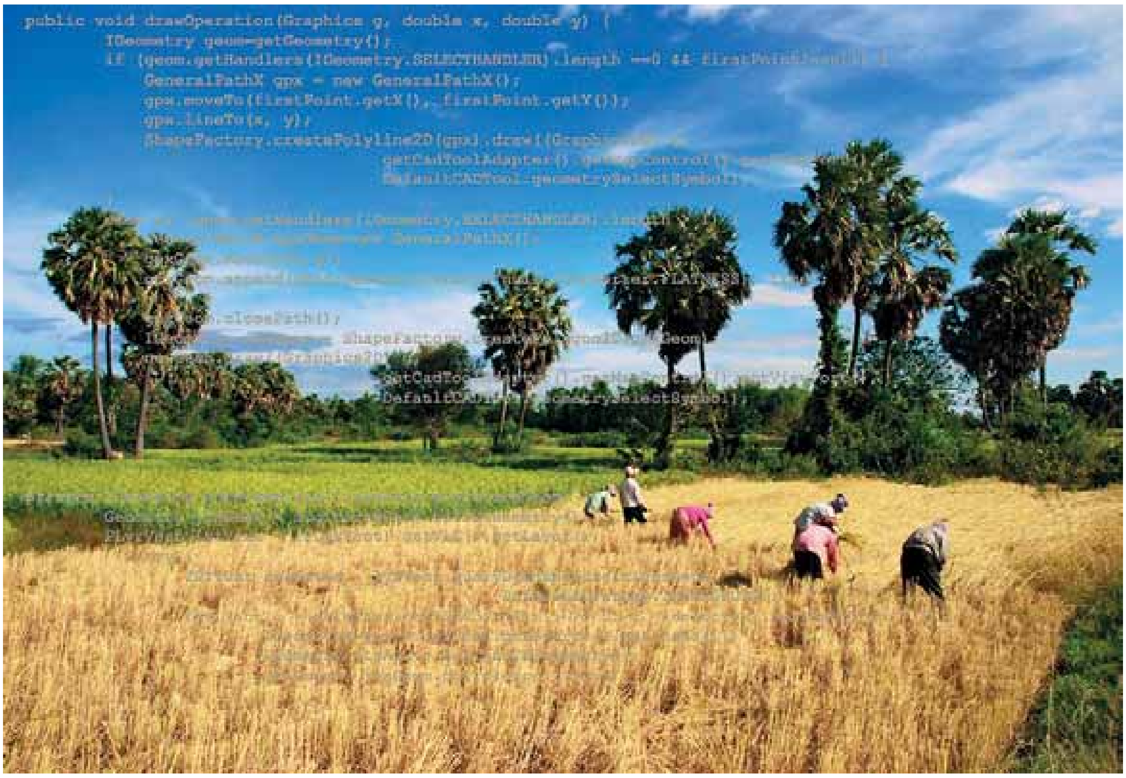
FLOSS in Cadastre and Land Registration

Opportunities and Risks



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Compiled and edited by
Daniel Steudler, Mika-Petteri Törhönen and Gertrude Pieper

April 2010

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FLOSS Cadastre

Compiled and edited by Daniel Steudler, Mika-Petteri Törhönen and Gertrude Pieper.

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This booklet would not have been possible without the support of many. We would like to thank the FIG-Commission 7, its delegates, and the many working group members for their continuing support of our work. We would especially like to thank the contributing authors for their invaluable input to this booklet. We also wish to acknowledge the support and assistance of FAO and its Land Tenure Group. Lastly, printing was made possible by the sponsorship of FAO.
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Foreword

It is our great pleasure to write the foreword for the "FLOSS Cadastre" publication in our respective functions as Chair of FIG-Commission 7 and as the officer responsible of FAO's Land Tenure Group. This booklet has been compiled and edited by the initiators of this work, Dr. Daniel Steudler (Chair of Working Group 7.3 of FIG-Commission 7) and Dr. Mika-Petteri Törhönen (Land Tenure Officer, FAO), as well as by Ms. Gertrude Pieper, who provided technical leadership for the entire initiative. We want to congratulate all three for this accomplishment and wish to express our gratitude for this new theme of exploration within our cooperation.

Land administration and cadastral systems in the 21st Century, which play an important role in practical implementation of responsible land governance, depend on the use of information technology (IT) tools. The application of these tools affects very much the systems' efficiency and costs. While commercial softwares have helped to establish the infrastructures of today and continue to do so, open-source alternatives, which have achieved considerable significance in many IT fields, have grown to provide credible alternatives for consideration. For various reasons, however, they are not often used in land administration and cadastre, even when their potential is increasingly recognised. This booklet aims to shed light on this potential, exploring the advantages, and disadvantages of open-source solutions within the context of cadastre and land registration.

This booklet is the result of four years of cooperation between FAO and FIG-Working Group 7.3. This cooperation has allowed the participation and contribution of a wide variety of authors, who come from different settings of different world regions. We would like to express our deepest appreciation to all of them and for their valuable insights into the "theory" and "practice" of open-source concepts and software, both in general and in the context of the cadastre and land registration. Finally, many thanks for swisstopo for facilitating the publication of this work.

We expect this booklet to be a contribution to further developments in support of the crucial basic infrastructure of a functioning society, and, through that, to improvements in social and economical development.

Dr. Paul Munro-Faure

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Department of Natural Resources and Environment

Food and Agriculture Organization of the United Nations FAO

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1. Introduction

Daniel Steudler, Mika-Petteri Törhönen

Background

When it comes to computer software, the old saying "you get what you pay for" may no longer apply. After years of skepticism towards open-source software, many of today's open-source solutions are as good, if not better than proprietary software solutions. The question is – why is it then that there are so few land administration systems making use of open-source software technology? Lack of knowledge about the possibilities might be one of the reasons. After all, marketing has never been a priority for developers of open-source software. Doubts about the security and available software support could further shy away cadastre agencies from making the switch.

Land administration and cadastral systems are playing a crucial macro-economic role in the collection, management, and dissemination of information about land ownership, use and value. Cadastral systems are documenting land tenure rights and are thus providing crucial economic, social and environmental benefits. Modern cadastral systems make extensive use of information technology (IT) supported by software systems. In developed countries, such systems have been established over the last 20-30 years and became powerful tools in operating cadastral systems. In developing and transitional countries, the need for efficient cadastral systems and the use of IT is as much a necessity as it is in developed countries, although there are substantial financial and operational constraints.

The motivation for FAO, World Bank and FIG to become active in the field of open-source software for cadastre and land registration comes from the observation that many systems and projects in developing countries struggle to provide appropriate and affordable services for tenure security. Reasons are related to governance but also to technological and financial shortcomings. Information technology plays a crucial role in operating cadastres and land registration systems. In developing countries, the on-going license costs of proprietary software often created serious constraints and have even stopped programmes.

The costs of proprietary software licenses have proved to be a constraint, but even more, the lack of capacity, models and support to develop software have stopped initiatives. Open-source software, which has become a credible alternative to proprietary software, provides a way forward. Open-source solutions are more flexible and adaptable to local conditions and languages than proprietary

software. By using and improving open-source software, cadastres can build local knowledge and contribute to the development of open-source projects that can in turn benefit other cadastres world-wide.

Aim of publication

The aim of this publication is to explore open-source software in general and in particular in the fields of cadastre and land registration and to come up with recommendations and hints for countries that are thinking of using open-source products. Open-source software has become an issue that cannot be ignored any longer and that actually might provide solutions to existing problems. This publication wants to explore and to develop an understanding of open-source software in as much a balanced and unbiased way as possible, give recommendations and reflect on lessons learnt with long-term validity on a conceptual and strategic level.

Structure and content

The publication is structured in the following five chapters.

Chapter 2 is providing some background information on the Open-Source concept. The **first section** gives an insight into the Governance side of Open-Source; the **second section** introduces the terminology and basic concept of open-source software; while the **third section** presents open-source software for geospatial data and the establishment of OSGeo, a foundation for open-source software in the geospatial domain.

Chapter 3 presents an overview of existing open-source tools and projects for the management of land information. The **first section** is looking at the software needs for cadastre and land administration systems and gives an overview of existing open-source tools and and possibilities. The **second section** looks into the experiences and lessons from an existing platform for open-source development, the GeoNetwork project. This section provides experiences in how to manage an open-source project, how user and developers communities are formed and sheds light on the steps to take for an open-source project in order to become a mature OSGeo project. The **third section** describes the OSCAR project, which is to develop operational open-source modules for use in several country case studies. The

OSCAR project is commissioned by FAO and carried out by the University of Otago in Dunedin, New Zealand. The **fourth section** presents the initiative taken by FAO to support the building and use of open-source products in the cadastral and land registration field. The **fifth section** introduces the "Social Tenure Domain Model", a standardized data modelling approach, a crucial aspect for the open-source idea in the geospatial domain, in particular the cadastral field.

Chapter 4 then gives the perspectives of six countries or states that already have adopted or are planning to adopt an open-source policy for their software application approach. It gives experiences and valuable recommendations for others.

Chapter 5 finally draws some conclusions.

2. Background on Open-Source and Linkage to Cadastre

2.1 Open-Source Software and Responsible Governance of Cadastral Systems

Mika-Petteri Törhönen, Rumyana Tontchovska, Gertrude Pieper

Responsible governance of tenure and information technology systems

Access to land, shelter and natural resources and the associated tenure security have significant implications for development. Secure access to land and other natural resources is crucial for hunger and poverty alleviation, and the protection of the environment. Land and other natural resources provide the platform for food and shelter, economic production and a basis for social, cultural and religious practices. Access to land and other natural resources is increasingly affected by climate change, violent conflicts and natural disasters, population growth and urbanization, and growing demands for land for agriculture and for new energy sources such as bioenergy. Security of tenure encourages long term investments on land and creates incentives for sustainable rural development.

Providing secure access to land and other natural resources is essential for the achievement of the World Food Summit Plan of Action and the Millennium Development Goals (MDG).[1] Access to land is a direct factor in the alleviation of hunger and rural poverty (1st MDG). Rural landlessness is often the best predictor of poverty and hunger: the poorest are usually landless or land-poor. Inadequate rights of access to land and other natural resources, and insecure tenure of those rights, often result in extreme poverty and hunger. Women are one of the groups that often have fewer and weaker rights to land. Through the registration of land in their own names, women will get better access to credit and agricultural inputs (2nd MDG). The project contributes indirectly to ensure environmental sustainability (7th MDG). Land tenure, by defining access and security of rights to land and other natural resources, affects how farmers decide to use the land, and whether they will invest in land improvements.

Weak governance is a cause of many tenure-related problems, and attempts to address tenure problems are affected by the quality of governance. Weak governance hinders economic growth and sustainable use of the environment, condemns

1 FAO-NLRA, see http://www.fao.org/nr/ltenure/lt-home/en/

people to a life of hunger and poverty, and may result in FLOSS of lives through violent conflicts. Responsible governance of tenure of land and other natural resources can help to reduce hunger and poverty and to support social and economic development. An effective and transparent land administration has an important role in ensuring the responsible governance of tenure. Responsibly governed tenure arrangements promote land use practices that enhance the environment. Inevitably in the 21st century IT systems are a critical element of good land tenure systems.

Grassroots realities

However land administrations commonly fail to secure land tenure rights of the poor and the vulnerable. Their services are not affordable and their staff incentives work against serving the needy. Weak governance as well as technical and institutional shortcomings reinforce the failures. The systems are inefficient, poorly structured and geared for serving a well paying client rather than a poor peasant. Land administrations' poor performance results partly from the lack of adapted and flexible software tools to standardise, structure and maintain the cadastre and the land registration. As a result, land administration operations remain unfeasible and only those that yield significant informal incomes survive.

The weak governance of tenure has most severe impact to the livelihoods and survival of people in developing countries, but it is important to notice that issues of governance of tenure are not country, region or development level specific, which for example the Global Corruption Barometer 2009 [2] has confirmed, highlighting the fact that corruption in land issues is a common-place throughout the world.

IT Systems improve responsible governance

Since their introduction IT systems have enabled quick improvements in transparency by providing electronic access to records, and in non-discrimination through standardising services and fee structures for electronic accounts. Introduction of IT systems to land registration is one of the most important steps in reducing opportunities for corrupt and non-transparent land management. Records and procedures are often standardized and logically structured for the first time with the introduction of IT systems. On another level innovative technology applied to land records and graphics improves knowledge based decision making and widens means for data dissemination and access to land records. Communities directly benefit from improvements in transparency.

Software has, however, also been a part of the problem in the inefficient management of land tenure data. In developed countries and countries in transition,

2 http://www.transparency.org/news_room/in_focus/2009/gcb2009

applying IT tailored around a relational database and geospatial software for land records and cadastral maps has helped, and often forced, agencies to standardise their workflows and land records to meet the logic of IT systems. However, IT has yet to help developing country land agencies much. The costs of proprietary software licenses have proved to be a constraint, but even more, the lack of capacity, and the lack of flexibility of models and the lack of support to develop software have stopped initiatives. Even when there are existing systems only narrow geographical coverage is reached. It is safe to say that developing country land administration IT systems currently do not serve the poorest parts of the community anywhere. It simply is not feasible.

Can open-source software help?

It is considered that the development of affordable and flexible information management systems in developing countries will provide more secure access to land and other natural resources in areas where this has not been feasible before and therefore for poor rural people.

Open-source software (FLOSS) [3], which has become a credible alternative to proprietary software, provides a way forward. Open-source means that, unlike proprietary software, developers have access to the software's "engine", which can be freely modified and adjusted. Open-source solutions are more flexible and adaptable to local conditions and languages than proprietary software. By using and improving open-source software, cadastres and land registers can build local knowledge and contribute to the public development of open-source projects (via for example web communities) that can in turn benefit other cadastres world-wide.

However, little knowledge and experience is yet available on the introduction of open-source systems in land registration and cadastral systems. While there are several examples of FLOSS used successfully in land records (see Chapter 3 of this booklet), land agencies in developing countries generally lack the IT expertise to build up a digital land records and mapping systems without external support. Open-source database and GIS (Geographic Information System) software is readily available, but there is a lack of awareness and lack of leading samples and success stories to encourage others to follow. It is clear, however, that the utilisation of FLOSS solutions for land records is a rapidly increasing trend and that the awareness is spreading rapidly. We don't need to wait for long for a leading sample to emerge.

Word of caution

FLOSS bears a promise for easier entry of developing countries to the era of IT system-managed land administration. However, we should be careful not to over-

3 Often referred to as FLOSS i.e. Free / Libre and Open-Source Software.

estimate its potential. The idea that IT systems can be installed within a limited amount of time and then used permanently thereafter is a common misconception. Building a digital land administration system, as any other digital administration system, is a continuous process rather than a one-time event. After installation, there will be new requirements and additional functions to be added. Hardware and software will need to be upgraded. Maintenance of the system must be planned and taken into account. System sophistication cannot exceed the available long term resources and in particular local capacities. System development relying in external know how should be used only with a credible exit strategy building local capacities. Although the costs of software maintenance and support when adopting FLOSS based systems will probably be lower than would be the case with proprietary software [4], they are not to be underestimated. FLOSS may make the maintenance easier, as problems can be solved without external support also making use of international user and developer communities, and cheaper, as license fees can be reserved for the maintenance and further development of the system. However, all IT systems require substantial budget and skills for maintenance, and developing country cadastral agencies have traditionally struggled to establish adequate resources for maintenance. Application of FLOSS will not change the fact that a proper business plan is the key requirement for introducing IT systems for land records.

Application of FLOSS to land registration and cadastral systems is likely to succeed in countries where the government embraces the idea of using open-source software for their information systems, and support the use of FLOSS in education and research activities. In such a national context, it will be easier to find local IT specialists who are familiar with FLOSS products that form the base and ability to maintain systems beyond their initiation.

2.2 Free and Open-Source Software

Arnulf Christl (President OSGeo)

In most cases the terms "Free Software" and "Open-Source" can be used synonymously as in the acronym FOSS. For the sake of clarification this text differentiates between Free Software as a licensing model and Open-Source as a development model. To emphasize the aspect of freedom sometimes the word "Libre" is included as an L to form the acronym FLOSS.

4 With proprietary software systems, typical maintenance fees account for a third of the software expenses. Service fees for FLOSS maintenance and support are more transparent and usually on a pay-per-service basis. See: *Are proprietary maintenance fees worse than open-source maintenance fees?* http://news.cnet.com/8301-13505_3-9827846-16.html

Free software licensing

The word "free" in Free Software refers to a degree of freedom and should not be confused with free as in gratis or in free beer. To make things a bit more complicated most software that comes with a Free Software license is available completely gratis or at a very marginal cost of a few cents for the actual download process. But the emphasis stays on the freedom of the user. With a Free Software license the user is free to:

- use the software anywhere and for any purpose;
- take it apart, understand and improve it;
- pass it on to anybody else in both the original or a modified version;
- make money by using it for any purpose;
- improve it in exchange for a monetary compensation or for any other reason;
- provide all kinds of services around it including training, installation, maintenance, etc.

These levels of freedom make up a Free Software license. For a comprehensive list of approved Free Software licenses please refer to the Free Software Foundation [5] or the Open-Source Initiative [6].

Proprietary software

The opposite of Free Software is **proprietary software.** The single but very central difference between the two types of licenses is that in the latter case the proprietor (owner) of the software will restrict some or all of the above mentioned freedoms. You (the licensee) are usually not allowed to use the software in more instances than is explicitly defined in the license contract. You are usually not allowed to take the software apart, or to modify it. You are not allowed to give the software away to anybody else. In some cases you are not allowed to make money by using the software in a certain way (by giving trainings or providing maintenance). In other cases you are not allowed to provide services for the software without an additional license. Basically, proprietary licenses are designed to restrict freedom and explicitly take away the rights that are defined by the Free Software license model. This sounds bad for the user, but it is actually not. It is just a very accepted, although somewhat different business model and for some time it has been very efficient in generating revenue and even made one such proprietor the richest person in the world. The proprietary software model, however, is in decline.

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5 Free Software Foundation at http://www.gnu.org.

6 Open-Source Initiative at http://www.opensource.org.

Open-source development model

In most cases "Open-Source" can be used synonymously for "Free Software". For the sake of this introduction we will look at Open-Source from a development model perspective. The source code of software contains all the functionality in a human readable format. To change, enhance or extend the functionality of most software it is required that the source code be modified. Thus Open-Source is a pre-condition for Free Software. End users will generally have no need to look into the source code and only work with the compiled, machine readable version. But it is still important to have the right to look into the software, because only then we can fully understand what it is doing. Even if we do not, we can still pass it on to someone else who does have the capacity needed to understand the code. This will give the user a degree of freedom from the monopoly of the vendor that proprietary licenses deny. All scientific research is based on absolutely transparent reproducibility which is not given if there is no possibility to look into the sources. Thus, strictly speaking, proprietary software cannot be used to analyze data for valid scientific research. Software developers naturally tend to drift to open development models because it makes reusing code a lot easier and allows for collaboration across organizational boundaries and between otherwise competing businesses. For many people these rather basic facts are completely new concepts, because they are not transparently communicated together with proprietary software.

Product and development cycle

The motivation to create and maintain open-source software is inherently different to that of a product vendor (see Figure 2.1). The left side of the illustration shows the typical development process of a vendor. The motivation of the vendor model is focused on making a profit. This will usually include a market study prior to starting the development. The development process itself is iterated in a closed environment until the software is released. The release date in most cases does not coincide with the software being ready to ship but with an event, for example a major industry trade show.

On the right side (Open-Source) the intrinsic motivation is often to solve a problem at hand. If the problem is common then the resulting solution can be of use to others and over time a number of regular users (participants) may emerge. In this case the software is said to "take off" and it starts to get published on the web on a regular basis. New requirements appear as more users use the software in different contexts. The requirements may then be implemented in the order of need or availability of funding. If the project is successful, development will stabilize either through a growing user community or through one or more businesses that profit from continuing development on the software. The diagram shows some aspects of these differences.

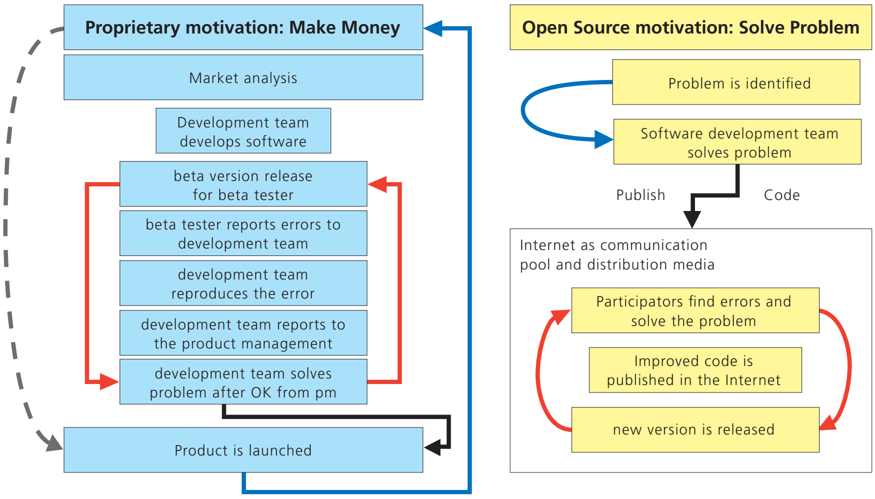

Figure 2.1: Proprietary and open-source development models (Christl, 2008).

Most noticeably the proprietary, closed development process limits the quality assurance to a restricted set of individuals. In the open development model everything is open to the scrutiny of many, which can result in the highest level of stability and security.

The obvious advantages of the open-source development can be seen in the emergence and success of major projects like the Apache HTTP server (now running more than half of all websites globally). More specifically in the geospatial realm this effect can be seen in software packages like GDAL/OGR, PostGIS, Proj4, MapServer, GeoTools and many more.

The open development model has that many advantages that all major proprietary vendors nowadays also naturally use the quick feedback mechanisms by asking users to fill out crash reports. Results from these reports may then be distributed as patches through web technology, which is exactly the way open-source software development environments are applying for many years. The difference here is again less transparency. While in an open-source software project all current open and closed issues can be seen and analyzed and reacted to, proprietary vendors will usually keep them locked away.

Open-source and security

At first sight being "Open" seems to contradict security, because in the physical world we are used to locking things away to prevent them from being stolen. Thus proprietary code – that is itself essentially locked away – would also appear

be more secure because none can look into its inner workings. But one of the very first paradigms of digital security says that security cannot be achieved by obscurity. Instead, all algorithms, architectures and concepts required to secure things must be open to the scrutiny of as many eyes as possible. This will ensure that they will get tested and verified by as many experts and in as many different settings as possible. Additionally it would not make any sense at all to try to lock away all protocols, code, software and architectures as “secret” because then no one can actually use and implement them. The only way out of this deadlock is to improve the software and architectures to the point that it becomes very hard to break. This is exactly how security in the digital world works. All the encryption protocols that form the core security layer of the Internet are based on open-source models. Real security has to stand up against being completely and thoroughly transparent. Only by opening up all processes to the scrutiny of as many participants as possible, a reliable security system can be built.

Proprietary black box security systems might be hard to break to start with. But up to now in history every single security system ever has sooner or later been broken. Therefore the most important issue of digital security is to know **when** it has been compromised so that counter measures can be taken. For that reason all major security systems that are in common use nowadays are based on open-source models. This does not mean that proprietary software can by definition not be secure because it can implement the same open-source algorithms, which is exactly what happens.

One example for geospatial open-source adoption in a high security domain is the US Department of Defense (DoD). It was one of the major initial supporters of geospatial Open-Source including the initial development of GRASS (the Geographic Resource and Analysis Support System). With the uptake of proprietary software in the 80s and 90s and the general need to reduce costs, new business models emerged and the DoD turned to so called CotS (Commercial off the Shelf) software. The hope was to be able to reduce the TCO (total cost of ownership) by not developing software in-house but to rely on external sources. Recent studies conducted by the DoD evaluated the results of this strategy and show that the open-source model is not inferior to the proprietary model from a financial perspective and that it is definitely superior with respect to security. As a result the DoD is shifting its focus again and has changed its documents accordingly (DoD, 2009) to allow the use of open-source in tenders, stating that open-source and proprietary software can synonymously be called “commercial software”.

FLOSS business models

Usually FLOSS business models are explained by listing activities that can be offered as a service. But it is a lot easier to work from the other end and acknow-

ledge that **all** business models around software naturally apply to FLOSS **except for** exclusive proprietary licensing. Estimates show that less than 5 % of all revenue generated by business activities around software is generated by selling proprietary software licenses (Perens, 2005). On the other hand there are practically no reliable numbers that could quantify the positive net productivity effect of any given software as it is not possible to compare one over another in a reproducible environment.

One reason why open-source models have been adopted early in the geospatial domain is the intrinsic interconnectedness of spatial data which relates well to the interconnectedness of knowledge – and code is nothing but formalized knowledge. Especially in the geospatial domain, a healthy business environment has emerged as can be seen in the Service Provider Directory of OSGeo, where a total of more than 150 companies are registered. This register represents only a fraction of all businesses that offer service, support, training, consultancy and maintenance for the whole range of spatially enabled software, ranging from the single contractor business to divisions of large enterprises that employ several hundred specialists.

FLOSS adoption by the industry

Unquestionably open-source is the superior development model. This has been proven by all major software enterprises, one of its pioneers being IBM which recognized the emerging paradigm shift at a very early stage. Nowadays all major software vendors including Oracle and even Microsoft have at one point either purchased open-source companies or product names or adopted the associated development methods. More specifically in the geospatial realm, open-source components are plainly used by proprietary vendors to support their own products – but only if it does not conflict with their core business interests of selling software usage licenses. Two recent examples are the company Oracle which uses the GNU Linux operating system to run their software, but not PostGIS to power their spatial database. ESRI on the other hand supports PostgreSQL (to avoid costly Oracle licenses for their customers), but not PostGIS because this would conflict with their own software product SDE. The intricacy of commercial acquisitions and their long term effects are hard to predict as can currently be seen with MySQL AB being bought by Sun Microsystems, which itself is coming under the control of Oracle. This illustrates that it is financially and strategically prudent not to rely on one vendor or product, but to use Open-Source and to diversify.

The proprietary conflict

FLOSS and proprietary software go well together, especially if they adhere to standards. We have to acknowledge, however, that the business model associated

with proprietary software does not go together well with Open-Source. Sometimes the discussion on the pros and cons are fought out as if it were a religious war. On closer inspection the problems at hand are quite transparent and result from the deprecation of the proprietary business model which is desperately trying to compete with evolution. As we have seen the core reasons for the uptake of FLOSS are neither religious nor altruistic but simply inherent to good software development. The reason for the intermittent success of proprietary models was the absence of a ubiquitous network of communication that worked at marginal cost – the Internet. Now that we have it and know how to use it the exclusive nature of proprietary software business models has a problem.

With proprietary software, customers need to pay in advance and decide periodically whether to extend the maintenance contract for the upcoming contract period. With Open-Source this is different. It can be run any time at no additional cost and without long-term contract commitment. If it does not work it can be exchanged – obviously with some cost but a lot less than what proprietary marketing wants to make us believe for so many years. This brings us to the most obvious problem in the proprietary/FLOSS struggle: Marketing. Proprietary has too much of it and FLOSS too little. Over time a lot of Fear Uncertainty and Doubt (FUD) has been spread to the detriment of open-source software. This has understandably caused a backlash of wild arguments against proprietary software from a marketing-unaware group of geeks. But these have organized themselves over the past years and done good work in removing most FUD so that Open-Source is now socially, technologically and financially acceptable.

FLOSS will make life a lot harder for monopolists who cannot innovate as easily as an open community of thoroughly networked developers on the loose. Especially monopolists are well advised to carefully adjust their business models to this new challenge. On the good side of business FLOSS is an enabler for innovation and a door opener for start-ups and small and medium enterprises. These will also make sure that business will be more local making it more efficient and more attractive for public administrations and governments as it strengthens the local economy.

Conclusions

It can safely be said that Free and Open-Source Software is here to stay. Change in large organizations has a high latency, therefore proprietary business models will be around for many years to come. Companies who employ hundreds of sales people cannot change their business model in a day. The same applies to organizations like cadastral base map agencies who operate very large and complex sets of data with high Vendor-Lock-In potential. On the other hand spatial IT also has a long tradition of using and adhering to standards because spatial data is by

definition boundless and needs to interoperate. The convergence of standards and Open-Source will be the core element for all future solutions.

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2.3. Open-Source Software for Geospatial Data – The Birth of OSGeo

Arnulf Christl

Introduction

Free and Open-Source Software experienced a strong uptake in the early days of the Internet, most notably through the GNU Linux operating system and Apache web server. But beyond these well known projects, Open-Source is still a new concept for many people. Interestingly, Open-Source has a long history of leadership especially in spatial software development. In the late 1970s development of the Map Overlay and Statistical System software (MOSS [7]) started after researching into existing code that was available as public domain. In the 1980s development of the Geographic Resource Analysis Support System (GRASS [8]) started, a project implemented mainly in C that over many years grew to over half a million lines of code.

With the rise of proprietary software the tendency for Vendor-Lock-In increased dramatically because vendors implemented closed formats. Therefore in the early 1990s the need for openness shifted away from developing software to making data formats interoperate more easily. To support this effort the GRASS community changed its focus and founded the Open Geospatial Foundation (OGF). Development of the GRASS software diminished and eventually subsided. But the emerging structures of the Internet allowed the project code to stay available, even although in a dormant state. In 1994 the OGF was transformed into the Open GIS Consortium (OGC [9]) later renamed to Open Geospatial Consortium to address the needs for standards by a growing global industry. Nowadays the OGC

7 http://www.scribd.com/doc/4606038/2004-Article-by-Carl-Reed-MOSS-A-Historical-perspective
8 http://grass.osgeo.org/
9 http://opengeospatial.org/

is the principal consortium for open standards in the geospatial world and works on ISO standards with geospatial relevance through a class A liaison with the Technical Committee 211 (ISO TC 211).

With the emergence of the Web as ubiquitous communication network on the Internet in the second half of the 1990s GRASS was reawakened by academia under the lead of Markus Neteler. GRASS development picked up speed again and started to grow into a highly committed community which recently celebrated the 25 year anniversary of GRASS.

At the same time the first versions of the MapServer [10] software emerged in the ForNet project. It was funded by NASA in 1996 and was initially developed by Steve Lime, a single developer who included the work on shapelib [11], implemented by another early contributor, Frank Warmerdam. It soon became apparent that this new type of web based software addressed the needs of a growing community of GIS users who recognized the potential of the Web (much later they would be known as Neo-Geographers).

In another parallel effort OGC members created the Web Map Server standard (OGC WMS) towards the end of the 1990s. Nowadays this is the standard open interface to an immense diversity of map services world wide. With the emergence of the Web 2.0 and a growing sense of belonging of the hitherto disconnected developer communities of GRASS, MapServer and several other projects, the need for a common organization was articulated. OGC was not suitable to develop or maintain software, because its structures had solidified around open standards and additionally the needs of mostly proprietary vendors who then would have become direct competitors. During this time, active users and developers of the geospatial open-source community started discussions, which eventually lead to the founding of the "Open-Source Geospatial Foundation" as is described below in more detail.

The challenges of Open-Source

Diversity and high turnover are essential to the success of Open-Source. At the same time they are the root for two major challenges:

- Anyone can publish anything under an open-source license. There is no inherent quality control in Open-Source.
- There is no single, compelling reason for continuity in an open-source project.

Both challenges also have to be addressed by proprietary software because they are not integral components of the proprietary business model. But the proprietary business model relies entirely on trust and reputation. Therefore brand quality

10 http://mapserver.org/
11 http://shapelib.maptools.org/

is one of the most important assets for a proprietary software vendor. The second is continuity which is the only leverage to maximize the return on investment. So even although the motivation of proprietary businesses to address these challenges is not based on the customer’s needs at least they get addressed. Open-Source in itself can be based on an intrinsic motivation that will take care of both continuity and quality but it is very hard to evaluate from the outside of a project.

The web based development platform SourceForge.net [12] hosts 230,000 open-source software projects (February 2009). The requirements to be accepted into SourceForge are that the code has to be published under a commonly accepted open-source license and that some code is published through the SourceForge code repositories. There is no other quality assurance. The SourceForge code repositoriy is just one web based development platform, there are an additional unknown number of projects that are simply “released“ under the open-source label, sometimes with legally dubious licenses or without specifying any licenses explicitly at all.

This demonstrates the importance of looking at code quality, project governance and license model separately prior to relying on any open-source software. Just because software is published under an open-source license does not automatically mean that it is good software. Anybody can publish anything and postulate that it is the best around. In many open-source projects there is no responsible legal entity to the project beyond the individual contributor.

Especially large organizations sometimes require that products which become structural core components of their IT infrastructure are backed by a reliable legal entity. Many small open-source projects lack this legal background which excludes them from being used in these organizations.

Organizations supporting Open-Source

There are three distinct types of organizations that support Open-Source for different reasons. The first two are commercial for-profit businesses and the public administration. The third type consists of community driven non-profit organizations whose mission is to further and promote Open-Source in distinct domains.

Commercial businesses and public administrations scale – meaning that there are many instances that use and also support all kinds of Open-Source. They have both specific interests but also inherent limitations to open-source projects as we will see below. These limitations can be compensated for by non-profit organizations.

Free and Open-Source Software is widely used by companies delivering commercial services as can be seen in the service provider director of OSGeo where

12 http://sourceforge.net/

product support, maintenance and training services are listed [13]. The Free Software license model does not conflict with their business interest; instead it is a comfortable means to enhance revenue by delivering solutions that do not incur external fees. In some projects it can even facilitate cooperation between competitors who collaborate on non-differentiating software. It is in the interest of these businesses to keep the open-source projects alive by supporting them through sponsorship or in-kind contribution and collaboration on development.

But the support will mostly be limited to the area where it is directly profitable to the business and also vary according to the overall financial situation of the company. In a difficult financial situation this type of sponsorship is top on the cut back. Widespread commercial use of Open-Source and the corresponding support will only start when the software has reached a mature state. There is little or no incentive in supporting open-source projects in their infancy.

Public administrations can develop a specific interest in supporting Open-Source because it can prevent Vendor-Lock-In situations. Larger governmental institutions have in the past often maintained development teams and implemented software on their own. Since the 1990s internal development budgets have been cut back considerably to reduce costs in the hope that "Commercial off the Shelf" (CotS) software would fill the gap. In parts this has worked out but in the long run created a much higher dependency, also because business mergers and acquisitions have led to monopolistic structures.

Currently a growing understanding of the inherent advantages of Open-Source especially for the public administration has fueled a renaissance of Open-Source support. But the years of neglecting internal capacity building can be seen, they must be compensated in order to be able to profit from all the advantages of Open-Source. Additionally the working conditions should be enhanced to be able to recruit a (young and) creative workforce. Budget cuts should not simply be accepted, there are many good reasons to create, maintain and provide access to spatial data in public administrations. These reasons should be laid out clearly to policy decision makers. Especially geospatial experts have the expertise to actually collect and convey these reasons.

Just like commercial entities the public administration has little interest in support fledgling projects that have a high risk of not succeeding. Public procurement processes have been modified in the late 80s and 90s of the last century to better address the needs of proprietary businesses, now they are not well prepared to support Open-Source. Some change is already taking place, even at highest levels as can be seen in the Department of Defense of the United States of America [14] or the European Union with the Open-Source Observatory Repository (OSOR [15]). But

13 http://www.osgeo.org/service_provider_directory
14 http://wiki.osgeo.org/wiki/Case_Studies#US_Department_of_Defense
15 http://www.osor.eu

it is a long and slow process that also has to deal with the fears and resulting resistance of deprecating but still strong proprietary business interests.

For all of these reasons community-driven non-profit organizations have emerged in all major IT sectors to cater for the needs of open-source projects that cannot be addressed by commercial businesses or public administration.

Community-driven non-profit organizations

The best organizational structure to address the challenges of Open-Source are community-driven non-profit organizations. They can ensure that open-source projects prosper and develop in the most effective way. They can protect them from potentially harmful proprietary interests and give them a long term technical and legal framework. They can be home for a creative and vibrant community which will maintain and further a diverse ecology of quality open-source software. They are also a framework for the orientation of potential users who can later turn into a new type of investor. These are not capital investors with a single interest of maximizing return on investment but with an interest of adding functionality, quality and longevity to software that helps to solve their day to day problems.

One of the earliest professional open-source software packages that were broadly deployed was the Apache http server. It caught the interest of IBM who had come to the conclusion that the open-source software was superior to what they were developing. This spawned the need for a legal organization for the developer community that had formed around this software and eventually gave birth to the Apache Foundation. The Open-Source Geospatial Foundation was born in a similar way.

In 2005 the hitherto thoroughly proprietary company Autodesk made an unexpected move by releasing their re-engineered Autodesk mapping software MapGuide as open-source under the GNU LGPL license. The launch was supported by the developers around the MapServer project who shared a common interest in building a non-profit organization for the geospatial domain. It soon became apparent that other open-source geospatial software communities (for example from the GRASS project) recognized the need for an overarching non-profit organization to help stabilize development, organize conferences, create a legal background and control the governance of projects – especially because the demand for open-source software was growing. The result was the formation of OSGeo.

The "Open-Source Geospatial Foundation"

In February 2006 the "Open-Source Geospatial Foundation" [16] – in short OSGeo – was founded by leading individuals from geospatial open-source soft-

[16] http://www.osgeo.org/

ware projects. OSGeo has developed into the leading voice for Open-Source in the geospatial domain. It is broadly inclusive because it is not driven by a single business with exclusive commercial interests but by a broad and diverse community of users, businesses, scientists and universities. OSGeo is home for projects implemented in different programing languages, for different user audiences and a variety of interests as such it is a community of communities.

The mission and tasks of OSGeo

The mission of OSGeo is to create and maintain a diverse ecology of highest quality open-source software for the geospatial domain. The goals are to provide a stable environment for collaborative software development, a freely accessible curriculum and to promote free access to spatial data.

To achieve these goals OSGeo provides resources for existing open-source communities and new software projects including the technical infrastructure, legal advice and financial backing. OSGeo supports FOSS4G (the acronym for Free and Open-Source Software for Geospatial) on a global scale and to this end also organizes outreach and promotion. The main task in this area is to build local capacities for conferences, promote OSGeo at trade fairs and to facilitate inter-project communication. OSGeo members work on a comprehensive curriculum to help educate domain experts instead of "brand-specialists".

All these activities combine to build a solid market for business which can then in turn solidify the financial basis needed to perform these tasks. This creates a chicken and egg situation which in the first years could only be overcome with the help of many volunteers spending uncountable hours of work in their spare time.

The formal structure of OSGeo

The structure of OSGeo has been gleaned from the Apache model and adopted to cater for the special character of binding existing communities that have already evolved in the geospatial domain. OSGeo is based on volunteer work and funded through sponsorship.

As a legal entity OSGeo needs some formal structure (compare Figure 2.2). In a nutshell, OSGeo is owned by 94 elected charter members who are extended by 20 members each year. The charter members nominate and elect 9 directors who appoint the president. The board also appoints the Executive Director who takes care of formalities like handling finances, signing contracts in the name of OSGeo and communicating with sponsors.

The board approves the budget and helps to acquire funds, for example by inviting sponsors (who act as investors) and by promoting the FOSS4G conference, which has in the past been one of the major sources of income for the organization. Formal committees are created to address different topics; each of them has

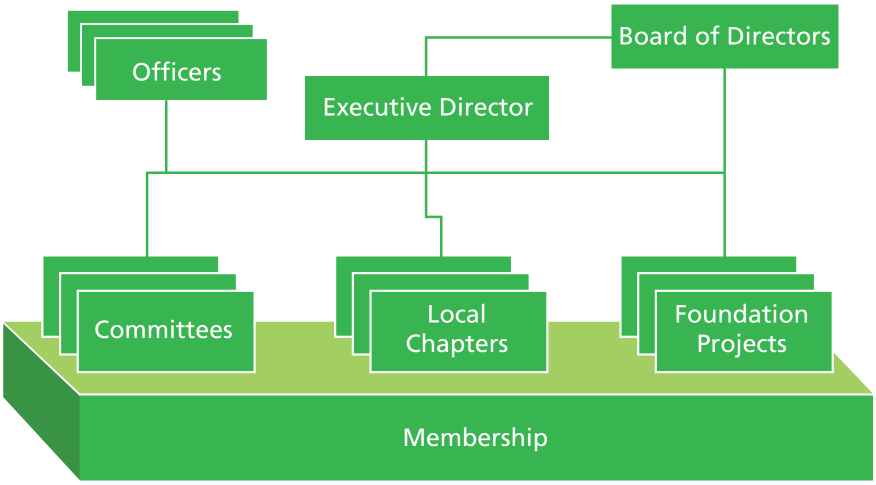

Figure 2.2: OSGeo's structure.

a list of members who vote for a chair who then becomes an officer and Vice President of OSGeo. There are committees for outreach, conference, web site, system administration of the OSGeo services, education, finance and free geospatial data as well as the Incubation Committee.

The OSGeo incubation committee

The first operational committee within OSGeo was the Incubator. It addresses the need for quality assurance that is missing in many open-source projects as was mentioned above. The Incubation Committee is formed by a broad group of developers from different backgrounds; programming languages include C/C++ and Java as well as web based technologies like PHP, JavaScript, Python and others.

Projects who are interested to join OSGeo first have to apply for the official incubation process [17]. One core criteria for acceptance is that all project code must be released under a license that has been legally confirmed by the Open-Source Initiative [18]. After a mentor who guides through the process is assigned the project can be accepted into incubation. Then the work starts: the source code is checked for license and copyright consistency and the governance of the project is evaluated to prevent monopolistic structures. Basic requirements for professional development have to be met including the use of code repositories, bug tracking systems and so on, all to assure highest quality.

17 http://wiki.osgeo.org/wiki/Incubation
18 http://www.opensource.org

To graduate from incubation the project needs to abide by the open-source rules of OSGeo as set forth in the Incubation documents. After the assigned mentor signals that the project is ready to graduate the incubation committee will scrutinize the project as a whole and eventually vote and approve for graduation. The last step to become an official OSGeo project is the approval of the board of directors.

Once accepted as an official OSGeo project users can be sure that the legal, organizational and technical structures of the project are healthy. Additionally, OSGeo will make sure that projects are provided with all that is needed to keep them going. Even in the case that a project falls out of use, the OSGeo community will make sure that there is a viable exit strategy that can be tailored to fit with the user's change management. This way the continuity and reliability of software from the open-source domain is much higher than any proprietary company can possibly achieve. This is also the reason why many proprietary companies start to use OSGeo software in their proprietary products, a process that would not have been thinkable a few years back.

The core of OSGeo

The core of OSGeo has always been the members of the communities that grew around the software projects. It is very simple to become a member of OSGeo; initially there is no formal process. Anybody can become a member, users, developers and academia, with a commercial, professional or hobbyist background. Becoming a regular member involves nothing more than creating a user account. The account can later be used to file tickets in the OSGeo repository, get write access the SVN repository, edit the web site and other services like shell accounts on test and build servers. Due to historical reasons the Wiki still requires a separate account; it is the place where many leave some personal information and a link to their contact data on other social networks. There are three types of membership:

- Participants collaborate on mailing lists, the Wiki, use and maintain the ticket system and work on the software stacks. This level of membership involves minimal authentication based on a valid email address.
- Regular members will sign up for mailing lists and become actively involved by working in committees. Usually it requires some time with active involvement in the corresponding project to become a member and vote on motions. As committees and projects are largely self organized the process to be accepted can slightly vary.
- The third category comprises the charter members. They own and control the foundation by voting for the board of directors from their midst. Currently the charter membership consists of 94 individuals from all walks of life [19]. Charter

19 http://www.osgeo.org/charter_members

membership is renewed and extended on a yearly basis and anybody can be nominated as a charter member.

The diversity of membership also reflects in OSGeo's projects, several implement similar or even the same functionality resulting in an internal competitive situation. But this is not perceived as a problem but instead as supporting healthy diversity. A new term has been coined to convey what this means by merging cooperation and competition into "coopetition". The result is highest quality, performance and stability. One example where the concept of competition can be seen is the annual "Map Server Shootout" during the FOSS4G conferences. The shootout is a friendly competition of different map server projects and takes place every year. As it turns out, the Java GeoServer and the C++ MapServer software are the fastest OGC WMS implementations around.

Local Chapters – OSGeo's local communities

One of the most important community aspects of OSGeo are over 40 Local Chapters. OSGeo Local Chapters are groups who share OSGeo's goals either in a common geographic region or through a common language or culture. Their status can be very different, some are legal entities, maintain their own funds, organize conferences, appear at trade fairs and give presentations at industry or scientific events. Others have a more informal character and provide a setting for people to meet locally or have the character of working groups with domain specific interests.

All of them share the intent to bring OSGeo into the local context, promote free and open-source software in the geospatial domain, localize documents and software and maintain local web sites or help maintain the main website in several languages. One of the prime interests of OSGeo is to connect with existing and emerging local communities and to support them with their local interests.

One big driver for Local Chapters is the recurring annual global FOSS4G conference. It already took place in Switzerland, Canada, South Africa, and Australia and will take place again in September 2010 in Barcelona, Spain. As OSGeo has signed a memorandum of understanding with OGC to collaborate on standards, we will see amongst other aspects recurring interoperability experiment on standardization at future FOSS4G conferences.

Conclusions

OSGeo supports free and open-source software in the spatial domain and is a stabilizing factor in today's highly dynamic software and business environment. You can participate and profit from this community of spatial expertise by using the software; secure in the knowledge that it is free of potentially disruptive pro-

prietary interests. OSGeo is the common roof for projects and communities, a platform to create and share software, information and know-how. This also ensures highest quality software and longevity of investment. Getting involved in OSGeo and OSGeo software projects means to benefit from a highly motivated pool of expert.

OSGeo's future foresees a continued and steady growth aiming for longevity and stability instead of a fastest possible expansion. With growing revenues from sponsorship, OSGeo hopes to be able to contribute more to the production and maintenance of a geospatial core curriculum that does not depend on one type or even brand of software but aims at educating geospatial experts. This will help businesses to continue building up a qualified workforce and organizations to focus on solving real world problems with geospatial software instead of solving software problems.

3. Tools and Initiatives

3.1 Existing Open-Source Tools – Possibilities for Cadastral Systems

Gertrude Pieper

Introduction

What we call cadastre today comes from a long history of keeping maps and descriptions of land boundaries, together with written records on land ownership. Although the organization of cadastre and land registration operations will vary from one country to another, cadastral and land registry offices usually handle administrative and technical tasks to document and maintain information on land property. The FIG statement on Cadastre (FIG, 1995) defines cadastre as follows:

A cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land (e. g. rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes, legal purposes, or to assist in the management of land and land use and enables sustainable development and environmental protection.

Even though there is a strong relationship between cadastre and land registration functions, they differ in content. While the land register holds the records on right on land through deeds or titles, the cadastre contains information about land properties and their boundaries within a certain administrative area. Land registration and cadastre functions complement each other and should ideally be handled within the same system. The second statement of the Cadastre 2014 model (Kaufmann and Steudler, 1998) foresees an abolishment of the separation between cadastral maps and land registers. Yet in many cases, they are functioning independently in separate organizations and not always co-operating in the most efficient way (Zevenbergen, 2004).

The design of digital cadastral systems must take the organization and required distribution of information into account. While new technologies allow data to be stored centrally, the cadastre and land registration functions might be implemented at local level with little cooperation between administrative areas within the same

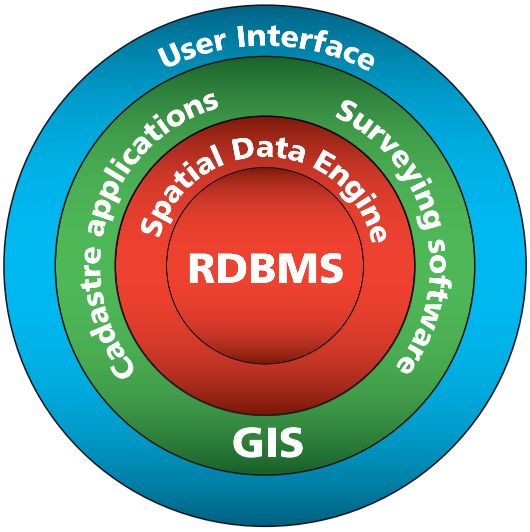

Figure 3.1:
Software components of cadastre and land registration systems.

country. Or the land register might be maintained at central level, while cadastral offices maintain the graphic information locally. Many countries have an incomplete coverage, i.e. only the most populated part of the country is registered while land in more remote areas is not registered at all. Some countries organize systematic registration with the objective to achieve complete coverage of cadastral registration. For other countries this is considered too expensive and land parcels might be included when ownership transfer takes place, or on demand through sporadic registration.

Whether the information is stored centrally or decentralized in lower administrative levels, the extent of cadastral coverage (or number of registered parcels), and the way in which cadastral information is accessed and updated, all these are considerations with a direct impact on the design of the cadastral system architecture and the choice of software. A digital cadastral system that is being built up from scratch in a small pilot region of a developing country will initially require simple tools and low-cost solutions that can be extended and upgraded later on. Centralized cadastres with online information services covering large administrative areas need sophisticated, scalable systems. What all cadastre systems have in common is the need for a spatial data store to keep and maintain cadastral data, and graphical editing tools to create and update cadastral boundaries. In different economic settings, open-source software can play a role.

Digital cadastre systems

In theory, a digital cadastre system consists of three basic software components as presented in Figure 3.1. The core of the system, represented in red, is the data

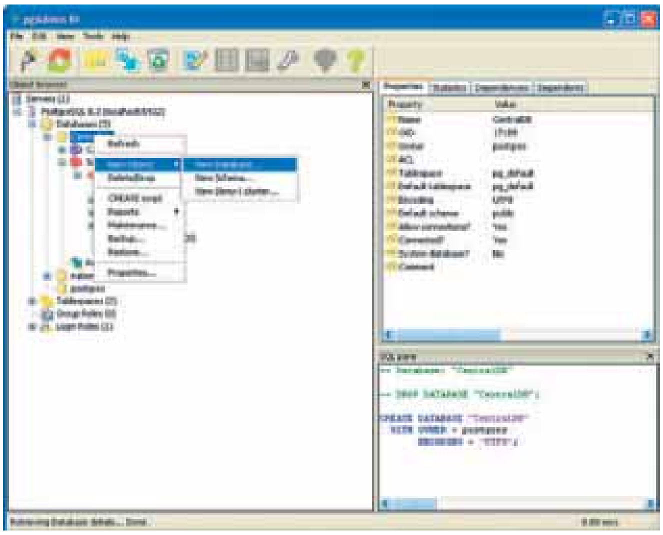

Figure 3.2:
The PgAdmin GUI lets users easily create and maintain PostgreSQL databases.

repository which stores the cadastral data. Alphanumeric data is usually stored in relational Database Management Systems (RDBMS). To be able to store and maintain spatial data, RDBMS are extended with spatial data engines.[20]

The green part of the diagram represents the mapping functionality, which may include a combination of GIS and surveying software with cadastre applications. The user interface is the outer layer, the visible part of the system through which users interact with the software and data. In reality, digital cadastre systems may have multiple user interfaces for different functions and different groups of users. For example, there might be an interface for cadastral officers to record transactions, an interface through which banks can access information on mortgages, and an online information service for public enquiries. When comparing cadastre and land registration systems from one country to another, the user interfaces will have little in common and reflect local implementation of land administration regulations.

Database software

The data repository, the core of any digital cadastre system, holds the cadastral boundaries and textual land registration data. It is very important that the data storage is reliable and safe. RDBMS software is used to manage large amounts of data while restricting unauthorized access to the information. For cadastre systems, RDBMS software that can handle spatial data is needed. Oracle Spatial is

20 Spatial data engines are designed to "spatially enable" relational database systems, so that apart from text and numbers also points, lines and polygons can be stored. Oracle Spatial, ESRI ArcSDE, and PostGIS for PostgreSQL are examples of such spatial data engines.

probably the most popular spatial database software used in cadastre systems, but open-source alternatives exist. When comparing open-source database software products with spatial capabilities, there are basically two options. MySQL includes native support for spatial functions, while PostgreSQL can be extended with PostGIS to handle spatial operations.

Both MySQL and PostgreSQL are reliable database products and gaining in popularity, but when it comes to geometry and topology support, PostgreSQL with PostGIS offers more functionality than MySQL. One of the strengths of PostgreSQL/PostGIS is that it has become the standard spatial database for all open-source GIS tools (Ramsey, 2007).

PostgreSQL can be installed on a number of different operating systems, including Linux and Windows. After downloading the installation file, the actual installation only takes a few mouse clicks and less than a minute of time. The Windows installer comes with PgAdmin, a graphic user interface (GUI) for PostgreSQL and guides the users through the installation of PostGIS as well. The PgAdmin interface does not take long to get used to, and users can easily start to create databases, add tables and columns. Although the design and maintenance of PostgreSQL databases does require database expertise and knowledge of Standard Query Language (SQL), PostgreSQL is certainly not more complicated than Oracle or SQL Server to install and use.

Desktop GIS software

Open-source GIS software has really taken off during the last few years and there is now a full range of desktop GIS products available that are potentially useful for cadastre systems. New versions are coming out regularly and there have been major improvements in vector editing, database connections and spatial operations. The subdivision and merging of polygons, which is so important to maintain parcel boundaries in cadastre systems, is now supported in Quantum GIS, uDIG, gvSIG, OpenJump and Kosmo GIS. More and more desktop GIS products (proprietary as well as open-source) are adopting the Open Geospatial Consortium (OGC) interoperability standards to access remote geographic datasets over the Internet. With Web Map Service (WMS) support, datasets from web mapping servers can be displayed as images, while the Web Feature Service (WFS) gives users access to the raw geographic datasets. While few cadastre authorities distribute cadastre datasets through WFS as yet, this technology is expected to gain popularity in the coming years.

Vector editing functions to create and maintain parcel polygons, topology validation, database connections and support for common vector and raster data formats are considered essential characteristics of GIS desktop software for cadastre systems. These and other characteristics are compared for GRASS, Quantum GIS,

uDIG, gvSIG, Open JUMP and Kosmo in Table 3.1. GRASS, which was the first and probably the best known open-source GIS tool, can now also be installed on Windows systems. Quantum GIS is a light-weight frontend for GRASS data which works also well with PostGIS data. uDIG, gvSIG, OpenJUMP and Kosmo are Java based desktop GIS products, each with its own strengths and characteristics. Of all the compared products, uDIG is the first software that fully supports transactional WFS (WFS-T), which means that with uDIG, edits can be made to remote WFS datasets. WFS-T connectors for gvSIG and Kosmo are under development. gvSIG is a very useful GIS product with extensive vector editing functions. A mobile version of gvSIG is being developed which can connect to GPS receivers and generate tracks and waypoints. Both OpenJUMP and Kosmo have good topology validation tools and vector editing functions. OpenJUMP has recently been integrated with Sextante (also used by gvSIG and Kosmo), which adds extensive raster analysis tools to the software. Kosmo is derived from OpenJUMP, and has improved the database connections and performance, which makes it more suitable to work with large datasets. Undoubtedly, there are other useful open-source GIS products that have not been mentioned here. Yet, the compared products are considered the most useful desktop GIS products in cadastre systems.

Surveying tools

Although the surveying software market is a specialized area dominated by commercial vendors, a number of open-source developments are worth mentioning. The GNU Gama[21] project is dedicated to adjustment of geodetic networks. Currently, Gama only supports the adjustment of geodetic networks in a local coordinate system, but new developments are underway to support the adjustment of geodetic networks in global geocentric systems (Cepek and Pytel, 2009). To support field mapping, several GPS tools have been developed as plugins to open-source GIS that allow the importing of GPS data. GPSBabel is an open-source product that reads, writes and manipulates GPS waypoints in a variety of data formats. GRASS and Quantum GIS have included GPSBabel so that almost any GPS data format can be loaded directly into the software. On the Java side, the Survey-OS project aims to develop surveying tools for Open JUMP. A plugin that enables users to import survey points to Open JUMP has recently been released by Survey-OS.[22] BeeGIS[23] adds GPS support to uDIG users. With BeeGIS, users can receive data from a GPS and export it to PostGIS or shapefile. These GPS tools are mainly oriented towards handheld GPS units and do not yet include functions for differential correction and post processing GPS data, which would be needed for

21 See http://www.gnu.org/software/gama/

22 See: http://surveyos.sourceforge.net/

23 See: http://www.beegis.org/

accurate cadastral surveying. The mobile version of gvSIG aims at adding more GPS tools in future releases, including support for DGPS and real-time differential correction.[24] Although a lot remains to be done in this field, it is encouraging to know that there are initiatives towards the development of open-source surveying software.

Server software and web GIS services

When it comes to web servers and server operating systems, the use of open-source software has already been widely accepted. Research shows that two-thirds of European companies choose open-source systems like Apache, Tomcat and Linux over proprietary alternatives (Ghosh, 2006). Also cadastre systems can benefit from the use of open-source server software. Especially in the area of Internet mapping and web enquiry systems, open-source products are increasingly popular.

GeoServer, MapServer and Deegree are open-source map server products focusing on Internet mapping applications using OGC webGIS standards. These OGC interoperability standards such as WMS, WFS and WFS-T allow for the cross-platform exchange of geographic information over the Internet. Using these standards, map data stored in Oracle Spatial, PostGIS or ArcSDE databases can be accessed over the Internet with a standard web browser or GIS client software. With WMS, map data can be accessed and displayed as an image that can be overlaid with GIS data from other data sources to produce composite maps. With WFS, users can access the actual geographic features in vector format, while WFS-T allows for creation, deletion and updating of features. MapServer, GeoServer and Deegree are server-based "map engines" to display spatial data (maps, images or vector data depending on the OGC web service) over the Internet to users based on their requests. In his State of Open-Source GIS, Ramsey (2007) states that *MapServer is easily the most successful open-source GIS project to date. It supports more input data sources than proprietary products, has higher performance and is simpler to install and set up.* And indeed, MapServer has proved to be a very mature and reliable product to distribute maps from GIS data sources over the Internet through the WMS, WCS and other OGC interoperability standards. GeoServer and Deegree are more recent projects built with Java technology. While comparable to MapServer in many ways, GeoServer and Deegree go further by supporting transactional WFS services, allowing users to insert, delete and modify geographical data at the source from remote locations through the Internet. In cadastre systems, this functionality would allow notaries to sketch new parcel boundaries resulting from property transactions on a digital map in their preferred

24 See the gvSIG Mobile Roadmap at ftp://downloads.gvsig.org/gva/descargas/RoadMap/gvSIG_Mobile_Roadmap_03_2008_en.pdf

Table 3.1 FLOSS Desktop GIS products compared.

PROPERTIES	GRASS 6.4	Quantum GIS 1.3	uDIG 1.1.1	gvSIG 1.9	OpenJUMP 1.3	KOSMO 2.0
Type of product	Open-source desktop GIS with raster, image processing and vector analysis functionality	Open-source desktop GIS with vector and raster support, to browse and create map data	Open-source Internet oriented desktop GIS	Open-source desktop GIS with CAD, vector and raster support	Open-source desktop GIS for manipulating spatial features with geometry and attributes	Open-source desktop GIS, derived from OpenJUMP
License	GNU/GPL	GNU/GPL	GNU/LGPL	GNU/GPL	GNU/GPL	GNU/GPL
Website	http://grass.osgeo.org	http://www.qgis.org	http://udig.refractions.net	http://www.gvsig.gva.es	http://www.openjump.org	http://www.opengis.es
Operating system	Linux, MacOSX and Windows	Linux, MacOSX and Windows	Linux, MacOSX, Windows	Linux, Windows, MacOSX	Unix, Linux, MacOSX, Windows	Linux, Windows
Supported vector formats	GRASS vector (native format), read directly Shapefile, PostGIS; can import TIGER, DGN, MapInfo and GML2	OGR formats (Shapefile, MapInfo MIF/TAB, ArcInfo Coverage, GML) PostGIS, GRASS	Shapefile, PostGIS, OGR vector formats, GML	Shapefile, dgn, dxf, dwg, PostGIS, WFS vector layers	JML (OpenJUMP GML) Shapefile, WKT Plugins for DXF, CSV, MIF, GeoConcept and PostGIS	Shapefile, dxf, dwg, csv, PostGIS
Vector creation	Point, line, boundary, centroid (v.edit module)	Point, line, polygon (also polygon with holes or islands)	Polygon, line, point, rectangle, ellipse (also polygon with holes), arc	Point, multipoint, Line, arc, polyline, polygon, rectangle, circle, ellipse	Point, line, polygon (also polygon with holes) rectangle, multiPoints, multiPolygon, multiLine	Point, Line, Polygon (also polygon with holes), rectangle, circle, arc
Cut and merge polygons	No	Yes	Yes (Axios editing tools)	Yes	Yes	Yes
Other editing functionality	Merge and break lines; copy/move/delete/ flip vector features; Dissolve polygons Trim/extend lines	Move line, split line (GRASS layers)	Clip, trim lines, dissolve (Axios editing tools)	Move, rotate or flip features, clip, dissolve	Move, rotate features, split lines	Extend / trim lines, draw parallel and perpendicular lines, rotate features, clip, dissolve
Buffer (around point, line or polygon)	Yes (v.buffer)	Yes	Yes	Yes	Yes	Yes
Vector Overlays (Union, Intersect, Subtraction)	Yes	Yes (v.overlay with GRASS toolbox)	Yes (Axios spatial operations)	Yes	Yes	Yes
Spatial queries on vector layers	Yes (v.distance)	No	Yes (Contains, crosses, disjoint, equals, intersects, overlaps, touches, within)	Yes (nearest neighbour / contained in)	Yes (intersects, contain, assign data by location)	Yes
Field calculator (perform calculations on the fields of a table)	No	No	No	Yes	No	Yes
Calculate area of polygons	Yes (v.to.db)	For GRASS layers (v.to.db)	No	Yes	Yes	Yes
Convert lines to polygons	No	No	No	Yes	Yes	Yes

PROPERTIES	GRASS 6.4	Quantum GIS 1.3	uDIG 1.1.1	gvSIG 1.9	OpenJUMP 1.3	KOSMO 2.0
Snapping tools	Snap function to snap one line to another while digitizing.	The software allows the user to set the snapping tolerance and snap to nodes and vertices	Snap radius can be set to snap to nodes and vertices.	The software allows users to set the snapping tolerance and snap to nodes and vertices. Snapping to elements from different layers is also possible.	Vertices can be snapped to the reference grid, as well as to other vertices or lines.	Snap tolerance can be set to snap to lines or vertices, or snap to a grid
Topology tools	Module v.build to build topology; v.clean to clean topology	Only for GRASS layers with the v.build GRASS module	With the validation plugin, vector layers can be checked for correct geometry, self-intersecting or overlapping lines and dangling nodes.	Topology extension to check and maintain correct topology	Topology validation tool to check for valid geometry	Topology validation tool to check for valid geometry
Raster support	More than 40 supported raster formats (through GDAL)	TIFF, ERDAS (.IMG) ArcInfo ASCII Grid SDTS (.ddf) DTED Elevation raster (.dt0) USGS DEM AIG GRASS	TIFF, JPG, GIF	TIFF, JPG, ECW, MRSID	TIFF, GIF, JPG, ECW and PNG	TIFF, PTIF, BMP, JPB, GIF, PNG, MRSID, ECW
Raster analysis	Yes	Yes (GRASS module)	Yes (JGRASS)	Yes (Sextante)	Yes (Sextante)	Yes (Sextante)
GPS tools	Import waypoints, routes, and tracks from a GPS receiver or GPS download file into a vector map (v.in.gpsbabel)	Supports GPX format, download from/ upload to GPS through GPSBabel	With the BeeGIS plugin, users can connect to GPS receivers, upload GPS data and convert to PostGIS or shapefile	gvSIG Mobile Pilot can connect to GPS receivers and generate tracks and waypoints in GPX format	SurveyOS plugin for importing survey data in OpenJUMP	No
Database / SDBMS support	PostGIS, MySQL, SQLite	PostGIS	PostGIS, Oracle Spatial, ArcSDE, DB2, and MySQL	PostGIS, MySQL, Oracle Spatial, ArcSDE	JUMP DB Query Plugin for PostGIS, MySQL, Oracle Spatial, ArcSDE	PostGIS, MySQL, Oracle Spatial
Programming language	ANSI C	C++	Java	Java	Java	Java
Development platform / class libraries	Software components depend on multiple libraries	Qt with PROJ4, GEOS, SQLite, GDAL/OGR and other libraries	Eclipse RCP with GeoTools libraries	Eclipse with GeoTools, JTS and other libraries	Java Topology Suite (JTS)	GeoTools, JTS
Command line / Menu bar	Both	Menu bar	Menu bar	Both	Menu bar	Menu bar
Interface language	Translated into 20 languages, more coming	Translated into 26 languages	English, German, Spanish, French, Italian	Valencian, Spanish, Galician, English, Czech, German, Basque, French, Italian, Portuguese, Chinese	English, Finnish, Portuguese, French, Italian, German, Spanish	English, Spanish, Basque, Catalan, Russian, German, Italian, Czech, Slovak, Brazilian Portuguese
GML	Yes	Yes	Yes	Yes	Yes	Yes
WMS	Yes (r.in.wms)	Yes	Yes	Yes	Yes	Yes
WFS	Yes (v.in.wfs)	Yes	Yes	Yes	Yes	Yes
WFS-T	No	No	Yes	Under development	No	Under development

GIS client software and send this new boundary information in the GML data format over the Internet to the cadastral database on the WFS-T server (Brentjens et al, 2006).

A number of European cadastres already use WMS and / or WFS to give citizens access to public cadastral datasets over the Internet, and are thus following the INSPIRE principles to provide public access to spatial datasets that are collected by the government. With the availability of high quality open-source Internet mapping tools, other national cadastre agencies are expected to follow this trend.

Conclusions

With the open-source tools that are currently available, complete low-cost but robust cadastre systems can be built. For the storage of cadastral datasets, PostgreSQL with the PostGIS spatial data engine can be used. For the creation and maintenance of parcel boundaries, a variety of open-source desktop GIS products is available. Through the map server tools GeoServer, MapServer and DeeGree, web geoportals can be created to make cadastral information available to the public. Although still in its infancy, gvSIG is developing a mobile GIS solution for the generation of tracks and waypoints, making it easier to record property boundary information in the field.

The software tools must of course be customized to fit the cadastral workflow according to the local requirements of land administration, but the same is true for proprietary software: there are no out-of-the-box solutions for cadastre systems. Specific cadastre tools must be developed that allow for the handling of parcel subdivisions and consolidations, while maintaining historic boundary information. Customization and localization are important aspects of building cadastre systems. The use of open-source software tools gives developers of such systems the advantage that they can be customized to reflect the local language and culture of land registration.

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3.2 The Story of an Open-Source Software Project – GeoNetwork

Jeroen Ticheler

The need for a geospatial catalog

How often do you find yourself searching for an administrative boundaries layer you can use to map your statistics? Or when was the last time you downloaded tons of satellite images freely available on the Internet to convert them from an obscure HDF format into a GeoTiff before you could simply see it as a backdrop in your GIS? There's a good chance you used your time in a more productive way!

Finding and accessing geospatial information from trusted sources can be a time consuming, expensive and sometimes frustrating experience. It can be just as difficult to find reliable reference data within your own organization or company as it is from others.

If we were trying to find information in written works such as books or journal articles, we often simply search the web using Google, Yahoo or other search engines. For more specific searches we may use a library catalog and probably connect with other library catalogs from around the world through the Internet. GeoNetwork opensource (or just GeoNetwork from here) helps us to describe, publish and find geospatial information. GeoNetwork is in essence, a digital library that enables you to find and access geospatial information. It allows data providers to systematically describe both their data and services to distribute it. A catalog of data and distribution services can then be published through the Internet for use by anyone trying to find geospatial information. Not only can they find that information, they may also be able to obtain it through a data distribution service listed in the catalog: on-the-fly data conversion and re-projection have made direct data access from a distribution service a viable option for those with good Internet access.

By providing a catalog for data and distribution services and facilities to exchange information with other catalogs as part of a network, GeoNetwork helps to organize and share geospatial information within and between the interoperable, spatial data infrastructures (SDIs) that many stakeholders are starting to build. Beyond the formal SDI domain, the information is also made accessible to the informal domain of the World Wide Web.

The GeoNetwork project started in order to address the internal need of the Food and Agriculture Organization of the United Nations (FAO) to more effectively use geographic information collected and maintained in the agency. Several attempts had preceded the project, resulting in a desktop database application and a derived web based catalog. In the mean time international standards to describe and publish geographic data emerged as well as a need to share the exist-

ing information between physically disconnected offices, projects and sister agencies. The need for a new catalog solution was born.

Why open-source?

Operating in an international context, export restrictions on software were in conflict with the interests and operational requirements of the agency. Training local staff in the use of proprietary systems negatively impacts the sustainable use of staff and resources because of prohibitive license schemes. The intention of training is often to convey the concepts behind a data management process. The practice often is that the tools used during the training become the instruments people are familiar with and want to use. Creating a dependency on expensive tools that may not be affordable or even legally be usable in the long run of a project is counterproductive and can even lead to illegal use of such tools. Encouraging the use of tools that can be legally used in the long run was one of the arguments to opt for an open-source software solution.

Projects usually have a limited lifetime, often constrained by the available resources within an organization, priorities at management level and influenced by the always recurring need to do things differently over time. A long term investment into one complex project can therefor not be expected to come from a single source. If it is possible to share the cost of development and maintenance, chances are much higher that long term sustainability can be achieved. Producing an application as open-source software helps to convince interested parties to take ownership of the tool and to contribute effectively to its further development.

The GeoNetwork project started in 2001 with an internal planning and development phase that produced a prototype system. The prototype system was presented and used within the FAO. Then, collaboration was started between the FAO and the United Nations World Food Programme (WFP) that had similar requirements and wanted to actively contribute resources to the development of the software. That second stage did not see any source code published and there was no activity undertaken to create an open-source community. The initial release of source code took place only after a first version of the software was finished. At that point we also setup a mailing list for communication with the broader community of potential users.

Driven by competition

During the prototype and planning phase different scenarios were discussed before we decided on the actual architecture of the software. The functional requirements were not met by any system we evaluated, most specifically related to the support of the ISO19115 metadata standard that was only available in a draft form at the start of the project. Alternative solutions supported other metadata

standards, were not available as open-source software and did not meet the web based requirements of a distributed system. The technical requirements asked for a suitable solution to process XML based metadata documents that was independent from the underlaying database system and was written in a computer language that was platform independent, free to use and well known by developers. This resulted in the choice to develop in Java, using available libraries to process XML documents and JDBC drivers to connect to the database system. The system was developed as a web application running in the servlet container Apache Tomcat.

The choice to start from scratch with the development of GeoNetwork was not taken lightly. We expected other solutions to be under development or to be started, but we didn't know for sure and didn't want to wait to find out. Instead we made it clear from the start that our intend was to create an open-source solution that was free to use and that offered room for others to have influence on or participate and contribute to. Presentations were given at relevant conferences and workshops were organized for users and other interested parties. A lot of effort went into communication with potential or existing users.

New solutions have been started over the years. Some of these have come up and disappeared, others are still out there and that is a good thing. It offers new ideas and insights to the GeoNetwork community and keeps the project developers sharp to ensure the majority of the community of users is happy with the resulting software. New requirements come up on a regular basis. They are prototyped in solutions for clients and are added to the core software when considered appropriate.

Building a community of users and developers

An active and healthy user and developer community around GeoNetwork ensures that new functionality is constantly added and existing functions are further improved. New developments in the global "GeoWeb" can be quickly tested and integrated if useful. The community almost doubles on a yearly basis. The project moved under the umbrella of the Open-Source Geospatial Foundation (OSGeo) in 2008. This move increased the collaboration with other geospatial open-source software projects and improved the long term sustainability and reliability as quality software that takes open-source software development as a community process very serious. People that see their own needs and contributions taken seriously are the involved users and developers that make the community. The majority of users are silent consumers, only a fraction signs up on the mailing lists to ask questions, discuss, provide feedback or help others by answering questions.

The active user group is key to the success of the project; they give the project hands and feet and let it prosper. An even smaller group actively customizes the

software and contributes back to the project in the form of bug fixes, small improvements and translations of the application into new languages. A group of about fifteen developers works on different so-called sandboxes, places where customized versions of GeoNetwork are developed and maintained. The new functionality developed in these sandboxes is often what is proposed to become part of the core software. The process of proposing new functions and adding them to the core has been formalized and requires a voting by the Project Steering Committee. Only a limited number of developers have the right to modify the core software, ensuring that the code will be well integrated and that quality is maintained at a good standard.

Evolution of project management

During the first years of the project, the user community was still small, almost nonexistent. Every new user deserved extra attention and had to slowly be convinced that the project was worth working with and that it would not suddenly die, leaving these early adopters with empty hands (and an upset boss). New functionality was added after consultation with the participating UN agencies. The project management relied on one person (the author of this chapter) the so-called benevolent dictator. The role of a benevolent dictator is to manage the project with the intention to involve a wider user community and take decisions that take the common needs into account. Such project management is very suitable during the startup phase of a project. Overhead in project management is kept to a relatively small size and implementation of new functionality is not hampered by bureaucratic processes that involve people that are not aware of the day-to-day developments that take place. It proved an effective way to grow the software and the user community.

In 2005 FAO and WFP organized a first GeoNetwork workshop that was open to interested parties. The community started to grow and with a larger community, expectations also increased and so did our responsibilities towards the community. We were in general able to make our own decisions without the need for long public discussions, but this started to change. We needed to get more formal and more transparent in our decision making. When in 2006 the OSGeo was established, we wanted to make GeoNetwork a more open community project that was not solely relying on the FAO and its partner agencies. A project steering committee was created during the second GeoNetwork workshop in April that year. Day to day management remained under the control of the benevolent dictator. The developer group was not solid enough to take over. However, this was about to change.

With the development team growing in size, experience and ready to accept greater responsibility, incubation into OSGeo became a viable option.

Incubation in OSGeo

OSGeo's mission is to support the development of open-source geospatial software, and promote its widespread use. To make this reality, projects are required to prove they can run effectively as community driven projects and have processes in place to assure continuity and quality. After consultation with the advisory board, it was decided during the workshop of 2007 to propose the GeoNetwork project for incubation into OSGeo. Although it was a logical next step for the project, it was also a courageous decision by the advisory board and by FAO management. It meant that the FAO had less control; it was giving away control of a project it needed and had invested in for years. The existing project steering committee was renamed Advisory Board and a new Project Steering Committee (PSC) was established consisting of seven members that would democratically decide about the new developments proposed for the software. Formalized procedures were established to support the PSC in the project management. A full source code review helped to remove source code that had a conflicting license in relation to the GPL license GeoNetwork is released under. After about a year of project management by the PSC, incubation into OSGeo was completed and the project was voted in as a full fledged OSGeo project.

Expectations and the reality

There is an interesting aspect of open-source projects: you can change everything you want. Obviously this is because you have full access to the source code and are given full freedom to act, respecting the open-source license. This aspect offers both opportunities and dangers.

The opportunities are obvious. You are not dependent on one supplier to adapt the application to cover your specific needs. You are also not dependent on a single supplier to understand and fix unexpected behavior or bugs in the software.

The dangers are less obvious, but are significant and need serious consideration from both the client and the solution provider. The freedom to change everything you need can cause you to invest significantly in custom functionality that has no wider uptake. Maintenance of such functionality can become a seriously costly practice. It creates the need to go through expensive migrations for every new release of the core software. This process includes a number of new test and bug fix cycles and can cause serious frustrations to software developers, project managers and end users. Software developers are faced with the not so interesting task of merging code; project managers are faced with longer release cycles and higher costs while end users see recurring or unexpected bugs and also face longer release cycles. The practice of creating highly customized applications can lead to effectively forking a project. Forking is in almost all cases not in the interest of both the development team and the end users.

Some practices should receive serious upfront consideration from both project managers and solution providers. Solution providers have the responsibility to warn their clients for potential forking and the related high cost of software maintenance. Both maintenance of a fork or maintenance of the alignment of a highly customized version to the core software deplete scarce resources and should be avoided.

Clients should focus on investing in new functionality that covers a common need. Such investment will see highest return on investment since it is more likely that others will invest in the same functionality for prototyping, development and maintenance. The resulting functionality will be more robust and better thought through. Often requirements a client puts forward should be evaluated with a highly critical eye; do these new requirements really cover a need, or can the need be covered by functionality already present? The solution providers should assist their clients by guiding them towards this goal and should accept only limited amounts of custom work. This seems to contradict their interest in getting more work, but will prove in their interest in the long run. Their clients will see a better return of investment and will thus be happier clients. The solution provider can offer a more standard solution and can focus on making that core better instead of spending resources on boring migration tasks and testing of exotic functionality.

The real challenge is in accepting the limitations of the existing product and in deciding what new function you really need to ensure it becomes widely adopted as a core component of the open-source project. This will make both client and provider happier.

The future of GeoNetwork

Even though the GeoNetwork project is no longer managed at and sponsored entirely by FAO, it is very much alive. The project never has a dull moment, is fun for the team to work on and has created a wide collaborative network between expert users and developers. Since the initial release, GeoNetwork software downloads have almost doubled on a yearly basis. GeoNetwork users world-wide are suggesting new functionality and requesting improvements. These suggestions and requests are acted upon by developers through contracted work for paying clients. The new functions that cover a common requirement will end up as part of the software. An open discussion takes place on mailing lists and during face to face meetings, resulting in proposals and a roadmap.

As any complex open-source project, GeoNetwork faces a number of challenges. Developers are spread out over different countries and continents, and rarely have the chance to meet face to face. Maintaining and upgrading the software requires effort, money and time. The development team regularly meets

online and during one or two annual events where time is explicitly dedicated to work of common interest. The future of GeoNetwork depends on if there will be sufficient interest from clients that keep investing in the project. The signs are positive, causing the GeoNetwork software development to thrive and the community of users to grow exponentially. Government agencies are increasingly interested in providing access to spatial datasets to citizens as part of an eGovernment policy, and use GeoNetwork for their metadata management. To provide services and support for GeoNetwork to these government agencies and other stakeholders, GeoCat BV was established in 2007, while other companies also offer services based on GeoNetwork.

With the increasing availability of spatial datasets on the Internet, users will need tools to share, find and browse through those datasets. GeoNetwork is providing these tools and rapidly becoming the most popular browser for geospatial datasets, proving its ultimate goal to offer the best geospatial catalog in the world.

3.3 The OSCAR Project

G. Brent Hall and Geoffrey Hay

Introduction

Building software for land records administration is difficult at the best of times. In addition to capturing spatio-temporal representations of parcel boundaries and associated records of title that do not always change in tandem with each other; such software has to accommodate a multiplicity of end user needs and settings. These factors may result in highly specific software that is not easily transposable between jurisdictions. Digital systems have the general goals of achieving greater transparency, currency, efficiency and quality assurance and control of data pertaining to land ownership. However, in developing nations, where processes are not well developed and data quality is often poor, there is a danger that complex digital systems may overwhelm local expertise and be too difficult to maintain relative to manual approaches. In these contexts the reality is that no single "prepackaged" solution can realistically meet all needs. Hence, beyond the above goals and the need for cost effective (affordable) solutions, land records management software must be built that is modular, robust, flexible, easy to use and highly responsive to changing conditions and local user knowledge and abilities.

The apparent paradox of introducing change to improve land records management while potentially making the process more fragile is difficult to reconcile. One solution is to implement digital systems with coverage limited initially to specific areas and with only basic functionality, leaving for future implementation

more complex issues such as customary rights and maintaining historical information for an individual parcel or collections of parcels (Törhönen, 2004; Österberg, 2002). However, it is possible, using a carefully planned software development cycle, to build generic and core land records management functions that are applicable to diverse application contexts (i. e. different countries as well as changing conditions within a country). Customized functions, written for the particular circumstances of one or another location as needs dictate, can then be built around this generic core. While proprietary software solutions are typically written with generic needs in mind, they often carry substantial overhead of various forms (e. g. high initial and on-going costs, unused and perhaps unusable functions, requirements for particular input formats, and limited opportunities for customization etc.) that render their suitability questionable in developing countries. In contrast, it is possible to build solutions using existing free / libre and open-source software (FLOSS) that can be fused together with custom coding in flexible, yet modular and robust designs that can meet generic and particular needs as well as satisfying the goals noted above.

FLOSS provides source code to a potentially open-ended community of developers with an open development license, forming a virtual workbench for developers that can be eventually expanded, in this case, beyond parcel mapping and title registration to include multiple interests in the management of land (e. g. valuation and taxation, planning, infrastructure such as roading and other utility networks, natural resources and so on). In addition to the manifold advantages of FLOSS adoption (Christl, 2008), this approach is particularly well suited to developing nations as the overheads of proprietary solutions can be substantially reduced, while producing tools that are sensitive to local needs, conditions and languages.

However, while FLOSS projects are currently widely used and constantly growing in popularity in the geospatial domain worldwide (Ramsey, 2007; Hall and Leahy, 2008; Steiniger and Boucher, 2009), there has been very little in the way of concerted FLOSS development for land records management. This chapter describes efforts underway to remedy this absence with the development of an open-source cadastral and registry (OSCAR) tools project. This project has moved from an initial software prototyping exercise and international scoping workshop held in May 2008[25], through to an assessment of the suitability of three nations, namely Ghana, Samoa and Nepal as initial development sites. Further, a proposal seeking multi-year development funding and a high level conceptual software design (Hay and Hall, 2009) have recently been produced. At the time of writing it seems likely that the OSCAR project will commence in earnest in the first quarter of 2010. The following sections describe the OSCAR approach and the results that are expected from its implementation.

25 see http://source.otago.ac.nz/oscar

Background

The vision of a FLOSS land records management project designed specifically for use in developing nations was initiated in late 2007 by the School of Surveying, University of Otago, New Zealand in collaboration with the Land Tenure Group of he Food and Agricultural Organization (FAO) of United Nations, Rome. Reviews of FLOSS geospatial projects by Pieper (2007, 2008), Ramsey (2007) and Steiniger and Boucher (2009) report numerous well-supported (in terms of their associated community of developers), mature and sophisticated projects that can contribute to this effort. In addition, projects officially supported and sanctioned under the auspices of the Open Geospatial Foundation (OSGeo)[26] add credibility to the readiness of FLOSS geospatial tools to meet the needs of land records management. Current FLOSS packages include database, geographic information system (GIS)-based mapping applications, software development environments and languages, Web servers, operating systems, and workflow designers and servers, most of which have been assessed also by researchers at the University of Otago.

In addition to the FLOSS geospatial projects under development, a large number of open standards associated with the integration, sharing, storage and retrieval of geospatial data in general and Web services in particular have emerged and are now in widespread use (for more information, see the Open Geospatial Consortium Web[27]). These standards are complemented by a relatively large body of research on data models for land administration systems and the temporal and spatial requirements of cadastral and registry records. Hence, it is timely and important now to integrate these independent developments with the production of a FLOSS solution to land records management. However, successful (i. e. sustainable) open-source projects require the creation and organization of communities of developers and users. To this end, establishing a sound user base provides the motivation for continuing development of a FLOSS project. Within this user base there is likely to be a group of curious and the committed users whom are also developers and whom have the need, desire and ability to produce software that can satisfy their own particular computing needs.

The "power" users within a FLOSS community typically contribute the most in terms of development effort and, simply stated, with a couple of exceptions the land administration domain has not yet reached the stage where a cadre of power user/developers has evolved and coalesced around a demonstrable FLOSS project (Pieper, 2008). There are currently several isolated national projects where various FLOSS components (such as PostgreSQL or MySQL for database management, PostGIS for managing spatial geometries with Postgre tables, and uDig for desk-

26 Open Geospatial Foundation (OSGeo) – http://www.osgeo.org
27 Open Geospatial Consortium Web – http://www.ogc.org

top GIS and Web Map Services) are being deployed to manage land records (Pieper, 2007). However, there is no integration of effort and no common suite of land administration functions yet developed for widespread use. Hence, this domain remains embryonic and software applications, whether FLOSS or proprietary, tend to be lead by external consultants. In order to avoid the well known pitfalls of not looking beyond short term, project-based gains, the OSCAR project will adopt a software development strategy that seeks to mentor local developers linked operationally between the three potential national sites.

The local OSCAR teams will manage the development process within each country adding locally relevant functions to a set of land records management tools that will be built into the generic OSCAR core in the first stages of the project. The multi-national user base will allow for improved testing of the core code (Mockus and Herbsleb, 2002), and beyond this the local developers will make decisions about which functions, some of which may be programmed by developers in other countries as plug-ins or add-ins, should be integrated into each build for their particular circumstances. The OSCAR project specifically focuses on variation in schema within the cadastral and land registry domain and how this may be resolved, without increasing system complexity or requiring specialized code. The approach will also integrate the storage and retrieval of historical data, the notion of evolving requirements, the use of local languages, distributed use within a wide area network, and process requirements within the core design. Some, but not all of these building block concepts are discussed in the next section.

Building blocks of OSCAR

The registry aspect of the land administration domain requires that each jurisdiction develop their own data model for implementation in a database of the entities and relations that characterize national laws and regulations regarding the rights, restrictions and responsibilities that accompany land ownership. The refinement of a generic or standard data model somewhat reduces the effort required for this and allows for some integration. However, this still implies fragmentation of development effort especially for supporting software. Each country will also have to model the domain processes which would typically be implemented in software code (such as data entry and management forms). These schema and processes will vary due to differences in language, culture, common practice, laws and legal definitions etc. Hence, it is unlikely that a single data model can unify all the possible variations, or that a single software package can provide all of the necessary process requirements. Hence, different nations will have to create their own database design and customize their application software around a common code base to implement the registry aspects of the land administration domain relative to their own reality and needs.

Initial research investigating cross-jurisdictional schema variation has shown that this problem can be addressed with the implementation of a process or "event" model (as opposed to a simplified structural or "state" model which requires re-engineering each time it is applied in a new and potentially different context). Data schema may also vary due to evolving requirements which become more sophisticated as the land administration infrastructure becomes more mature. This temporal schema evolution is considered conceptually similar in nature to cross-jurisdictional schema variation. Solutions that are coded based on what is known at the time will be difficult and costly (in terms of the maturity of developer resources in developing nations) to modify. Importantly, it is expected that these systems will require more modification over time than systems developed in economically advanced nations where infrastructure is more mature, well-understood and less prone to change. Hence, it is essential to consider the dynamic evolution of schema so that the effort required to evolve a mature land records management system is reduced.

The building blocks of the OSCAR project consider both of these types of variation in the hope of providing a solution that can evolve between countries (and therefore provide a foundation for a FLOSS community to develop) and over time (without major development effort) as each nation matures in it's use of the common functions programmed into the generic code base. The proposed solution also address issues of data integration (which would be difficult if each country developed its own schema independently) and the lack of human resources by not necessarily requiring fundamental code to be (re-)developed by each jurisdiction. Rather, it is expected that functions can be built within and around the conceptual model outlined by Hay and Hall (2009). In essence, this approach conceives of an "instrument" which signifies a legal change associated with the status of a land parcel through a formal registration and land surveying process. Instruments link Agents (people such as surveyors and conveyancers), organizations (such as banks and government departments), groups (such as land developers and companies) to Objects (a Register Object such as a parcel of land, an apportionment of a parcel, or a building that exists on a parcel or a unit within an apportionment) via Events which implement the temporal aspects of land administration. Together instruments, agents, objects and events form workflows (or business processes) and capturing the relations between instruments and documents (such as titles, cadastral parcel boundaries, survey plans etc.) as they move through the land administration process is the foundation of the OSCAR approach.

Recent research in the area of semantic markup and ontology for the cadastral domain argues for the use of semantic web technologies especially in the area of data integration (for both applying updates and cross-jurisdictional data sharing). This also highlights the inflexibility of the structural or relational model for both domain and temporal modeling (Spéry et al., 2001; Schuurman and Leszczynski,

2006). Process and temporal aspects of the domain noted above are also the subject of recent research with specific importance placed on the concurrent definition of spatial data (in this case parcel boundaries and their physical and title-based attributes) and associated process models (van der Molen, 2002; Albrecht et al., 2008). In addressing these issues, the architecture proposed for OSCAR externalizes the domain terms and concepts in the form of a domain ontology made up of resources that describe and link concepts and terms within the domain. The Resource Description Framework (RDF)[28] is used to detail the associations and relationships between data items and their types. This, together with the use of a process or event based architecture, allows a highly dynamic data model to be used and results in the conceptually straightforward database design and development approach described at a high level by Hay and Hall (2009).

Implementation approach

Like most database modeling paradigms, land administration domain modeling for OSCAR involves gathering the concepts (entities, attributes etc.) and their interactions (rules, processes, functions) into a design that is machine understandable. However, for OSCAR, the translation of the real world focusses on the definition of individual processes (e.g. parcel subdivision or title change) rather than on a data structure. One advantage of this approach is the reduced need for an explicit and complete translation of the entire domain before implementation can start. Data items are defined as they are required for the definition of workflows. Furthermore, workflow process definitions and associated code snippets are more easily shared than raw software code especially for specific requirements. There is also less need to consider underlying schema issues (such as normalization or redundancy) to the extent that is required by other data modeling paradigms. Hence, initial domain analysis for a given application of the OSCAR approach should focus on business processes first within and then between departments, which are translated into linked workflows.

OSCAR therefore provides a range of generic workflow processes which can be reused either by versioning, inclusion, or simply used as code examples in the generation of new workflow definitions that stem from additional input requirements as they are defined. Generic workflow processes model the kinds of basic operations that are required within the general domain of land administration and include such processes as parcel creation, retirement, subdivision, amalgamation, realignment, title change, attribute update, document production, search, query, etc. Clearly there are many workflow processes that can be added subject to needs in any given application context. However, the point is that once these processes are known they can be added to the OSCAR workflow manager and integrated

28 http://www.w3.org/rdf

into the system relatively easily. Workflow processes will be managed to the maximum extent possible with a fully visual, drag and drop interface which will require defining a process properly and then dragging and dropping the new process within an existing process or defining a new process.

In a typical implementation scenario, OSCAR will be able to move land records management from the paper-based systems that characterize most developing countries to a digital workflow. For example, in a paper-based system an applicant is given documents to fill in with appropriate information, and these documents may detail other supporting documents that are required for a particular application. Application forms and supporting documents are completed and submitted to initiate an application process. In OSCAR, this process is defined as a workflow. Rather than moving paper forms manually through various departments, the software will allow data to be input through a user interface directly into a digital OSCAR workflow. To do this a staff member would log onto the system using secure access, be presented with an interface that contains all the tasks he/she is currently involved with, as well as a menu of workflow processes to initiate, select relevant application process, and cause a new instance of a predefined workflow process to be executed.

Intended outcomes and conclusion

This chapter has outlined the background to, building blocks of, and implementation strategy for the OSCAR tools project. The outcome of this project is anticipated to involve implementation and every day use of FLOSS land records management software in three initial countries, selected because of their particular characteristics and the fact that they are currently involved in conversion of their land records from paper-based to digital systems. The approach adopted in these countries involves more than software development. It seeks to create expertise in each country through mentoring of local application programmers by international software developers who will work in each country for up to eighteen months of the three year project time frame. In addition, a significant component of the project plans in each country will involve systematic and repetitive training of government staff within the land administration offices to encourage them to use the digital tools and data as routinely as they used the previously manual methods of defining parcel boundaries and entering title information.

It has not been possible to discuss either the details of the proposed software architecture, underlying data model and implementation, or the precise project implementation strategy in this chapter. However, it is important to note that the both the software and the implementation strategy incorporate the concept of temporal change as a fundamental design principle. This provides not only the ability to recover and present, through use of structured query language, historical

data (both attribute and spatial in terms of the associated parcel fabric), but also the ability to be agile in responding to changes in workflows that may include cross jurisdictional differences or the inclusion of additional land-related functions beyond cadastral survey and land titling.

The proof will, of course, be in the successful realization and use of the OSCAR approach, and this is yet some way in the distance. However, in the interim the time is ripe for implementing this FLOSS cadastral project that incorporates a simple yet robust and highly adaptive approach in software to land records management.

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3.4 Piloting Open-Source Cadastre and Registration Software

Mika-Petteri Törhönen

Background

In the past FAO has supported the use of open-source software and has acquired in-house knowledge in the development of FLOSS systems through the FAO-GeoNetwork project.[29] FAO has been involved in monitoring and evaluation of land administration projects and systems particularly in relation to cadastre and land registration in countries in all of the inhabited continents of the world for as long as information technology (IT) systems have been considered to aid land administration. FAO is currently involved in dozens of land administration IT investments through World Bank and other cooperation programs. It is safe to say that FAO hosts one of the leading centres of excellence in the fields of security of tenure, access to land and in land administration. FAO is therefore well positioned to address matters of low-cost land tenure security and to help member countries to innovate with new technology for the benefit of the security of tenure.

The on-going initiative to investigate affordable systems for land tenure security started 2007. The initiative has, among others, promoted affordable IT systems that enable quick improvements in transparency and equity of governance. The introduction of IT systems to land registration is one of the key ways to reduce corrupt and non-transparent land administration and management practices. In fact, IT improves the structure and accessibility of records, facilitating knowledge based decision making and wider data dissemination. Open-source software is increasingly seen as an alternative to proprietary software products, due to its reduced costs, accessibility and high adaptability. Open-source software is arguably in a situation of scarce resources, the more sustainable alternative to proprietary software products, due to the initially and annually saved costs, as well as the high adaptability ensured by the open-source code. An initial review screened available OSS options for land administration systems and found several of the available database and GIS products to be of good value. However, in this field open-source software solutions have not been applied in any substantial way to real cases in developing countries.

Initially FAO, the International Federation of Surveyors (FIG)[30] and the World Bank[31] held an Expert Group Meeting on the use of open-source software in cadastre and land registration systems, which led to further exploration of the idea and collaboration with a land records linkage system in Bosnia Herzegovina. In

[29] The FAO GeoNetwork project GeoNetwork opensource is a standards based, Free and Open-Source catalog application to manage spatially referenced resources through the web. See: http://geonetwork-opensource.org/

[30] The Commission 7 (Cadastre and Land Management) of FIG.

[31] The Thematic Group of Land Policy and Administration.

May 2008, an International User Needs Conference was organized at the University of Otago, New Zealand to identify stakeholders' needs and requirements for such systems. A year later, after the very promising prototype OSCAR[32] work by the University of Otago team contracted by FAO, the time had become ripe for applying the researched approaches and tools to real life cases.

Moving from theory to practice

In this context in December 2009 Finland and FAO signed a partnership agreement to assist countries to develop sustainable and affordable land administration systems to improve tenure security and land governance in both rural and urban areas. The USD 2.4 million project aims to help FAO member countries to test and adopt low-cost open-source technology for the benefit of their land records maintenance. The Open-Source Cadastre and Registration software development will be escalated and the approach applied to real cases in Ghana, Nepal and Samoa. The project will build on the experiences and achievements, in particular on that of the OSCAR concept, so far.

In Ghana the implementing Ministry will be the Ministry of Lands, Forestry and Mines, which hosts the multi-donor Land Administration Project (LAP) supported by the International Development Association (IDA), Nordic Development Fund (NDF), Canadian International Development Agency (CIDA) and the UK Department for International Development (DFID) as well as the German Bank for Reconstruction (KFW). In Nepal the implementing Ministry will be the Ministry of Land Reform and Management on Land Administration), which hosts the Department of Survey, the Department of Land Reform and Management, the Department of Land Information and Archive, the Department of Land Revenue and the Land Management Training Centre as well as a separate trust, Guthi (Trust) Corporation. In Samoa the implementing agency will be the Department of Lands and Survey.

The target agencies and countries pursue initiatives improving the security of tenure of rural communities. Land administrations are being reformed and agencies show interest in testing open-source code software systems. In general, the interest lies in the increased flexibility and lower acquisition and maintenance costs of open-source software in comparison with proprietary software. Developing and transitional countries' land administrations as a rule also struggle with capacities to address the introduction and maintenance of IT systems and see cooperation in a form of software sharing and development community as a step forward in the field of land administration IT solutions. This project helps participating countries to test and adopt open-source technology for the benefit of their land records and above all concentrates on capacity building for the sustainable maintenance of any software installed or solution developed.

32 See http://source.otago.ac.nz/oscar/OSCAR_Home

Call for partners

FAO intends to support the building of an Open-Source Cadastre and Registration development project and community in the Web, which will allow a peer production development of source code for the software that is made available for public collaboration. As described the developed initial product will be tested with the three real cases in Africa, South Asia and Asia Pacific. The final result, applied modules of Open-Source Cadastre and Registration software with an active user community, aims to lower the barriers for entry level of developing countries to use IT for improving land registration systems and the security of tenure. FAO welcomes all interested parties to join the community of Open-Source Cadastre and Registration software initially by emailing interest to mika.torhonen@fao.org.

3.5 The Social Tenure Domain Model – A Pro-Poor Land Rights Recording System

Christiaan Lemmen, Clarissa Augustinus, Solomon Haile, Peter van Oosterom

In developing countries, large portions of land remain untitled, with less than 30 % of cadastral coverage conforming to the situation on the ground. Where there is little land information, there is little land management. Conventional land information systems cannot adequately serve areas that do not conform to the land parcel approach applied in the developed world. As a result, a more flexible system is needed for identifying the various kinds of land tenure in informal settlements. This system has to be based on a global standard and has to be manageable by the local community itself. Enter the Social Tenure Domain Model.

STDM is intended to introduce new, unconventional approaches in land administration by providing a land information management framework that would integrate formal, informal, and customary land systems, as well as integrate administrative and spatial components. The STDM makes this possible through tools that facilitate recording all forms of land rights, all types of rights holders and all kinds of land and property objects / spatial units regardless of the level of formality. The thinking behind the STDM also goes beyond some established conventions. Traditional or conventional land administration systems, for example, relate names or addresses of persons to land parcels via rights. An alternative option is being provided by the STDM, which instead relates personal identifiers, such as fingerprints, to a coordinate point inside a plot of land through a social tenure relation such as tenancy. The STDM thus provides an extensible basis for an efficient and effective system of land rights recording.

The STDM development activity has generated conceptual, functional and technical designs. The prototype is under development at the International Institute for Geo-Information Science and Earth Observation (ITC) in close co-operation with Global Land Tool Network / UN-HABITAT and the International Federation of Surveyors (FIG).

The STDM Concept can of course be implemented in both commercial and open-source GIS and database management software or combinations of both.

In this chapter it is illustrated that new, unconventional approaches need to be supported, combined with a data acquisition based on imagery. A prototype software is presented with a first field test results.

The STDM Concept

The Global Land Tool Network (GLTN [33]) aims to establish a continuum of land rights, ranging from non-formalised or recorded rights at all to full property rights, with all possible variations in between. This means informal rights such as occupancy, adverse possession, tenancy, use rights (this can be formal as well), customary rights, religious rights and indigenous tenure, as well as formal rights, are recognised and supported (with regard to information management) in the STDM-enabled land administration system.

The main aim of this is to come to a more just and equitable system of land management that benefits all people. The existence of a continuum does also exist for the other core components in land administration: parties and spatial units. This was recognised in two papers presented at conferences from the International Federation of Surveyors (Augustinus et al, 2006; Lemmen et al (2007). Parties can appear as natural or non-natural persons or governments as in conventional land administration but also as tribes, group persons, families etc. Spatial Units concern the area's where land rights or social tenure relationships appear. The Spatial Units can be overlapping in case of overlapping claims. The representation of Spatial Units in a land administration has a wide range of options, from no representation at all, to a description in text of the location of the boundaries, to points, sets of lines or polygons identified from aerial imagery or field surveyed.

This approach has an impact on the traditional or conventional basic concepts of land administration. They are affected in three ways (see Table 3.2).

A party (person, non person), a group of persons, or a group of groups can have one, or more types of rights, or social tenure relationships associated, where

33 The Global Land Tool Network (GLTN)'s main objective is to contribute to poverty alleviation and the Millennium Development Goals through land reform, improved land management and security of tenure. The GLTN originates from requests made by Member States and local communities world-wide to the United Nations Human Settlements Programme (UN-HABITAT), who initiated the network in cooperation with the Swedish International Development Cooperation Agency (Sida), the Norwegian Ministry of Foreign Affairs and the World Bank, in 2006.

The Party	an individual, or a group with an explicit, or implicit definition of membership Therefore, a Party can be a natural person, a company, a municipality, a co-operation, a married couple, a group, a group of groups, or a ministry, to name some examples.
The Social Tenure Relationship (the right or "relationship" between parties and spatial units)	the recognition of types of non-formal and informal rights (possibly to include: ownership, responsibilities and restrictions, apartment right – which can be formal, or informal for shared units, and individual units, informal tenures, customary types, indigenous rights, co-operations, tenancy, flexible tenure, possession, use rights, leases, such as primary, demarcated, and registerable leases).
	long leases, Islamic rights: miri – milk – waqf; restriction types; state property (including public restrictions), (certificates of) comfort.
	conflict situations: disagreement, overlap, occupation, uncontrolled privatization.
The Spatial Unit	units other than accurate, and established units. Apart from parcel, apartment, and building, we have shown that it is possible to represent spatial units as a single point (geocoding), a set of lines, or a polygon (with low or high accuracy), also topologically structured parcels, or a 3D volume. Quality labels have to be included for this purpose.

Table 3.2: Impact of STDM on Conventional Concepts in Land Administration.

each right concerns one, or more spatial units; spatial units can overlap (in certain explicit cases) and can always be identified with a label. A right, or social tenure relationship is always between Party and Spatial Unit. It may happen that a social tenure relationship is only documented by recordation, that means without formal source documents. The gender issue has been modeled in the STDM, and conflict situations can be represented. The UN-HABITAT continuum of land rights is covered.

The UML (Unified Modeling Language) Class diagram is presented in Figure 3.3. Apart from Parties, Social Tenure Relationships and Parties it also includes classes to represent Source documents and Survey Points.

Data Acquisition for STDM

In an STDM-enabled land administration, data from diversified sources is supported based on local needs and capabilities. This pertains to both spatial and administrative (non-spatial) data. For example, in informal settlements there may be sufficient information to relate people-land relationships to a single point. Attributes such as photographs and fingerprints can be attached to the records. A cadastral map may be derived from satellite images and combined with descriptions of rights and rights holders. Using satellite images in the field can be considered as a pro-poor and participatory approach. People can "sit around the image" and point the location of the land-use boundaries in the field. Extra observation

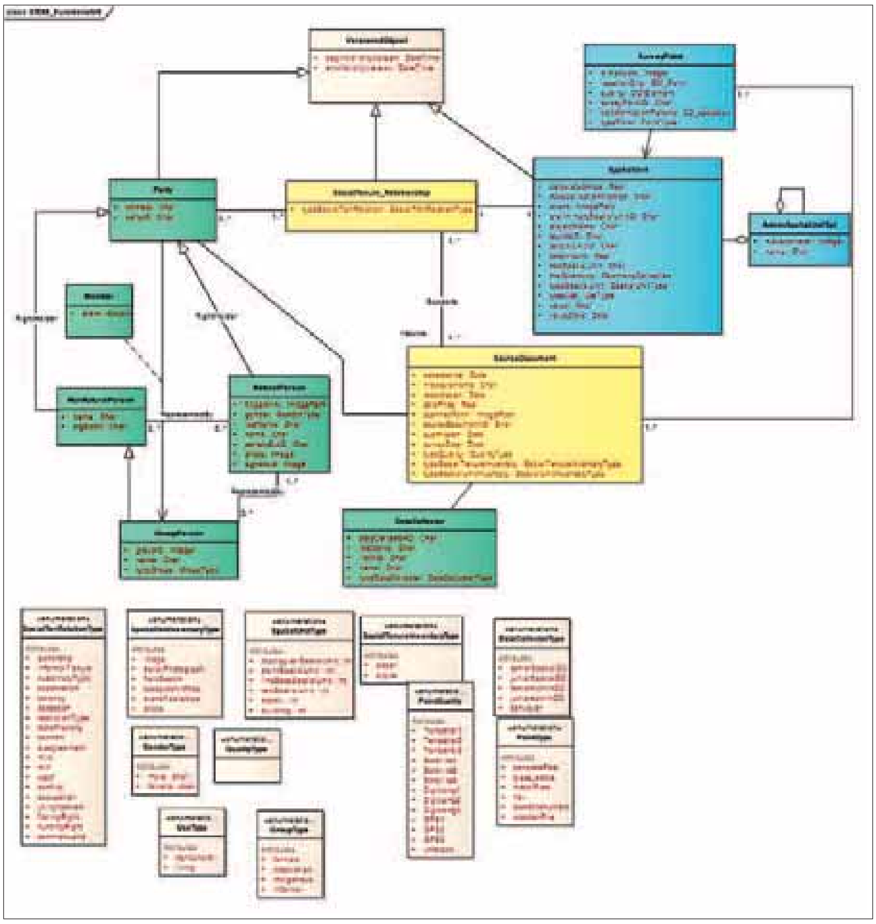

Figure 3.3: STDM Class Diagram.

collected with simple GPS devices may be included. The STDM encourages and caters for all these variations within a standardised environment.

High-resolution satellite imagery is one of the emerging and very promising sources of spatial data for land administration. A large-scale plot of such images can be used to identify land over which certain rights are exercised by the people themselves, in a participatory manner. As proof of the concept, the World Bank, with GLTN funding, organised and led an exercise in Ethiopia in June 2008 which included preliminary tests on the feasibility of high-resolution satellite images for land records. The results of this experiment are encouraging. Similar initiatives in other countries like Rwanda are also yielding comparable outcomes. Figure 3.4 shows the data collected in the field. Figure 3.5 gives the result of the fieldwork:

Figure 3.4: Fieldwork, identification of boundaries on the satellite image.

identified boundary data. This can be considered evidence from the field; neighbours were represented as well as village officials. The digitised boundary data resulting from this exercise can be seen in Figure 3.6.

STDM Prototype

The Social Tenure Domain Model (STDM) application is currently a client/server application that has been developed using open-source software. The application requires PostgreSQL (Database Management) and Tomcat (to organise a Client Server environment) at the server side and ILWIS (Integrated Land and Water Information System) on the client side. This system supports the raster data management very well. All standard software is open-source. The STDM prototype runs on top of ILWIS.

The software is rather flexible, which can be applied independent from the way work flows are organised. This is an important achievement, workflows are not easy to standardise because of the different institutional and organisational settings of land administration – also where social tenure is concerned.

Figure 3.5: Collected field data on satellite image.

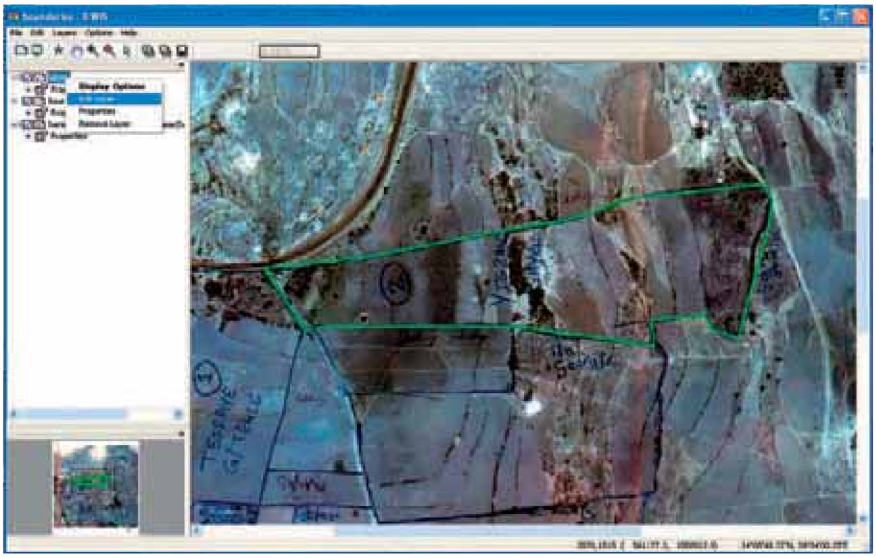

Figure 3.6: Printscreen with vectorized boundaries in STDM Prototype based on ILWIS.

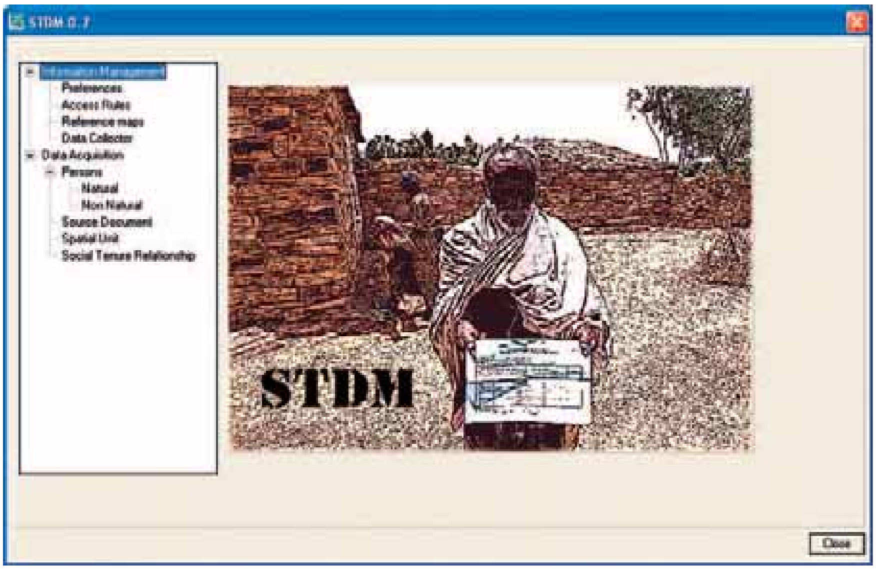

Figure 3.7: STDM Main window.

STDM Functionality

The final version of the STDM Prototype contains the functionality to support the processes as described above, mainly:

- Plot images for data collection; this is the basis for collection of boundaries of spatial units in the field
- GPS data input; easy combination with the raster data from the images
- Scan images; the collected evidence from the field is scanned. In this way a digital access to source data is possible.
- Vectorise the drawn boundaries
- Link spatial and administrative data: the prototype has functionality to insert and manage data on Parties, Spatial Units and to link them in Social Tenure Relations
- Manage history: it's possible to introduce timestamps for all objects; this allows to "look back" in time
- Source documents; all inserted data should be derived from source data (images, forms)
- Insert names of data collectors; the responsible employees are linked to the data in the database.

The STDM Prototype (see Figure 3.7) can be used independent from the way transaction processes are organised. The software supports the insertion, change

or deletion of parties, social tenure relations and spatial units. Shares in social tenure relations between people (parties) and land (spatial units) are possible. New types of social tenure relations can be included in a code table, which allows for a very flexible approach.

STDM Field test

A first cycle in the prototyping has been tested in user environment in the field test in Ethiopia. Some of the observed shortcomings have been repaired and are available in the version delivered at the end of December 2009. The following observations can be made in relation to this test.

The installation of the software components in its Java, POstgreSQL, Tomcat, ILWIS and the STDM application in combination with the creation of the database is of a complex nature – even with an installation guide available.

Transaction management. This is included in STDM in an implicit way. Transactions like splitting and merging spatial units are supported, as well as buying / selling or inheritance. There have also been discussions on other transaction issues:

- How to go from informal social tenure relation to a formal one? And from a personal use right to a formal one? The inventory of informal rights is a "what to do list" for the government.
- How to move from a conflict situation (conflicting claims) to a formal one? Again a "what to do list" for the government – upgrade the rights or take other decisions based on the recordation of rights.
- How to protect women's access to land – this can be organised by using shares in rights. This is supported as an attribute share in STDM, but the required calculations to make the sum of the shares equal to one is not yet available. Question: can there be religious based regimes in the same territory?
- How to organise a split combined with a merge?

The co-ordinate system – need to move to WGS84; then the link with satellite images and GPS is easy to make.

Adjudication not in the field but in a room where all inhabitants (right holders) are together; projection from a computer by beamer on a screen. Villagers can identify the boundaries on the screen, the boundary can be vectorised on top of the raster image. This is in conflict with the principle of collecting evidence in the field. In any case this approach was successfully demonstrated in Bahir Dar and discussed.

Public inspection (after all data have been collected and digitised) based on the same approach. This means that the people from one area are together in a room; projection of the results of adjudication from a computer by beamer on a screen. Villagers can recognise the boundaries on the screen, if everyone agrees it can be given status "agreed". There can be geo-referenced scanned images with field

work results under the image or the paper plots can be used to vectorise directly. This means dispute resolution on a transparent and participatory basis. This was not worked out in Bahir Dar, but is an impact of the proof of concept as described above.

A main issue is further the organisation of the first data input. This can be organised in many different ways; with different responsibilities for different people. The same for digitizing the data after being collected in the field. Depending on the way the data acquisition is organised the digitizing can be organized in different ways. For this reason different roles are available in STDM. See Google spatial data, some surprising example cases from Ethiopia. The available data set on Google Earth for Ethiopia has a very good quality. Better then expected by the experts.

The role of source documents. In principle all adjudication observations should be recorded on paper or digital. But the paper based approach seems to work best.

Holdings (of groups of spatial units) by the same party with the same right or social tenure relation and the identification of spatial units. If the complete holding gets an identifier (the same for all spatial units) the identification is complex. If one spatial unit gets the ID of a new holding (and the remaining part of the selling holding remains the same) then different appearances of the same holding have the same identifier, this is confusing. A parcel based approach avoids such problems. Or, new holding identifiers in case of sub-divisions (always combined with merge in case of holdings, except if the buyer represents a new holding). This is again complex. In Bahir Dar the opinion was that holdings should be supported.

ICT security and back up is most relevant. In case the computers are connected to the Internet a virus scanner is needed. This requires a connection where updates for the virus scanner can be easily downloaded.

Next Steps

New versions of the components (the database, the GIS, theClient/Server support software) have to be tested in an integral way (so: if there is a new version of Tomcat then the complete software application (the STDM) should be tested. This is well known, the same is valid for the use of commercial software.

An open-source community still has to be established where further software developments and exchange of source code can be organised.

Raster data is big, sometimes huge and often enormous. On the other side the bandwidth of any network is limited; same with processing power of any computer is limited. The problem is that transferring raster data costs time, raster file size should be minimal for that reason:

- Unless strictly needed use byte images.
- Color images use 3 to 4 times as much bytes as byte images

- What resolution is really needed? Using larger pixel size quadratically lowers the size of the dataset
- Subdivide large datasets into smaller sets that are still practical to use.
- STDM poses no limits to the size of data but
- Data is often transferred over the network so the smaller the sets the quicker this works
- Some operations are done on the data. Again, the smaller it is the quicker it works
- Storage server side is big but even the biggest servers can run out of disk space when many big datasets are used.
- Reference maps must be in ILWIS format.

The size of the images should be reduced to the minimum can be managed by the available hardware. Further it is recommended to standardize the spatial reference system for raster data. Further: the selection of data is not an easy job, same for composition of mosaic – without clouds. Local expertise is required. The trend is that raster data become faster and bigger available than can be supported by the processor capacity. Also the storage management should not be forgotten. Files with 20,000 by 30,000 pixels are normal. In Client/Server environment this has impact on the bandwidth. Processing power is limited in many cases. Data sets should become as small as reasonably possible. Colour images do not contain extra information for many applications. Large images should be subdivided before use (not compressed). Transformations of pixel based data sets are of a sensitive matter: one should know the impact. ILWIS is proven to be supportive in raster data management, for this reason this tool is selected for STDM.

Concluding remarks

The STDM is a flexible concept which has the capacity to introduce unconventional approaches in land administration. A user-friendly prototype software has been developed allowing to demonstrate this approach has been developed and is available in a second version. The prototype is based on open-source components: Postgres as database and ILWIS as GIS. The software runs in a Client Server environment. The STDM concept can be developed on many platforms, GIS and database management software: commercial or open-source or combinations.

Further Reading

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4. Country Experiences

This chapter gives the perspectives of six countries respective states that either already have adopted or are planning to adopt an open-source policy for their software application approach.

4.1 Bavaria, Germany

Markus Seifert

General framework

Germany is a classic example of a country that takes great pride in its highly accurate maps and cadastral data. In the last three decades several independent geoinformation systems has been developed in the field of cadastre and topographical mapping. Right now a redesign of the German digital cadastral information system ALK (Automated Real Estate Map) is under development. The new approach – called ALKIS (Official Cadastral Information System) – was launched in order to harmonize the structures of ALK and the topographic database ATKIS on the one hand and to integrate the cadastral map and the land titles into one single model which was usually separated for historical and technical reasons. Adding also the geodetic reference points (AFIS) almost all official data of the surveying and mapping agencies are defined in a common and harmonized data model, called the AAA data model (AFIS-ALKIS-ATKIS Data Model).

For that reason the Working Committee of the Surveying Authorities of the States (Länder) of the Fedaral Republic of Germany (AdV) has started developing a new conceptual data model based on international GIS standards which helps to fulfil this harmonization. That will bring the surveying and mapping agencies in Germany to a nation wide well defined data that can be used as a baseline for many other thematic application schemas. For the increasing efforts in building up a spatial data infrastructure, the AAA data model can generally be used for standardization of these thematic data as well and could help to standardize the Geoinformation in Germany brick by brick.

While the data model is a common approach for all Länder in Germany, the corresponding transposition of this concept and the software development and im-

plementation is up to the Länder. Except Bavaria, all Länder in Germany launched calls for tender in order to buy software solutions from specific GIS vendors.

The consequent use of GIS standards

There is a strong benefit of using international ISO standards for geographic information. ISO standards for geographic information provide methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations.

The standards AFIS, ALKIS and ATKIS of the AdV are described in the GeoInfoDok in a **conceptual** format on the basis of ISO 19109 Rules for Application Schema. This means specifically:

- Modelling in UML (Unified Modeling Language), stadardized interface using GML (Geographic Markup Language - ISO 19136)
- Compliance with the regulations of ISO 19103 for the use of UML
- Use of relevant ISO standards, e. g. 19107 (and therefore by implication ISO 19111), ISO 19115, ISO 19123
- Automated derivation and mapping of feature catalogs in accordance with ISO 19110.

An automated derivation of the data exchange interface for AFIS, AKIS and ATKIS objects, the NAS, completes this picture.

The application of ISO standards in any GIS (e. g. ALKIS) will help to:

- Increase the understanding and usage of geographic information
- Increase the availability, access, integration, and sharing of geographic information
- Promote the efficient, effective, and economic use of digital geographic information and associated hardware and software systems
- Contribute to a unified approach to addressing global ecological and humanitarian problems
- Allow any software developer to analyze the specific demands and to derive an implementation model out of the conceptual data model.

The AdV has consequently adopted these objectives and decided to consider the ISO standards within the new AAA application schema as far as possible.

Open-source in the surveying administration in Bavaria

The Bavarian Administration for Surveying and Geoinformation uses open-source software and self-developed tools at the level of data capturing (measurements in the field with self-developed software), as well as data storage

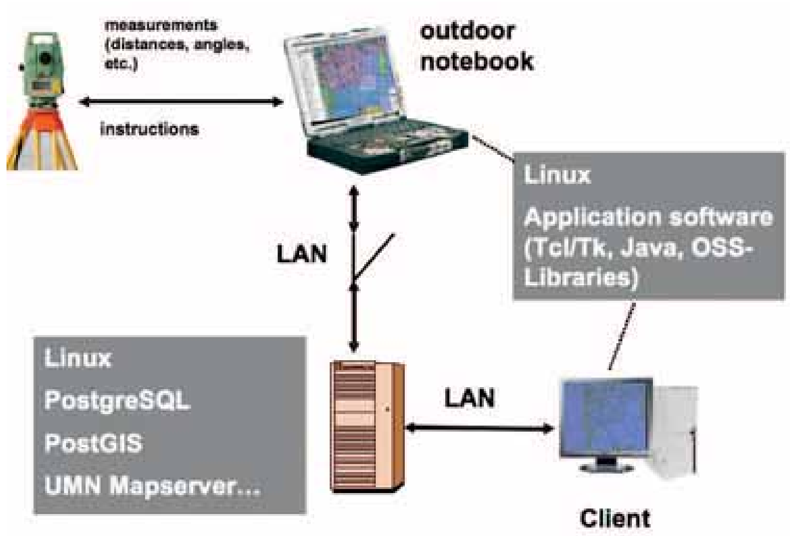

Figure 4.1: Elements of the Bavarian surveying and geodata management.

(PostgresSQL, PostGIS) and data delivery via web services (UMN Web server). Figure 4.1 shows the corresponding elements.

For integration the cadastral data in the national spatial data infrastructure several web services have been established also using open-source software. The customization for the requirements of the cadastral administration has been done by own developers.

Right now there is no open-source GIS software available in Germany fulfilling the requirements of such a complex system like the German cadastre. Therefore, some basic software and data base tools have been applied, but an additional development of specific requirements is crucial for the implementation of practical solutions for the daily work. In Bavaria these developments are not done by contractors or software vendors, but by own software developers within the Bavarian Administration for Surveying and Geoinformation. After running open-source software since many years, the main experiences for such a self-development in Bavaria are:

- The policy strongly requests the public administration to implements open-source software as far as possible and to limit the increasing costs for licences and software maintenance.
- There are just low costs for licensing (the administration holds some 2500 personal computer for the employees).
- Customized solutions perfectly adjusted to the requirements and the demands of the people working with the software.
- Smooth integration into the business processes

- Homogenous ICT system environment (hardware and software) that allows low costs for maintenance, implementations and integration (e. g. the maintenance is don remotely; no ICT specialist are necessary at the local level in the cadastral offices)
- Independency from any software vendor
- Updating and bug fixing can be done very quickly and efficiently.

Open-source experiences, advantages and risks

In terms of **technology** the following positive experiences can be stated:

- Technical requirements (performance, stability etc.) are sufficiently fulfilled by open-source software products at least as the surveying administration is concerned.
- PostgreSQL is a powerful database for GIS purposes that is sufficient for cadastral applications
- System requirements are lower for open-source products than for professional proprietary products
- Good maintainability
- Installations can be automated in an efficient way (from one location to 73 servers and 2500 clients without manual interaction)
- Fast reaction on changing frameworks (data model, data exchange interfaces etc.).

Regarding the **software** that has been developed with open-source tools or based on open-source solutions (e. g. PostGIS) the following conclusions have been drawn:

- Non-open-source proprietary software solutions do not really meet the specific demands of a country and of specific workflows. A customization has to be done in any case.
- There is a demand for open-source cadastral functions (no one should reinvent the wheel); maybe the LADM (Land Administration Domain Model) leads to a solution for that.
- Open-source solutions for web services (e. g. WMS, WFS) are modular components inter-operating on Internet services that support the implementation of a spatial data infrastructure by improving the accessibility to cadastral information ("web services for geo-enabling the world").

There are also **some limits and potential risks** by using open-source products in the field of cadastre:

- Specific technical personnel is required with particular skills in the field of programming languages (Java etc.), DBMS, SDBMS (PostgreSQL), system, networks and implementation of ISO standards.

- By introducing a new system, most efforts have to be done in the field of data migration (to meet the rules of the data-model) and data acquisition, which in Bavaria is the most labour-intensive and technical challenging task. Software development is not the most expensive component.
- The reputation of open-source software is not the very best. People assume that installation is difficult, the operation complicated and there is bad support. Even it has been proved that it is not the case in the Bavarian Administration for Surveying this prestige is still there.

However, even if there are also some potential risks and definitely a lot of things to be done before open-source software can be sufficiently implemented, the experiences in Bavaria are very positive. It has been shown that the implementation of open-source applications is a reasonable approach in the field of cadastral administration.

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4.2 Bosnia and Herzegovina

Jean-Luc Horisberger, Kemal Osmanović

Historical development

The first cadastre and land registry system covering systematically the entire territory of Bosnia and Herzegovina has been established by the Austrian-Hungarian Administration before WW I on the model used in Austria. After WW II, cadastral maps were progressively replaced by a new survey using a classical aerophotogrametric method to establish new maps with better quality and homogeneity. These maps are now under digitization and, even if they were not systematically kept up-to-date, offer a good homogeneous technical basis for establishing a fully digital cadastral system. In the 1990s, different software applications were developed to manage textual information only, but no graphical information, except in very limited areas.

In the years 2005-7, a cadastral data model has been developed as a standard [34] for data description, structures and exchange interface, in accordance with the

[34] By-law on cadastre data management, Administration for geodetic and property-related affairs of the Federation of Bosnia and Herzegovina, see http://www.fgu.com.ba/index.php?part=stranice&id=208

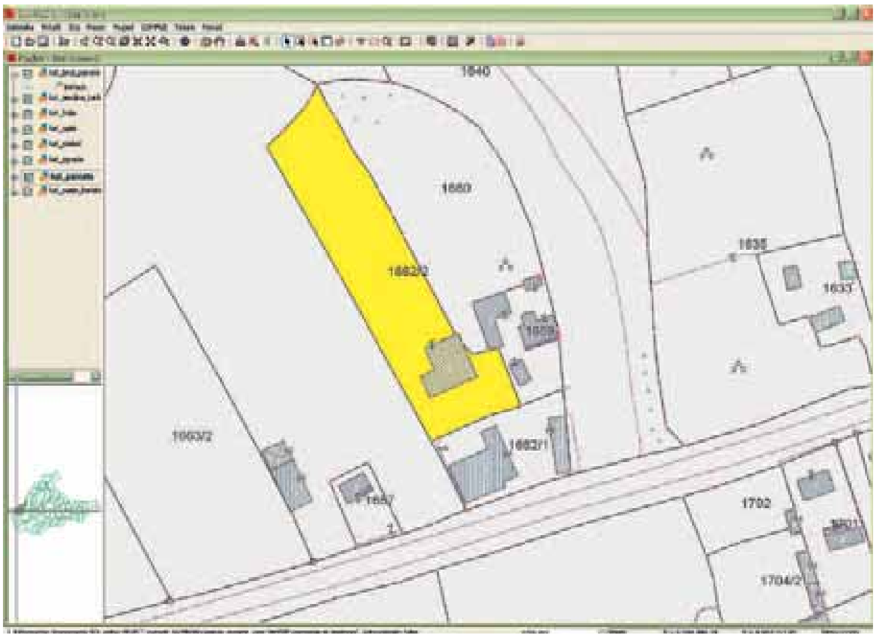


Figure 4.2: Graphical display with layers' tree (column left).

ISO 19000 standards. Since the digitization process of graphical data has been accelerated in the last years in particular within a World Bank funded project, the need for an appropriate database maintenance tool has significantly grown. The financial resources of the Administrations in charge of the cadastral maintenance are limited, so that an analysis was conducted on potential software solutions using open-source platforms (Mićanović et al., 2008).

New software application for cadastral data management

Using recommendations made in this study, and referring to the legal prescriptions, terms of reference were drafted to launch a software development in 2008. Part of the Municipality of Brcko has been defined as test area, where tests were made during the first half of 2009. The results are very positive and encouraging. The functionality of CAMPUS (Cadastre data Management, Processing and Updating Software) covers the main needs for managing and updating graphical as well as textual cadastre data with all consistency requirements. Thanks to the use of a standardized data model, it is interoperable with the land registry database, and there are no redundancies any longer between the cadastral and land registry databases.

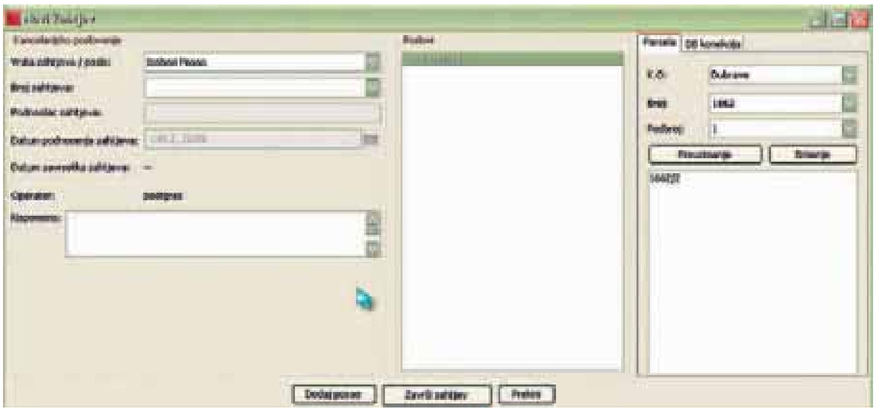


Figure 4.3: Entry menu in the case management system.

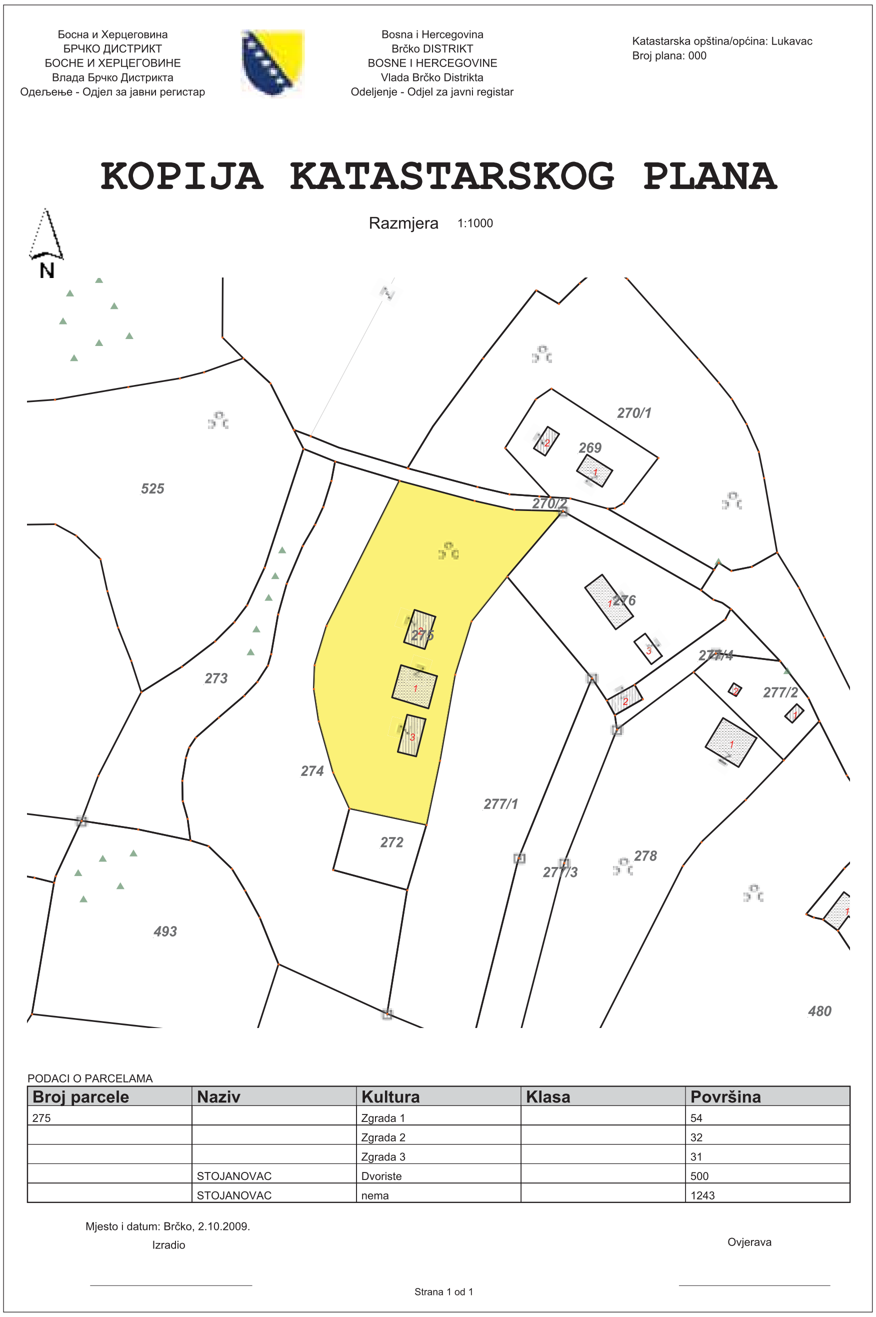
Benefitting from the experience made, and according to potential changes in the legislation, the software will be continously upgraded and adapted. The flexibility offered by open-source solutions is a big asset as the established know-how will remain in the country. Software development as well as maintenance costs are consequently affordable.

Functionality of CAMPUS

For the first time in Bosnia and Herzegovina, geographical and textual cadastre data shall be managed in a single database and in accordance with a specific data model. Hence CAMPUS has been designed as an easy-to-use data processor with graphical presentation of data for simple, understandable and user-friendly data maintenance and updating by non-experienced operators (see Figure 4.2). Data can be visualized according to standard GIS interface with multi-layer architecture, and data processing, topological control and consistency checks are performed automatically.

The main functionality of CAMPUS includes:

- A case management system with usual information about every change to be made (see Figure 4.3), from the initial order to the completion of changes to the database,
- Usual processing functions for data updating (parcel division, modification of parcel boundaries, insertion of new buildings, etc.)
- Data viewing functions including production of cadastre extract with map and corresponding textual description. Such documents can be printed and signed for official use, or stored as .pdf files (see Figure 4.4).



Босна и Херцеговина
БРЧКО ДИСТРИКТ
БОСНЕ И ХЕРЦЕГОВИНЕ
Влада Брчко Дистрикта
Одјељење - Одјел за јавни регистар

Bosna i Hercegovina
Brčko DISTRIKT
BOSNE I HERCEGOVINE
Vlada Brčko Distrikta
Odeljenje - Odjel za javni registar

Katastarska opština/općina: Lukavac
Broj plana: 000

KOPIJA KATASTARSKOG PLANA

Razmjera 1:1000

PODACI O PARCELAMA

Broj parcele	Naziv	Kultura	Klasa	Površina
275		Zgrada 1		54
		Zgrada 2		32
		Zgrada 3		31
	STOJANOVAC	Dvoriste		500
	STOJANOVAC	nema		1243

Mjesto i datum: Brčko, 2.10.2009.

Izradio

Ovjerava

Strana 1 od 1

Figure 4.4: Automatic generated extract of the database.

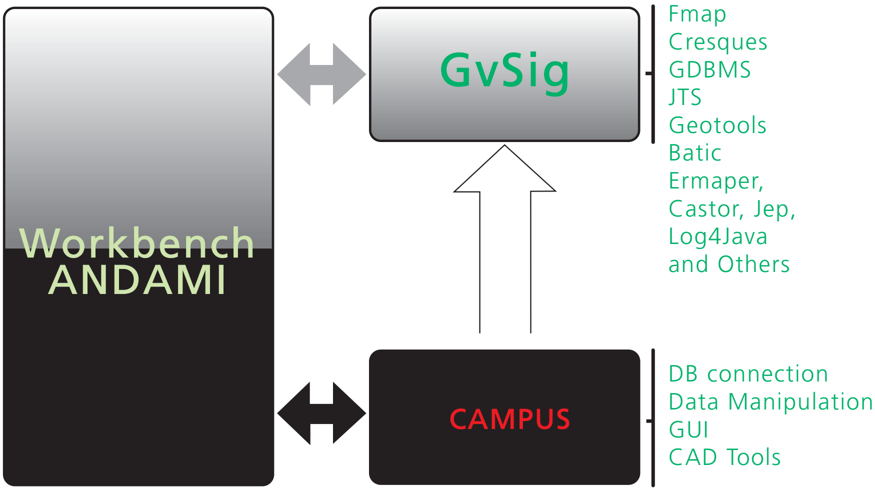


Figure 4.5: Relations between application and platforms.

The CAMPUS application uses GIS functionalities offered by PostGIS template introduced by PostgreSQL database. It is designed as a GUI shell that calls procedures stored in the database, which perform majority of data processing and consistency control. The application is customized to ensure multi-user surrounding. Data in use are locked to prevent irregular situations, to ensure data consistency and full recovery in case of error.

The CAMPUS application is implemented as a set of extensions to gvSIG[35], which is a multipurpose open-source desktop application designed for geographic data management and representation. Main design feature of gvSIG is its modularity allowing easy adding or excluding of plug-ins (called extensions). Thus gvSIG offers an ideal platform for creating, maintaining and further developing of customized applications.

Technical characteristics

The application design is made of two parts, i.e. a common database storing and processing data, and a client application to visualize data and operate database procedures. The database supports the tracking of time and user performing changes, so that the history of any object can be reconstructed. The document templates are editable by the user, offering quick and easy edition of document layouts. CAMPUS 1.0 was designed to meet multi-platform requirements and is suitable for Windows XP / service pack 3, Linux (Ubuntu distribution) and OS X operating systems with the same usability.

35 See http://www.gvsig.org/web/

CAMPUS 1.0 is designed as a set of 19 gvSIG extensions monitored by the main CAMPUS extension. These extensions can also be further extended by any other party who would like to customize further, continuing the process of extensibility of both gvSIG and CAMPUS.

CAMPUS 1.0 uses the following gvSIG tools:

- geospatial libraries (vividsolutions, geotools packages);
- database manager (GDBMS project);
- scripting console (extScripting project);
- GUI objects for representing data table content, geospatial and topology symbols (com.iver.cit.gvSIG.project package); and
- Symbology package (FMap).

GvSIG is based on the extensible platform ANDAMI (see Figure 4.5.) which performs reading and mounting of extensions immediately after application start. ANDAMI also provides a user interface for placing menus, toolbars and user windows and offers a multilingual support. Text files (.properties) for each language need to be added to the config folder of a _appANDAMI project, which contains text labels in a term=translation manner. This allows further use of the application in other languages.

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4.3 Cambodia

Gertrude Pieper

The Cambodian cadastre would seem the ideal candidate for the implementation of free and open-source software. Technical and financial resources are limited in Cambodia, one of the poorest countries in South East Asia. During the Khmer Rouge regime in the 1970s, all land records were destroyed. Now, a land register is being built up from scratch through systematic land registration, village by village. Each month, around 25,000 land parcels are registered through a digital land registration system. Computers and software licenses have been bought to equip land registration teams in 15 provincial cadastral offices. The costs to maintain the system and to meet future demands in terms of data volume and user requirements are considerable. The idea of using of open-source software as an alternative to proprietary database and GIS software is met with enthusiasm, and efforts are underway to implement open-source software solutions. The obvi-

ous financial benefit is one of the reasons why open-source solutions are popular in Cambodia. However, the cost of software licenses is probably the least of the many challenges that the Cambodian cadastre is facing.

A good start

Even though Cambodia is one of the poorest countries in the region, its government managed to initiate systematic land registration successfully using a digital system. After several pilot projects, the Cambodian Ministry of Land Management, Urban Planning and Construction (MLMUPC) started to implement systematic land registration in 2002 under the Land Management and Administration Project (LMAP) supported by the World Bank and the governments of Finland and Germany. The main component of the project, supported by the government of Finland, aimed at the surveying and adjudication of 1 million land parcels and the issuing of land titles for at least 80 % of the surveyed parcels (World Bank, 2002) within five years. By the end of 2007, this ambitious goal had been reached and surpassed. Currently, over 1.7 million land parcels have been surveyed and adjudicated and for most of these, land titles have been issued to the owners. Monthly progress is steady and land records are processed and updated in decentralized digital databases in provincial cadastre offices. Sale transfers, subdivisions and consolidations are digitally registered as well. The costs of land registration in Cambodia are relatively low compared to other land registration projects in the region and world-wide. In fact, the cost per land title was calculated to be only 9 USD, less than a third of the projected cost (World Bank, 2009). Also, the land registration activities are generating income through taxes on the transfer of land parcels. In theory, the incoming funds from land transfer taxes, if channelled to the MLMUPC, would be enough to finance all land registration activities including the procurement of hardware and software licenses.

As in multiple other land registration projects, the Cambodian digital land registration system is based on MS Access and the ArcView edition of ESRI ArcGIS; low-cost solutions that are relatively easy to implement. Customized cadastre tools and a Khmer interface have been developed locally with technical support of the Finnish government. The idea has been to start with simple tools that can be upgraded and extended later on when data volumes, local technical capacity and user requirements increase.

Challenges

Now, seven years after the start of the systematic land registration under LMAP (renamed to LASSP or Land Administration Sub Sector Program in 2009), data volumes and requirements have increased indeed. The MS Access databases can no longer handle the increasing amount of data and transactions. The data must be

migrated to server-based databases, but the MLMUPC does not have database experts to maintain such database systems. Local technical capacity has not kept up, and IT expertise within the MLMUPC is almost non-existent. The MLMUPC finds it hard to contract and keep skilled Cambodian IT experts in the civil service, and still relies largely on foreign technical support.[36] The hardware was bought in 2002 and needs replacement. Electricity cuts are frequent and the UPS devices that are supposed to protect the computer networks from power cuts, have stopped working a long time ago. Even small expenses such as RAM upgrades and replacement of non-functioning hardware are a problem, not necessarily because of the cost, but mainly because of the logistics of the approval chain and procurement procedures involved.[37] Software upgrades are problematic too. Three different versions of ArcView licenses are used spread over the 15 provincial offices, since the older licenses have not been upgraded when new licenses were bought. There is little that can be done to speed up hardware procurement, but when it comes to software, the use of open-source solutions would make software installations and upgrading a lot easier.

From MS Access to PostgreSQL

Up to now, Cambodian land register data has been kept in MS Access databases with the expectation that the data could be migrated to more powerful database software as the data volume grows. One of the useful functions of MS Access is that it can link to databases in other formats through ODBC (Open Database Connectivity). In that way, the ease of the MS Access interface can be combined with the reliability of server-based database software to form an efficient database system. PostgreSQL, which is considered the most advanced open-source database software, has grown in sophistication and reliability and is now used by many large companies for mission critical operations. The maximum amount of data that can be stored in PostgreSQL databases is as yet unknown, but databases that store multiple terabytes of data are not uncommon. With the spatial extension PostGIS, which is also open-source, also geographic datasets can be stored in PostgreSQL. The powerful database capacities combined with spatial functions make PostgreSQL especially suitable for land registration projects such as LASSP.

Migrating from MS Access to PostgreSQL may seem a daunting task, but is in reality rather easy. There are not many conversion tools for PostgreSQL available, but most of the conversion work can be done simply by copying data from the Access tables into the linked PostgreSQL tables. For the Cambodian Land Register

36 Contracting skilled IT experts to the civil service is subject to the government's public sector recruitment policies and cannot be directly influenced by MLMUPC alone.

37 The credit agreement between the World Bank and the Government of Cambodia was ended on 4 September 2009 and all procurement has been postponed. Alternative financing options for the hardware procurement are currently being studied.

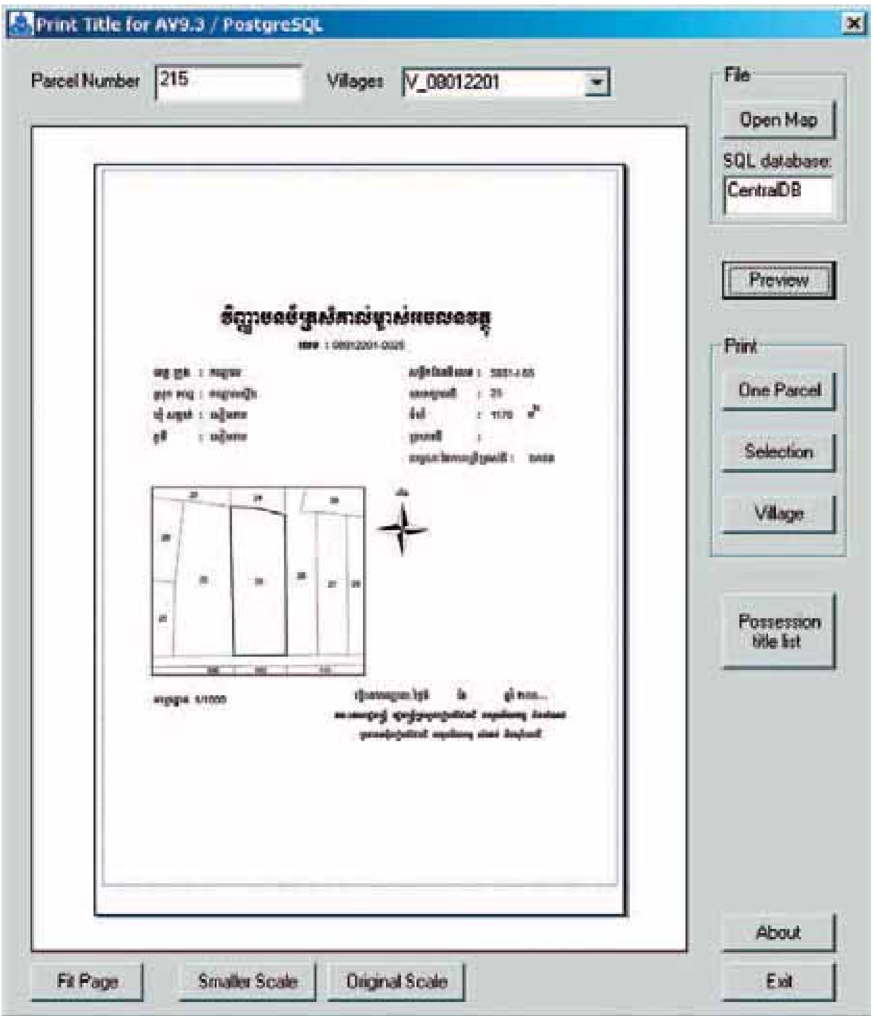

Figure 4.6: Printing land title certificates.

databases, the following procedure is followed. To begin with, a table structure was created in PostgreSQL. This can be done through the PgAdmin interface that lets users create database tables with columns, restrictions and indices. The table structure created for the Cambodian Land Register was almost identical to the tables in MS Access, with a few differences in data types. Once the data structure was created, the tables were linked to the MS Access application. Then, data from the MS Access tables was copied into the linked PostgreSQL tables through append queries. After appending the data, the MS Access tables were deleted from

the application. Apart from setting the connection parameters, only a few modifications were needed to make the application work with the PostgreSQL database. The result is a database system that still uses the familiar MS Access interface, but with a more reliable database back-end that can store millions of land records. Retraining of database users will not be needed, since the interface still looks the same and none of the database functions have changed.

GIS tools for PostgreSQL

Since the start of the LMAP project, a number of GIS tools have been developed to facilitate the land registration work. The tools work with ArcView and are used for digitizing of land parcels, updating area information in the database and for printing Land Titles. Before the PostgreSQL database with MS Access interface can be deployed in the provincial offices to be used for land registration activities, these GIS tools had to be modified to be able to connect to the PostgreSQL back-end database through ODBC. The printing of Cambodian Land Title Certificates is fully automated; and printing hundreds of land titles for the same village is a matter of minutes. As shown in Figure 4.6, the Land Title includes a map of the land parcel as well as ownership information. The parcel map comes from an ArcGIS map document; while the ownership information is pulled from the PostgreSQL back-end database. Here, the advantage of using PostgreSQL compared to MS Access is that more users can simultaneously access and edit the database without problems. Now, all is ready to migrate the MS Access databases to PostgreSQL, use ArcView to digitize and maintain the cadastral boundaries, and print Land Titles through the ArcView/PostgreSQL connection.

For LASSP, this combination of low-cost proprietary and open-source software will work for some time. However, when multi-user editing of GIS data is needed or when map data must be shared over the Internet, more than ArcView is needed. Should LASSP invest in the costly ArcServer[38] licenses or find open-source alternatives instead?

Open-source GIS software

Open-source GIS software has really taken off in the last few years. To name a few, uDIG, Quantum GIS and gvSIG are recent desktop GIS products that could be used instead of ESRI ArcView. When LMAP started in 2002, these products had not been developed yet, and open-source GIS was not really an option. So far, the LMAP/LASSP project has made use of ArcGIS software with success. The costs of ArcGIS/ArcView are relatively low compared to other commercial GIS software,

38 ESRI ArcServer replaces the earlier ArcIMS and ArcSDE licenses and provides tools for managing large spatial datasets and Internet mapping services.

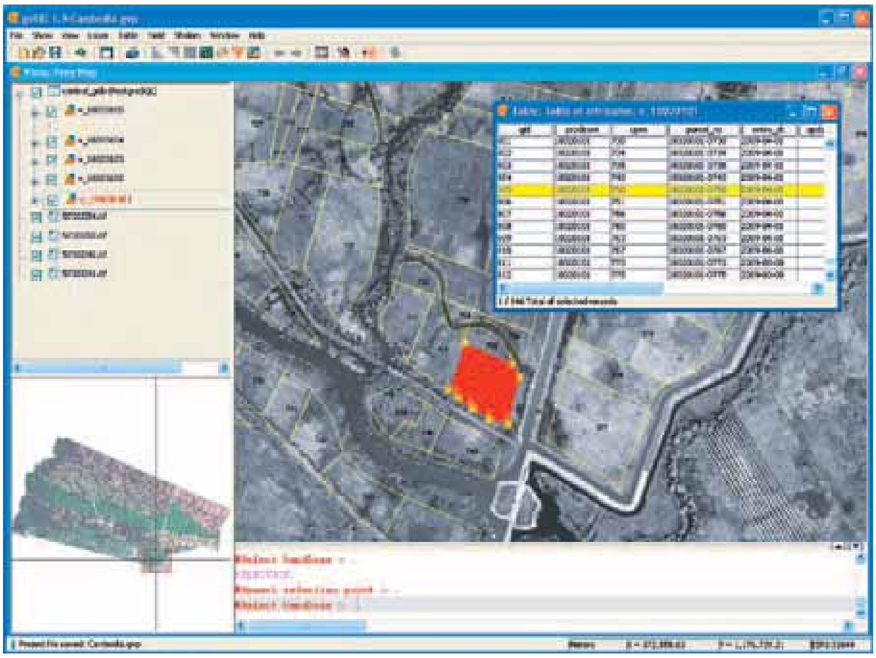

Figure 4.7: With gvSIG, users can directly edit geographic datasets stored in PostgreSQL.

and it offers good value. It is hard to find other GIS software with as many vector editing capabilities as ArcGIS. The ArcObjects development kit that comes with the software makes it relatively easy to customize ArcView for almost any GIS requirement. But with only the ArcView licensing level of ArcGIS, LASSP is running into software limitations in terms of topology validation and multi-user editing.

GvSIG is one of the most promising open-source GIS products. With a user-friendly interface, editing tools to maintain vector data with a CAD-like precision, and direct database connection to PostgreSQL, gvSIG is the ideal software to replace ArcGIS in LASSP. The latest version of gvSIG includes a topology extension and new editing tools for cutting and merging polygons.

Developments have started to build customized LASSP tools to print land titles, handle parcel subdivisions and consolidations and produce the Cadastral Index Map with gvSIG.

When this is done, the LASSP geographic datasets can be migrated to PostgreSQL with PostGIS. The central storage of land register data in PostgreSQL would be more reliable than in the current ESRI personal geodatabases spreaded over multiple PCs, and it would open up possibilities for data sharing in an NSDI and public enquiry services.

National land register database

So far, not much of the open-source plans have been implemented in LASSP. The installation of PostgreSQL in provincial cadastral offices and migration of all land registration databases from MS Access to PostgreSQL has been postponed until the arrival of new computers and network servers. The migration of the geographic datasets to PostGIS must wait until cadastral tools for gvSIG have been developed. But there is one area where the use of open-source software in LASSP is already successful.

The Cambodian Land Register exists as separate provincial databases which are updated in provincial cadastral offices. Backups of these MS Access databases are sent regularly to the central cadastre in Phnom Penh. Using these backups, the data from 15 provinces has been combined into a national land register database in PostgreSQL. With over 1.7 million land records, the data could never have been stored in a MS Access database. The national land registration database is used to monitor the registration progress in the provinces, extract information on land transactions, and for statistical purposes. Whenever new provincial backups are available, the national database is updated. As a central data store, this national PostgreSQL land registration database forms a good basis for the development of a Land Information System with public information services over the Internet.

Looking ahead

The use of PostgreSQL database software for the Cambodian land registration system brings considerable advantages. More users can simultaneously access the database; the amount of data that can be stored is virtually unlimited. The data storage and processing becomes more reliable and more secure. The installation and upgrading of open-source GIS will be so much easier than the handling of multiple ArcGIS versions. But with the introduction of open-source software, the Cambodian cadastre will not solve all of its IT problems. The difficulties to replace and repair old hardware, and the lack of skilled IT professionals remain a concern. The MLMUPC recognizes these limitations and is considering the establishment of an IT department, and the contracting of IT staff to work on the maintenance and further development of the digital cadastre system. The combination of local IT expertise and the use of open-source software would make the Cambodian cadastre system truly sustainable.

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4.4 Ghana

Wordsworth Odame Larbi, Benjamin Armah Quaye, Kofi Abakah Blankson

Land tenure and registration arrangement

In Ghana, Land is owned predominantly by customary authorities (stools, skins, clans and families). Together they own about 78 % of all lands, the State owns 20 %, and the remaining 2 % is owned by the State and customary authorities in a form of partnership (split ownership) normally termed as vested lands.

Two types of land registration systems operate in the country: the Deed Registration System and the Land Title Registration System. Whereas the Land Title Registration System operates in areas declared as compulsory land registration districts the Deed Registration System operates in all areas which have not been declared as compulsory land title registration districts. Currently only the Greater Accra region (comprising 20 districts) and Kumasi (only one district) have been declared as compulsory registration districts.

Land information management constraints

The information management system currently operating in the country is mainly manual. Data and information are stored in the form of hard copy graphical maps, cadastral data and textual records. The linkage between these manual records is poor and access to data difficult. Keeping records up-to-date in the land agencies is therefore a challenge. All this seriously constrains the operation of the land sector agencies.

Furthermore, land records are deteriorating with use and this deterioration is compounded by

a) The sub-standard conditions under which many of these records are stored and,
b) The extensive use they are subjected to through retrieval and re-filing of the ageing manuscript documents.
c) The records are also at risk should there be some disaster such as fire as there is no backup system.

All of the above constitutes a significant records management problem.

Modernization of the land information management

Under the ongoing Land Administration Project (LAP), efforts are being made to address the challenges regarding land information management. A consultancy has been awarded for the development of a computerized Land Information System for the Land Sector Agencies (LSAs).

The implementation of the LIS is planned to be in three stages. The current consultancy, which is the first stage, seeks to satisfy the immediate and urgent needs

of the LSAs by providing the design and implementation of a hands-on system which will be the nucleus of the final holistic LIS. It involves the design and implementation of one sub-system in each of the LSAs, computerising their day-to-day core business processes, so that no further manual records are produced, once the sub-system is installed in a LSA. In addition, a proposal of the way in which the sub-systems could be integrated in the core LIS to be finally maintained by the New Lands Commission is to be prepared.

A decision was taken early in the system development to use open-source tools. As a result, the database management system adopted is PostgreSQL/PostGIS and SharpMap GIS has been adopted for the graphical component.

Data model

There is no underlying "data model" in Ghana. Rather land information data lie scattered across the different LSAs in different formats, at different stages of currency, and with varying levels of quality and standards compliance. In addition, there exist a number of other projects which to some extent also seek to modernize the land records system but may not be appropriately linked to the development of the LIS.

However, with the passage of a new Lands Commission Act, 2008 (Act 767) in 2008 which makes provision for the establishment of a Land Information Unit (LIU) it is envisaged that a rationalization of data will ramp up in the near future. In the interim, the closest that the current data comes in terms of forming part of a functional data model is in the adoption of the Social Tenure Data Model (STDM) for the LIS. This model is not yet deployed in any of the LSA offices and pending the outcome and approval of the project this may become a de facto data model for the land sector agencies of the Government of Ghana. However, it is not yet operational and this still appears to be some way off.

The most significant land ownership data available in digital format are the sectional maps used for title registration held by the Survey and Mapping Division of the Lands Commission (SMD). These maps show the delineation of land parcels for within a Land Title Registration District. A district, comprising one or more sections, is part of a region or area, and is defined (declared) according to the Land Title Registration Law PNDCL 152 of 1986 but with no cadastral description. These digital maps are for only the areas declared as compulsory registration districts under the Land Title Law. These are in the Greater Accra Region (22 districts) and one district in the Ashanti Region. There rest of the country are not covered by any digital maps for cadastral purposes.

The Greater Accra region is zoned into Land Title Districts, demarcated into sectional areas. Parcels within the section are surveyed by licensed surveyors. Each sectional area has an average of 1,500 parcels. The sections are further sub-divided into blocks of 30 parcels per Block.

To date approximately 7,000 parcels have been surveyed and registered (or in the process of being registered) at the Land Registration Division of the Lands Commission.

Open-source policy

Whilst there is no formal government policy in Ghana regarding the use of open-source software, there is every indication that the Government of Ghana supports efforts in that direction. Speaking at a free and open-source software media training conference in Ghana in April of 2007, the then Minister for Communication noted that the government had already mandated the Ghana-India Kofi Annan Centre of Excellence in ICT to spearhead the national consultation process on an open-source policy and to provide an initial draft document for consideration. There is, however, no evidence that this consultation process has been concluded and whether a policy document has been prepared.

The Minister hinted that the use of FLOSS was important because it allowed the Government to reduce costs and retain ownership of its own technology. Importantly, he noted that relevant courses in open-source, including courses tailored to specific client needs, will be offered at the Kofi Annan Centre.

It is possible that the transfer of knowledge underlying the geospatial tools used in the OSCAR project may be dovetailed to fit within this process, maintaining consistency with the stance taken by the Government in general. Hence, if there is passage of a formal policy on FLOSS in Ghana, the OSCAR project will be entirely consistent with this.

Currently there is no formal mandated requirement within the LSAs in Ghana to adopt specific land-related standards or to require agencies to use one form of ICT over another. However, informally, there has been a general convergence within Ghana to the use of a small number of proprietary software packages (especially ArcGIS, although Microstation is used for drafting work, and one or two other minor GIS packages are used). In particular, the relatively high profile of the Environmental Systems Research Institute's (ESRI) suite of tools across a number of the LSAs suggests that any FLOSS venture should maintain, at least in the short term, compatibility with ESRI's informal de facto industry standards, such as the use of shapefiles or the ability to exchange data with personal or file geodatabases.

In the longer term, the prohibitive acquisition costs of ESRI software and the need to pay high annual support and maintenance fees in order to remain up to date, are significant disincentives to follow this path indefinitely, especially when computerized land information systems is to be deployed nationwide in the national LIS. There is also an implied dependence on external consultants whenever customization of any sort is required.

Lessons learnt

Even though one of the main reasons for the adoption of open-source software tools for the development of the LIS in Ghana is to ensure sustainability through the elimination of the payment of huge license fees on proprietary software, it has been realized that there is the need to have skilled personnel who understands the open-source concept and have programming skills. Unfortunately, such personnel have not yet been recruited. To compound the situation, the implementation strategy adopted by the consultants for the development of the stage one LIS required most of the development activities to be done in the home country of the consultants. There has therefore not been any transfer of knowledge.

Efforts are however being made to improve the IT skills of staff and also recruit staff with requisite skills to manage the system. In the interim therefore, reliance will have to be placed on external sources. In the long term however, strategies will have to be put in place to attract and maintain skilled personnel in the area of programming and software development.

In conclusion Ghana believes the open-source approach to the development of the computerized land information system is in the right direction. The requisite capacities would have to be built to get the system underway.

4.5 Samoa

Vitaoa Pele Fuata'i, Neil Pullar

Samoa land tenure

The Independent State of Samoa gained independence in 1962 having been administered by Germany (1900–1914) and then New Zealand (as a United Nations Trust Territory from 1945–1961). It has a population of 181,000 (2006 census) and a land area of 2,831 square kilometres. Agriculture (primarily coconut based products), fishing, tourism and remittances from Samoans working overseas are the main contributors to the Samoan economy. All government cadastral and registration services are provided by the Ministry of Natural Resources and Environment (MNRE) located in the capital Apia (on the island of Upolu). Apia is also the main commercial centre of Samoa and most of the private sector surveyors licenced to undertake cadastral surveys are based there too.

80 percent of the land in Samoa is held under customary ownership and this land is protected under the constitution. Samoan society is still strongly focussed on village life and the associated traditions. Customary land is not owned individually but communally with most land being associated with a chiefly (matai) title. The matai has authority (pule) to decide on the permitted uses for that land by

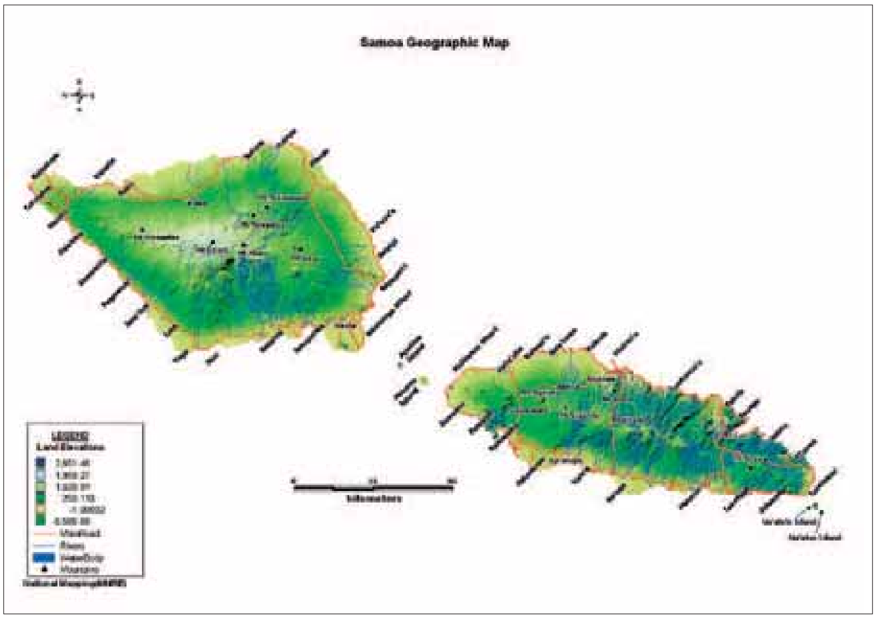

Figure 4.8: Samoa geographic map.

other members of his family group. One forum for the resolution of disputes concerning customary land is the Land and Titles Court (but it should be noted that "Titles" in this case mean chiefly titles).

The remaining non-customary land consists of 4 percent of freehold land and 16 percent of public land. Cadastral and registration records of parcels of land within these non-customary categories of land are recorded within the formal cadastral and registration systems. A small number of blocks of customary land subject to a lease are also with the formal systems. The computerised cadastral mapping system, known as Samoa View, has 21,000 parcel records (July 2009). The computerised Land Registration System has 12,000 current titles.

Current cadastral arrangements

Currently (July 2009) cadastral surveys are undertaken under the Survey Ordinance 1961. New legislation for cadastral surveys is currently under consideration by Parliament.

Any change in boundaries for freehold or Government land (or for the registration of a lease over customary land) requires a cadastral survey signed by a registered surveyor. Most of these surveys are performed by private sector surveyors. A survey plan is lodged with the MNRE where it is checked by the Quality Assurance

Section of the Technical Division. Once the survey is considered to meet all requirements (including the standards described in the Survey Regulations) the survey is approved by the Chief Executive Officer. The survey is then able to support registration actions including the issuance of new titles. Once the survey is approved the new boundaries are recorded in the (computerised) Samoa View mapping system.

Current registration arrangements

Samoa moved to a system of title registration with the implementation of the Land Title Registration Act 2008 on 2 March 2009. This change was accompanied by the introduction of standardised forms, the implementation of a computerised system and the legal recognition of the computer based records and in particular the "computer folio".

Although it is possible for individuals to complete their own documents for registration, it is common practice for people needing to register a land transaction to engage the services of private lawyer to prepare and lodge the necessary documents with the MNRE. Details are entered into the computerised system at the time of lodgement. Staff from the Registration Section scan all lodged documents and associate them with the lodgement record, which has also been referenced to the appropriate computer folio (title) at the time of lodgement data entry. Registration staff then checks that the lodged documents are able to be registered. Once these checks are done the Registrar registers the transaction and the computer folio is automatically updated to reflect the new registration.

The public can also request various computer folio search products and these are produced by the computerised system. Likewise the computerised system creates new computer folios when a new survey plan is registered (as well as cancelling the superseded computer folios).

Modernization initiatives with Ministry of Natural Resources & Environment

Since early in 2005, the World Bank funded Samoan Infrastructure Asset Management Project Phase II (SIAM-2) has supported MNRE to undertake various land administration modernization initiatives including the introduction of a title registration system (including the computerised system), the design and implementation of a new geocentric datum, mapping projection and survey control system, the preparation of a Land Information Integration Strategy and the implementation of a computerised system of cadastral mapping including the conversion of the manuscript cadastral index sheets into the computerised system. The support from SIAM-2 Project concluded in 2009.

Expectations from involvement with Open-source initiatives

Samoa, through MNRE, began its interest in open-source initiatives through attendance at the FAO supported Open-Source Cadastral and Registration (OSCAR) workshop in Dunedin, New Zealand in May 2008. At that stage they had made the transition from paper based land registration and cadastral mapping systems to computerised systems based on proprietory commercial software. Although the land registration software was custom developed for Samoa and MNRE owned the source code, there was an ongoing need for software support and potential future costs because the land registration software was written in a Microsoft environment.

For these reasons, MNRE expects the use of open-source software (including OSCAR) and the migration of the current two computerised systems to an open-source environment will reduce the future cost of proprietory software. Specifically, Mapinfo and potentially Microsoft SQL Server software licences. OSCAR would also minimise the MNRE's current dependency on international experts for software and computer mapping support through the OSCAR pilot's goal of building up expertise in these areas within Samoa and the MNRE.

MNRE are committed to several futher cadastral and land registration reforms and are aware that these initiatives will require further computerisation developments to support them. These initiatives include:

- New legislation to allow for the issue of titles to apartments including those located on customary land (proposed Unit Title Bill is under consideration by Parliament).
- Replacement software for the current DOS based cadastral survey calculation (SDRMap) software used by both the Quality Assurance Section and cadastral surveyors.
- Improved assess to Samoa View cadastral mapping and title registration information (initially within all sections of MNRE but ultimately to other government and private sector agencies).
- Digital lodgement of both registration transactions and cadastral surveys.

MNRE's interest in open-source software solutions is not limited to its cadastral and registration functions. Through MNRE's environmental responsibilities it plans to be part of the proposed Integrated Climate Change Adaption in Samoa (ICCAS) project which will use the same POSTGRES database management system as is proposed for OSCAR. Open-source software is also being investigated by the Ministry of Education.

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4.6 Solothurn, Switzerland

Horst Düster

The Canton of Solothurn in Switzerland provides services and infrastructure to 250,000 citizens. In the year 2001, the cantonal Parliament decided to migrate from Windows to Linux. The main motivations were to become independent from one particular vendor, to encourage free enterprise, and reduce license costs. As a result, the cantonal office for geographic information (SO!GIS) started to deliver the GIS services for more than 3,500 employees according to a FOSSGIS strategy.

The first step was the introduction of UMN MapServer and the creation of a SO!MAP client that offers an easy to use WebGIS client for all 3,500 employees. The second step was the migration of all geospatial data from Shapefiles to the PostGIS spatial database engine. The introduction was successful, although an easy-to-use desktop GIS was lacking.

In 2006, after the evaluation of different desktop GIS, the decision was taken to use QGIS in conjunction with GRASS, replacing ESRI ArcInfo and ArcView3. The decision was driven by the following aspects:

1. Due to the use of desktop GIS in a Linux Terminal Server environment, Java was not an option;
2. OSGeo Project-Organisation;
3. GUI translated in German language;
4. Documentation written in German language;
5. An active developer nearby;
6. This developer has been mandated to implement missing features such as digitizing and map composing;
7. Application and plugin developement with Python;
8. Growing user community;
9. Active developer community;
10. Independence from any particular operating system.

Where QGIS is being used

In contrast to the interactive maps served by UMN MapServer, the desktop GIS has to offer a flexible view of the several geospatial data of Solothurn. QGIS Desktop GIS is in use by more than 50 users for their daily work, although they are no GIS experts. Their main work is to visualize and/or capture geospatial data with an intuitive user interface.

One of the most important Desktop GIS issues is the question: "How do I get the information from the PostGIS geodata repository?". Since our end users are

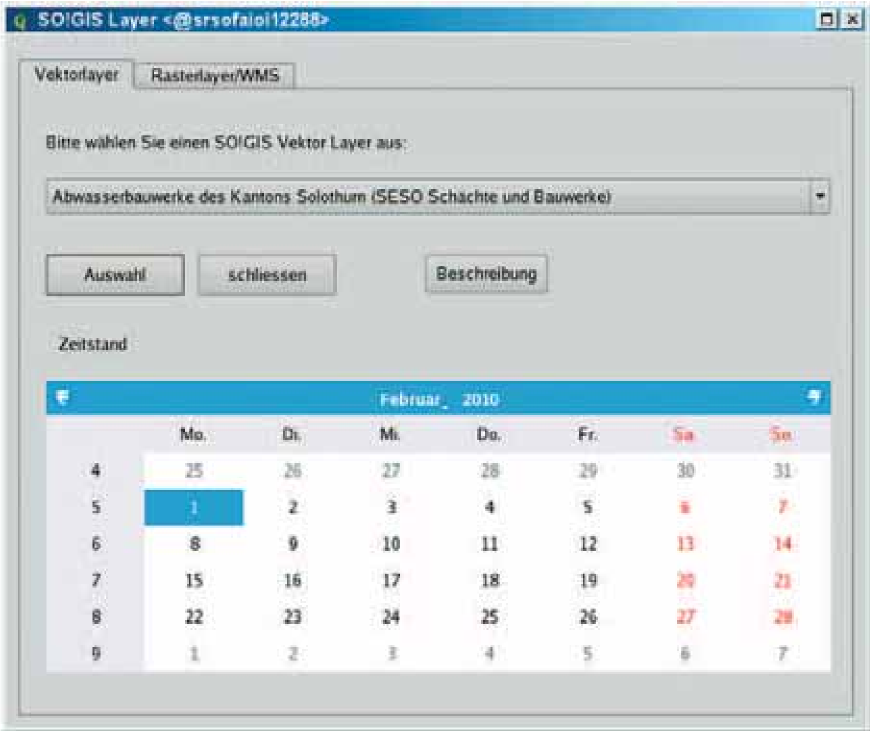

Figure 4.9: “SO!GIS Layer” plugin developed at the Canton of Solothurn.

Figure 4.10: “SO!GIS Suche” plugin developed at the Canton of Solothurn.

not familiar with data models and underlying structures of our spatial database, it was not option to just offer them a raw connection to the PostGIS DB. It became necessary to establish a metadata database that stores the descriptions of all data, called "SO!DATA".

SO!DATA contains a human readable inventory of the data models and the non-GIS-expert users are able to use this database to discover the information they need.

To remove the need for end users to interact directly with PostGIS connections and table selection dialogs, a plugin has been developed in python. The plugin is called "SO!GIS Layer" (see Figure 4.9). The plugin connects to the SO!GIS PostGIS repository, retrieves the information of all published geospatial data layers from SO!DATA and offers the user a GUI to find the data layers they need. With this infrastructure in place, the users are satisfied – they can individually prepare for geoprocessing, editing and map composing.

Another required QGIS plugin that has been created, is called "SO!GIS Suche". This plugin provides the possibility to search for locations such as townships, addresses or cadastral parcels (see Figure 4.10). As a result, the user is able to navigate easily to an area of interest.

There are many other plugins under development. These will support data manipulation, analysis or mapping for different projects. Our in-development plugins cover topics such as nature reserves, soil conservation, cadastral data verification, crisis management, abandoned sites and similar issues.

Conclusion

In conclusion, it can be said that QGIS was the right decision for the canton of Solothurn. QGIS can offer most of the features that were requested by the users. The canton of Solothurn subcontracts the development of features that QGIS lacks to commercial support providers. With PyQgis and PyQt there are excellent options for easy in-house application development based on QGIS. One huge benefit is the unlimited number of installations. To push the development of QGIS, the Canton of Solothurn has invested approximately USD 30,000 into QGIS every year since 2007. This is much more efficient and target-oriented than the payment of support into the black box of our former software provider. Apart from using FOSSGIS, the canton of Solothurn also provides public geodata free of charge via the SO!ONLINE web portal.

5. Conclusions

Mika-Petteri Törhönen, Daniel Steudler

Information technology systems are crucial elements of cadastre and land registration everywhere in the 21st century. Introduction of automation to land administration has improved systems' efficiency, standardisation and accessibility, which in turn have contributed to responsible land governance. Developing country land administrations are, however, often inefficient and poorly structured. This results partly from the lack of adapted and flexible software tools to standardise, structure and maintain the cadastre and the land registration. More flexible and feasible systems are needed.

The chapters in this booklet clearly demonstrate that open-source software, or FLOSS, has become a credible alternative to commercial off-the-shelf software in the field of cadastre and land registration systems. The development of open-source database management and geographic information systems has been rapid in recent years and they are increasingly applied to spatial data management. This is relevant globally, but it is seen that, in developing country contexts in particular, the emerging awareness of alternative approaches and tools to support cadastral and land registration systems is a very important innovation. Flexibility and the ability to be adapted to local conditions, and saved licence costs are among the features that make open-source software attractive in low resources settings.

Open-source software should not, however, be seen as the panacea for sustainable information technology systems. Cadastral systems' software needs continuous maintenance and constant development, which require resources regardless of the software policy over access to the source code. Adequate business planning remains the key requirement behind feasible and successful introduction of automation and digital systems into cadastre and land registration. It is also evident, however, that there are cases and conditions where partial or full system solutions relying on open-source software can be the most feasible and successfully introduced option.

This booklet has been prepared and published to serve as a source book for people working with and for cadastral and land registration applications using FLOSS.

This booklet can, in addition, be taken as a baseline study. This is what the FLOSS cadastre and land registration scene looked like in April 2010.

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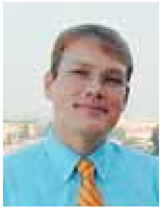

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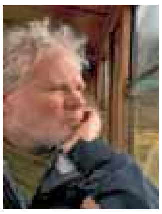

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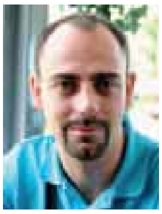

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