information exchange across the edge of the Internet.

2.1 Education

Education is not only essential to bring general awareness and knowledge to Waorani children, it is essential for the digital preservation of their culture. The first schools to bring knowledge of the outside world to the Amazon were established by visiting missionaries. Today, the Waorani are exploring Moodle, a Learning Management System, to enhance the learning process, including distance learning. Due to the isolation of many Waorani communities – specifically the lack of electricity, telecommunications, and Internet infrastructure – indigenous students will use solar-powered laptops to take off-line classes taught by teachers in Quito, the capital of Ecuador hundreds of kilometers away. Teachers and students will communicate in weekly batch cycles with homework and assignments exchanged via USB flash drives on aircraft serving missionaries, supply lines, and tourism. During this process, the digital heritage of the Waorani can be captured, preserved, and shared with the rest of the world.

Waorani children are curious and intelligent. Even with limited educational facilities, they show tremendous promise. These children love the forest and all of the wonders it brings. The forest is part of their heritage. As they cross the edge of the digital divide, they will be able to make significant contributions to the memory of the world by sharing the secrets of Amazon.

2.2 Healthcare

Many of the Waorani do not have access to modern medical facilities in their jungle communities. In the event of an emergency (e.g., snake bite) or a serious illness, a patient must be transported to the nearest city for treatment. Often times, the availability of transportation makes all the difference between life and
death. These communities need medical clinics to serve local residents as well as medical tourists from other countries (most notably the USA) seeking alternative medicines found only in the Amazon.

These Indian tribes for the most part have lived in isolation from other civilizations, and they have never been exposed to diseases, like Influenza A, which are very common in other parts of the world. These communities have no significant cases of heart disease, cancer, or stroke. Their unique immune system and dietary conditions provide scientific clues into the origins of certain diseases. Dr. James W. Larrick, a physician who made several trips to Waorani community during 1976 conducted several studies on relatively pristine immunologic state of these tribes.9

From these perspectives, the Waorani are prototypical of indigenous communities elsewhere in the world. They provide a good example for studying how to preserve the digital heritage of indigenous cultures.

3. The Amazon Information Pipeline

The first aspect of guiding indigenous communities towards digital self-determination is to provide them with an understanding of the legal frameworks that govern their ability to preserve their digital heritage.

Fulfilling Waorani goals – in education, health, territory, and community development projects – involves the free flow of information between the Waorani and other parties such as publishers, research scientists who visit the Amazon, and international organizations concerned with helping the Waorani (e.g., www.saveamericasforests.org). The Waorani are very sensitive to the extraction – and in some cases exploitation – of natural resources from the Amazon (e.g., oil and timber). Regarding the import/export of their information across the edge of the Internet, they would like to retain some degree of ownership and editorial control over indigenous content when published by third parties. We call this effort iPEACE – Information Pipeline for Education and Amazonian Culture Exchange.

3.1 Importing Information into Indigenous Communities

Importing information from industrialized world into Waorani communities appears to pose little legal risk – the Ecuadorian constitution guarantees the right to free access of information. However, once an indigenous community starts communicating and interacting independently with outside cultures, they enter legal structures and economic interests that might intentionally or unintentionally exploit their culture. The following are some excerpts from the Ecuadorian Constitution regarding the [digital] rights of Ecuadorian Citizens:10

- Free, intercultural, inclusive, diverse and participatory communication in all spheres of social interaction, by any means or form, in their own language and with their own symbols.
- Universal access to information and communication technologies.
- To build and uphold their own cultural identity, to disseminate their own cultural expressions, and to have access to diverse cultural expressions.

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• The right to protection of personal information, including access to and decision about information and data of this nature, as well as its corresponding protection. The gathering, filing, processing, distribution or dissemination of these data or information shall require authorization from the holder or a court order.

• The right to inviolability and secrecy of hard-copy and on-line correspondence, which cannot be retained, opened or examined, except in those cases provided by law, after court order and under the obligation to uphold the confidentiality of matters other than those motivating their examination. This right protects any type or form of communication.

The Ecuadorian constitution confers additional rights to Indigenous Communities and Peoples:

• All forms of appropriation of their knowledge, innovations, and practices are forbidden.
• To uphold and develop contacts, ties and cooperation with other peoples, especially those that are divided by international borders.
• Ecuador is the first country to recognize Rights of Nature in its Constitution.¹¹

Duties of the state:

• Facilitate the creation and strengthening of public, private and community media, as well as universal access to information and communication technologies, especially for persons and community groups that do not have this access or have only limited access to them.

• Not permit the oligopolistic or monopolistic ownership, whether direct or indirect, of the media and use of frequencies.

3.2 Exporting Information From Indigenous Communities

Special care should be taken when introducing an indigenous community to the Internet for the purpose of bringing that community's culture to the outside world. Protecting indigenous culture through western intellectual property protection systems is difficult, particularly when copyrighting folklore. The international systems of copyright protection require elements not traditionally found in folklore, such individual ownership, fixing the copyrighted material to a fixed tangible medium, and minimum standards of individual creativity. Should a native story be incorporated into a book or film, the Waorani want to have copyright protection to ensure that the story is presented accurately. Although the Ecuadorian Constitution guarantees such rights to local communities, a closer look into international enforcement and Ecuador's political position is essential to determining protection. When introducing the culture to the Internet or bringing the community's culture to the outside world, care must be taken so that any profit generated from their contributions are properly distributed to the rightful owners. The current global intellectual property protection systems may have to be extended or modified to cover the special nature of information shared by these communities such as their folklore or medicinal methods.

Furthermore, when western pharmaceutical companies extract information from the Amazon regarding indigenous plants and remedies, their focus is on economic interests such as securing patents; less consideration is given to preserving the culture and stories that accompany the use and application of those plants and traditional remedies, even when this accompanying cultural content is captured.

¹¹ http://therightsofnature.org/ecuador-rights/.
4. Education – Challenges and Awareness

Education is the second aspect of guiding indigenous communities towards digital self-determination as they preserve their digital heritage. Education empowers them to deal with challenges on their own terms, particularly in an environment of competing economic forces.

We studied the challenges that they face (when preserving their digital heritage) in the form of patterns of human and business interactions, particularly on the Internet. Many of these concepts are especially challenging because they are both difficult to mitigate and difficult to explain to indigenous authors seeking to document their culture and heritage in electronic form. We found that these patterns and challenges are best explained by analogy to concepts that indigenous people find in the jungle.

- **Symbiosis (Win–Win)** – Leaf-cutter ants and the fungus that eats the leaves cut by the ants share a symbiotic relationship. The ants bring leaves back to their nests to feed the fungus that grows in their ant mounds. In turn, the fungus consumes the leaves and produce a by-product that feeds the ants. Neither species can exist without the other. This symbiosis is analogous to the relationship between participants in a digital marketplace: Google’s Android apps and Apple’s iStore are market makers that provide an infrastructure on which market participants build and sell applications. Thus, developing mobile apps that provide access to indigenous content is win-win for everyone.

- **Framework or Infrastructure (Win–Neutral)** – Bromeliads are epiphytes that grow on trees; the trees provide the structure and environment in which bromeliads grow, but the bromeliads offer little to the trees. Neither species harms the other. Another example well-known to indigenous communities is a jungle airstrip. By analogy, there are many examples of frameworks and infrastructure in software. One of them is Microsoft’s .NET.

- **Viruses in Software (Win–Lose)** – Strangler figs are vines that grow around trees, constrict them, and eventually kill the very hosts that support them. Likewise, computer software viruses infect a host application, cause damage, and eventually die with the rest of the system.

- **Censorship** – Consider an oil drilling company in the Amazon that requires its employees and indigenous people to sign nondisclosure agreements regarding pollution. How do indigenous communities balance their need for clean drinking water vs. continued payments for drilling rights in their territories? How can they turn to the industrialized world to provide best practices for preserving digital heritage when oil drilling companies in the USA use nondisclosure agreements and sealed court records to block independent scientific research into the adverse health effects of hydro-fracturing drilling? Censorship – however justified – impedes the free flow of information into archival systems, which in turn limits the value of such systems.

- **Adaptation (or extensibility)** – Termites adapt to their environment by building nests to suite their environment. In Africa, termites build towers on the ground in a dry environment. In the Amazon, termites build nests in trees so they do not wash away during torrential rainstorms. This adaptability of termites is analogous to the software design concept of adaptability and extensibility, namely that a system (its structure, functionality, and/or intended use) is permitted.

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to change over time, subject to constraints such as technical limitations or contractual obligations to customers.

- **Information hiding** – A publisher blocks, limits, or alters information produced by a content originator (both roles may be the same entity). Example one (positive): Digital Rights Management (DRM) systems use encryption to protect the intellectual property rights of the content owners by hiding information from non-authorized parties. Example two (negative): In the USA, doctors withhold information from their patients to protect against being sued. In some cases, patients withhold information from their doctors to protect their privacy (because doctors are required to release medical data that they collect to insurance companies).

- **Information Expiration** – Information in an archival system is destroyed after a certain period of time, generally to save disk space once records retention requirements have been met. This pattern is analogous to the spoiling of food in the jungle. Another example is store receipts with invisible ink that disappears after the merchandise return period has expired (the Waorani do see receipts with invisible ink at stores in the town of Puyo). Another example is a doctor who uploads information with the intent that it will only be available for a limited time.

- **Proprietary vs. open-source data formats and computer software** – It is important that indigenous authors understand both the licensing terms and encoding schemes of the software they select record and archive their cultural heritage. Proprietary software is typically leased as a license to access, but not own. Open-source software is generally distributed freely with support services sold separately. To explain these concepts, we demonstrated proprietary vs. open file formats to the Waorani leadership. We showed them the same file as viewed in both Microsoft Word 2007 running on Windows 7 and LibreOffice running on Ubuntu. Then we showed them how these two programs store files in different file formats. It became clear to them that open formats such as DocBook XML can be viewed independently of the source application while proprietary formats such as Microsoft Word require the original program for interpretation.

Figure 3 maps these patterns and metaphors to concepts in the jungle. Additional patterns follow:

![Figure 3](image)  
Figure 3. Guiding the Waorani towards digital self-determination with metaphors.
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- **Intellectual property, leasing vs. owning** – if the Waorani post their stories on the Internet, who owns them? How are they paid for their content? Do they sell a subscription or make a one-time sale of their stories? Indigenous people should understand the consequences of this issue prior to signing contracts involving intellectual property ownership.

- **Intellectual property, exclusivity** – in intellectual property law, exclusivity applies when the subject of content grants exclusive rights to a single party (such as a publisher) and foregoes the possibility of granting similar rights in the same content to another, unrelated party. We recommend that indigenous communities grant non-exclusive rights to their stories. This way, they retain ownership over their content and the ability to resell or re-license it to another party in the future.

- **Hyperlink Transitivity** – the legal claim that a website owner becomes responsible for all content reachable by hyperlinks on the site. If an Internet user visits a Waorani website, and that site links to other blogs (e.g., perhaps critical of the oil industry), do the Waorani become liable for third party blogs?

- **Content aggregation** – Mixed content from different sources, in particular different indigenous communities that aggregate their content together to make a compelling website about their region.

- **Broker** – A neutral, third party who mediates between a provider or a consumer. For example, a real estate agent takes a commission to broker sales. An electronic clearing house of data or transactions that charges an e-fee to connect indigenous people (e.g., to bring Indian handicrafts to market).

- **Information Escrow** – A variation of the broker pattern in which an independent, third party holds information on behalf of two counter-parties until a transaction between those two counter-parties has been completed. For example, if a publisher insists that Waorani stories be encoded using a proprietary digital rights format, then the Waorani could insist that the publisher keep the original content in unencrypted form on deposit with an escrow service.

- **Information quarantine** – Temporarily isolating data or programs so that they cannot interact with the rest of a computer system. For example, antivirus software quarantines suspicious files.

- **Monopoly of supply** – one company (monopoly) or a few companies (oligopoly) that dominate a market by controlling the supply of product or server. This is the classic definition of monopolistic power. The Organization of Petroleum Exporting Countries (OPEC) is an example of an oligopoly because it controls a large portion of the world’s supply of oil. The indigenous people of the Amazon understand the power of oil drilling companies.

- **Monopoly of demand** – one or a few companies dominate a market by controlling the demand for a product or service, or the payment thereof. The health insurance companies in the USA provide an example by effectively acting as one organization by sharing private patient data and controlling almost all payments to medical providers such as doctors (i.e., the demand-side of the monopoly). Unfortunately in the USA, insurance companies are except from the Sherman Anti-Trust Act, a federal law indented to protect citizens against the abuses by monopolies.¹³ Rescinding this exception would improve healthcare in the USA.

• **Value-added reseller** – A travel agent who’s website sells tour packages into the Amazon and provides additional services to complement those of the Waorani.

• **Affinity groups / social networks** – The ability for like-minded people to gather on the Internet for a common purpose. For example, Mycologists traveling to Waorani territory study mushrooms and fungus. An affinity group would allow Mycologists to interact with each other and share data on the Internet – under terms controlled by the Waorani – for their common causes such as researching mushrooms within Waorani territory. Another example is enabling the Waorani to band together to face the oil companies with one e-voice.

• **Lock-out** – Some doctors in the USA do not take cash (even though US currency states that is “legal tender for all debts public and private”). Instead, these doctors only see patients who can pay for services through health insurance. Further, if a patient has insurance, some doctors will not allow that patient to pay with cash.

• **Extortion (a.k.a. Protection)** – A third party demands payments for continued business operations by threatening to shutdown the victim’s website. Criminals flood the website with fake page hits to flood the servers in a denial of service attack. Service is restored when the victim pays “protection” money.

• **Reuse by framework** – A software framework is a reusable infrastructure that can be extended and customized to solve similar problems.

• **Reuse by libraries** – A collection of software building blocks that can be combined to solve similar problems.

• **Protocols** – peer-to-peer, point-to-point, multi-cast, push vs. pull

• **Syndicated content** – the ability of the Waorani to join other indigenous communities throughout the Amazon, either to sell their web content (and generate revenue for Waorani communities) or to purchase access to a wider market.

• **Content authentication** – Methods to verify that the content originator is in fact who he claims to be.

• **Content non-repudiation** – Methods to assert that the content originator cannot deny previously originated content.

• **Copyright law varies by country** – Copyright laws protecting Waorani content vary from one country to the next.

### 5. Technical Solutions to Preserving Digital Heritage

The legal frameworks that govern the preservation of digital heritage often come into conflict with competing commercial interests that drive digital content processing, ownership, and permitted usage. Technical solutions exist to mitigate these challenges. Providing such solutions is the third aspect of guiding indigenous communities towards digital self-determination as they preserve their digital heritage.

A key theme of this paper is that archival systems are only as valuable as their input data. A secondary theme is that competing economic interests may bias, impede, or even prevent the free flow of
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information into archival systems. Thus, organizations like UNESCO can help indigenous societies by bringing awareness to research into technical solutions that protect indigenous rights to digitally preserve their culture and heritage in an environment of competing commercial interests.

For example, the Waorani would like to use the Internet and archival technology to preserve and share their ways of traditional medical care using natural resources found in the Amazon. One potential source of this information is Waorani healthcare clinics, which serve the Waorani as well as foreigners—medical tourists—who travel to Waorani territory to seek out traditional healthcare. The Waorani encourage foreigners to visit their healthcare clinics for two reasons: first this brings money into Waorani communities; second, this is another way in which the Waorani can share their cultural heritage and traditional methods of healthcare with the outside world.

Unfortunately, medical tourists from the USA who travel to Waorani territories may be reluctant to visit indigenous medical clinics because some medicines and medical practices from the Amazon may be considered experimental or otherwise not viewed favorably by health insurance companies back home in the USA. Further, the medical data collected from these traditional treatments could be used against them to deny future insurance applications and/or claims. The unintended consequence is a disincentive to archive valuable information. This adversely affects everyone from patients to independent researchers who study anonymous medical data to determine the efficacy of traditional Waorani medicines.

The problem is that in the USA, patients have little control over the scope of information permanently released by their doctors to third parties such as health insurance companies and the Medical Information Bureau (www.mib.com) which archive medical data. These companies do have a legitimate business need to use archived medical data to combat insurance fraud. However, in some scenarios, they can infringe upon a patient’s right to privacy by collecting medical data when the patient has no legal obligation to provide it. Consider that the MIB maintains personal medical records for seven years while some insurance applications only require applicants to provide medical history within the past five years. What happens if a person applies for insurance six years after he is diagnosed with cancer? If that diagnosis occurred in the USA, then it would likely be discoverable by the insurance company and used as justification to deny the application for medical coverage. However, if that diagnosis occurred in an indigenous medical clinic outside of the USA, then the insurance company would likely not have access to that diagnosis and would approve the application for medical coverage. In both cases, the applicant can be truthful on his insurance application and no laws are broken. Yet, the outcomes are very different.

The fourth amendment to the constitution of the USA guarantees a citizen’s right privacy in their personal effects, which applies in this case. In practice, however, there is little privacy in the USA because businesses control many aspects of the information systems that facilitate daily life in the digital age. The Ecuadorian constitution provides even more explicit protection of personal [electronic] information than the constitution of the USA. But if ubiquitous business practices have the unintended consequence of undermining the constitution of the USA, what is to stop the same fate in Ecuador?

There is a simple and effective technical solution that addresses these challenges via identity escrow, which separates medical data from the authentication data used to identify patients. This separation of concerns gives patients (and potential medical tourists to Waorani territories) the privacy and peace of mind they require before they consent to the collection, archival, and limited, directed release of their medical data. Likewise, from the perspective of medical service providers, the government, and authorized third parties, identity escrow provides the accountability and transparency infrastructure that could support the involuntary release (from the patient’s point of view) of authentication and medical data when
necessary to comply with the law. This combination protects the digital self-determination of citizens who provide content for archival systems while meeting the needs of commercial interests.

The rest of this section describes our proposed technical solution, Identity Escrow, in more detail. The system separates authentication data from medication data via two, encrypted databases each with separate access security. These databases are joined together by Medical Record Locator (MRL). The identity database is populated when patients initially register to use this cloud service (e.g., name, address, date of birth, government-issued identification number). The medical database is populated when doctors upload medical data via the MRL after treating a patient. The doctor only has access to the patient’s MRL and all associated medical data; no patient-related information from the identity database is available to the doctor. Figure 4 illustrates how the use cases of this technical solution work together.

Use case: Medical Service Provider Registration – A provider such as a doctor registers with Identity Escrow by creating an account and providing his or her authenticating information. Depending upon the jurisdiction, it may be necessary for third party such as a government agency to verify that the doctor has a valid license to provided the services in question.

Use case: New Patient Registration – A person seeking medical care with privacy registers with Identity Escrow by creating an account and providing authenticating information. Depending upon the jurisdiction, it may be necessary for a third party such as a notary public to attest that the registration and identity information has been independently verified (e.g., using the patient’s passport as documentation).

Use Case: Patient Visits a Provider – When a patient visits a provider such as a medical clinic staffed by doctors, the patient does not provide any identifying information. Instead, the patient presents an Identity
Escrow account number, which the clinic staff use to look up the patient’s account. The patient then answers challenge questions, presented by Identity Escrow, to authenticate himself (e.g., to confirm that the account number has not been stolen). Thereafter, the medical examination can commence. Doctors have access to any previous patient medical history provided that the patient has marked such information as visible in his Identity Escrow account. Once the medical services have been rendered, the doctor can upload new medical data into the patient’s medical records at Identity Escrow. Payment for services rendered is arranged separately and is outside the scope of Identity Escrow.

**Use case: Voluntary release of patient information** – A patient may wish to voluntarily release his medical information to a third party, for example to support an application for insurance coverage or to apply for a new job. This use case involves two sub-cases that both start when the patient logs into Identity Escrow to schedule a release of information:

1. The patient identifies a third party who has previously registered with Identity Escrow (e.g., another doctor in the USA who will examine the medical data uploaded at a Waorani clinic in order to render a second opinion). Identity Escrow sends a message with a security key to the third party Identity Escrow with an authentication token that matches information sent independently by the patient to the third party. The key is valid until its time-to-live value expires. Finally, the third party uses the key to pull the required medical data from Identity Escrow.

2. The patient logs into Identity Escrow to schedule a release of information, and Identity Escrow provides the user with a temporary access number. The patient provides this access number to the third party. The third party pulls the relevant medical data from Identity Escrow.

**Use case: Involuntary release of patient information** – To protect the medical provider and third parties such as insurance companies, Identity Escrow may release protected patient information when necessary to comply with the law. The patient must agree to this condition during the registration process. Generally, a court-ordered warrant or subpoena is required to release authentication and medical data without the patient’s consent. This varies by jurisdiction.

**Use case: Research** – Depending upon the jurisdiction, Identity Escrow may release medical data only (without identifying information) for educational and research purposes.

**Other use cases** – Other cases include account closure. When a user closes his account, Identity Escrow will maintain archived medical data to comply with requests for involuntary release of patient data.

In summary, Identity Escrow provides an example of how a technical solution can mitigate the challenges to digitization by separating competing concerns, namely the digital content vs. the business transaction that produced it. This protects the content originator’s right to preserve his or her digital content in an environment of competing commercial interests. Thus, a content originator – such as a medical tourist to a Waorani alternative health clinic – is encouraged (not discouraged) to authorize the archival of sensitive personal information. The data collected from thousands of patients over time will become part of the digital heritage of traditional Waorani medical treatments. The example presented above mitigates the following patterns of challenges to preserving digital heritage: censorship, monopoly (of demand), information hiding, expiration, and Identity Escrow.
6. Conclusion

We finish with the following conclusions and recommendations for future work:

- There are three paths to preserving the digital and digitized heritage of indigenous cultures: leave them alone, let them take their chances on their own, or provide them with guidance. Guided preservation is the best path, especially when performed by organizations like UNESCO and NGOs whose mission and values are aligned with the best interests of indigenous societies.

- Any system of archival is only as valuable as its input data. This presents a problem when the commercial interests of the owners of archival systems are not aligned with the interests of the content originators. For example, the archival of medical data by health insurance companies in the USA is driven by financial concerns, not the patient’s desire to store a life-time portfolio of useful medical information in the context of privacy. This struggle by citizens for digital self-determination is part of on-line culture in the digital age. And it biases the information to be archived.

- Indigenous communities in the Amazon will encounter the same problems as their North American counterparts when they cross the edge of the internet unless organizations like UNESCO and NGOs encourage governments to improve laws that protect individual rights to the digitization and preservation of personal information. Input data that is entered into archival systems depends on these protections.

- Such legal and technical protections will encourage more medical tourists to visit medical clinics in the Amazon to experience alternative medicines and exchange culture with indigenous communities such as the Waorani.

- Technical solutions can mitigate legal, ethical, and economic challenges to digitization and preservation. For example, identity escrow separates the concerns of content originators vs. the owners of commercial archival systems by separating the information produced by a transaction from the financial and personally-identifiable information about the transaction. This facilitates data privacy, right to oblivion, and right to access.

- Indigenous people must develop the skills to approach the Internet on their own terms. This requires education regarding the challenges to preserving their digital heritage. They should not become dependent upon outside influences to control their data and Internet access. Ironically, they need help to do this, namely from trusted organizations like UNESCO that do not have a vested interest in exploiting these societies. This is the surest way that they can empower themselves and preserve their culture in the brave new world. Indigenous information must flow both ways without diluting cultures. They are eager to learn our ways; we must help them preserve theirs.

- Finally, any solution computer-based learning center deployed in the jungle must be self-sustaining and permanent. The indigenous population must be taught to administer their computers by themselves.